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29 September, 2022

Department of Mines, Industry Regulation and Safety (DMIRS)
Mineral House
100 Plain Street
East Perth, WA 6892

Attention: Mr Damien Montague, Team Leader - Native Vegetation Clearing Permits

SUBJECT: Airlie Island Clearing Permit Application - Supporting Information

Dear Sir,

Re: Clearing of 3.94277 ha for investigative and remediation works as part of the Airlie Island asset retirement.

Background

Santos WA Southwest Pty Ltd (Santos) is the operator of the remaining Airlie Island (AI) oil and gas infrastructure on the Northwest Shelf, Western Australia (WA) within production licence TL/2 and onshore pipeline licence PL 14. Production from the AI facility ceased in 2002, with the majority of associated infrastructure being removed during a 2016 remediation campaign.

The application area is located on Airlie Island, which lies approximately 35 km NNE of Onslow. Airlie Island is a 'C' class nature reserve (Crown Reserve 40323), vested in the Conservation Commission of Western Australia under the *Conservation and Land Management Act 1984* and managed by the Department of Biodiversity Conservation and Attractions (DBCA).
In 1991, a lease was granted under the *Conservation and Land Management Act 1984* over a portion of the reserve for the purpose of constructing, operating, inspecting, maintaining and repairing the pipeline specified in Pipeline Licence 14 (R1) (Lease 1901/100). The Lease area occupies 10 ha or 38.5% of the land area on AI (26 ha). The lease is still current and lease conditions require Santos WA to have an environmental management plan in place, undertake regular environmental monitoring and prepare annual reports to regulators.

The Island is now in a care and maintenance phase, managed under the Varanus Island Hub Operations Environment Plan (State Waters). To inform management of future asset retirement, Santos plans to undertake investigative works on the remaining onshore and offshore pipelines, to characterise any contamination that may be present in and around the pipelines.

Proposed works

The investigative works will involve cutting sections of both onshore and offshore pipelines. The cut sections will then be recovered and transported to the mainland for further analysis, the collection of soil samples and the potential replacement / reinstatement of five groundwater monitoring bores.

Future asset retirement works may involve remediation of contamination and removal of remaining infrastructure.

To access the sections of pipeline and other infrastructure, some vegetation clearing will be required. The proposed clearing area lies within the existing disturbance footprint that has been historically cleared. A previous clearing permit (CPS 6972/2) issued to Quadrant Oil Australia Pty Ltd (now part of Santos) expired in September 2020.

The island will be accessed by a charter vessel. As AI does not have a jetty the vessel will remain offshore and transfer personnel to shore via a small tender.

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Tracks will be cleared for light vehicle access using existing disturbance areas where possible. The tracks will allow access for a drill rig and excavator.

Figure 1 – Application Area location with associated regional context

Proposed clearing activities

Select areas (predominantly historic access tracks with vegetation regrowth) within a 3.94277 ha potential disturbance application area will be impacted when mobilising a small drill rig to select investigation areas or with mobilisation of machinery/vehicles to access locations where sections of pipeline will be unearthed and cut.

Proposed measure to avoid and minimise impacts of clearing of vegetation include:

- Investigative activities will be undertaken and executed in alignment with the current in-force DMIRS approved Varanus Island Hub Operations Environmental Plan (State Waters);
- Activities will be undertaken outside of the turtle and migratory bird nesting seasons (October – April);
- Personnel accommodated on vessels offshore;
- Activity footprint restricted to within the Airlie Island Lease boundary and previously disturbed areas will be prioritised where possible;
- As per routine practice the Santos Quarantine Management Plan and associated controls will be implemented for Airlie Island mobilisations;
- Santos activity risk assessment and hazard control procedures to be implemented for all aspects of the scope; and
- Annual environmental monitoring campaigns (marine turtle, seabird and vegetation etc) will continue on Airlie Island after the investigatory works program has been completed.

Assessment against the 10 clearing principles

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Principle a – Native vegetation should not be cleared if it comprises a high level of biological diversity

The application area is on Airlie Island, which lies approximately 35 km NNE of Onslow within the Roebourne subregion of the Pilbara Interim Biogeographic Regionalisation of Australia (IBRA) bioregion within the Cape Range subregion (CAR1).

Vegetation associations on the island were first described by Astron Environmental Services (Astron) in 1988. Flora and vegetation monitoring began on AI in 1987 and has continued on an annual basis to comply with conditions of Lease 1901. Since decommissioning works began, natural regeneration of vegetation has occurred over much of the disturbance area.

The five vegetation associations that are described on AI are:

+ beach association
+ foredune association
+ grassland
+ low shrubland
+ open shrubland.

These are described in the attached/ vegetation assessment report (Astron 2021).

As a small, isolated island with poor soils and hot, dry climate, AI supports relatively few species of vascular plants. A total of 44 taxa from 16 families have been recorded on the island. Of the 44 confirmed flora taxa recorded on AI, four are listed as weed species and a further four are native mainland species that have been introduced to the island (Astron 2021).

Given the above, It is considered that the application area does not comprise a high level of biodiversity and is not at variance to this principle.

Principle b – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of as significant habitat for fauna indigenous to Australia.

There are nine species present on AI that area listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999* or protected under the Western Australian *Biodiversity Conservation Act 2016*:

+ Wedge-tailed Shearwater (*Ardenna pacifica*) (Marine, Migratory – EPBC; BC);
+ Crested Tern (*Thalasseus bergii*) (Marine, Migratory – EPBC, BC);
+ Lesser Crested Tern (*Thalasseus bengalensis*) (Marine, Migratory – EPBC);
+ Roseate Tern (*Sterna dougallii)* (Marine, Migratory – EPBC; BC);
+ Osprey (*Pandion haliaetus*) (Marine, Migratory – EPBC; BC);
+ White-bellied Sea Eagle (*Haliaeetus leucogaster*) (Marine, Migratory – EPBC);
+ Green turtle (*Chelonia mydas*) (Vulnerable – EPBC; BC)
+ Hawksbill turtle (*Eretmochelys imbricata*) (Vulnerable – EPBC; BC)
+ Flatback turtle (*Natator depressus*) (Vulnerable – EPBC; BC)

Previous reports have made reference to the Airlie Island skink (*Ctenotus angusticeps*), however, this species has since been removed from Commonwealth and State threatened fauna lists.

There are no mammal species found on AI however, the island supports high value habitats including nesting habitat for wedge-tailed shearwaters, potential nesting habitat for lesser crested and crested terns, roseate terns, ospreys and white-bellied sea eagles and breeding habitat for marine turtle species. The sandy beaches of AI support nesting for three threatened (Vulnerable) turtle species:

+ Flatback turtle (*Natator depressus*)

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+ Green turtle (*Chelonia mydas*)
+ Hawksbill turtle (*Eretmochelys imbricata*)

The peak time of year identified for nesting and interesting areas identified as habitat critical to the survival of marine turtles is (CoA, 2017a):

+ Flatback turtles, Pilbara genetic stock: Oct-Mar
+ Green turtles, North West Shelf genetic stock: Nov-Mar
+ Hawksbill turtle, Western Australia genetic stock: Oct-Feb.

No vegetation on beaches works will be undertaken within peak nesting periods to avoid disturbance. Airlie island also provide important nesting habitat for several seabirds, particularly the wedge-tailed shearwater. The Wedge-tailed Shearwater is a pelagic, marine bird known from tropical and subtropical waters. The species breeds throughout its known range, mainly on vegetated islands, atolls and cays (DAWE). Studies undertaken at breeding sites on the North West Shelf of WA confirm the laying period for wedge-tailed shearwaters occurs from late October to early November (DAWE, 2020). The fledging period for the species in this region is primarily in April (Pendoley 2021). Seabird monitoring undertaken by Santos has identified wedge-tailed shearwater colony sizes within or above previously reported ranges (Pendoley 2021).
Annual monitoring of wedge-tailed shearwaters and turtles is undertaken as a condition of Lease 1901/100. Six seabird species are also targeted as part of the monitoring program: Bridled Terns, Silver Gulls, Crested Terns, Lesser Crested Terns, Roseate Terns and Pied Cormorants.

Based on the above, the proposed clearing may be at variance to this principle.

Principle c – Native vegetation should not be cleared if it includes or is necessary to the continued existence of rare flora.

None of the flora species recorded on AI are currently listed as a Threatened or Priority flora species (Astron 2021). Therefore, the proposed clearing is not at variance to this principle.

Principle d – Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of a threatened ecological community.

There are no Threatened or Priority Ecological Communities within the application area. Therefore, the proposed clearing is not at variance to this principle.

Principle e – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

The application areas fall within the Pilbara Interim Biogeographic Regionalisation of Australia (IBRA) bioregion. The proposed clearing is within a previously cleared area and that the clearing of native vegetation will be predominately regrowth. No Beard vegetation association has been mapped for Airlie Island. The majority of the Pilbara Islands are mapped as Beard vegetation association 117: Hummock grasslands, grass steppe; soft spinifex (Shepherd et al 2001). Vegetation mapped on Airlie Island resembles this vegetation association. The Beard vegetation association 117 retains approximately 96% or above of the pre-European extent at both the state and bioregion level (Government of Western Australia, 2018). If it is assumed that the vegetation on Airlie Island is similar to that of Beard vegetation association 117, then the area proposed to be cleared is not a significant remnant of native vegetation. Based on the above, the proposed clearing is not at variance to this Principle.

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Principle f – Native vegetation should not be cleared if it is growing in or in association with an environment associated with a watercourse or wetland.

There are no permeant water courses or wetlands on AI. Therefore, the proposed clearing is not at variance to this principle.

Principle g – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

The proposed clearing of 3.94277 ha of native vegetation is unlikely to cause appreciable land degradation. The application area has been historically cleared and disturbed and the nature and scale of the clearing is unlikely to result in large open areas of disturbance that would result in land degradation. Therefore the proposed clearing is not likely to be at variance to this principle.

Principle h – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

The application area is located within Airlie Island Nature Reserve, a 'C' class nature reserve (Crown Reserve no 40323). The proposed clearing is proposed to enable investigative works to occur that will inform decommissioning requirements which will be beneficial to the conservation area. Given the small scale of the proposed clearing and the resulting remediation activities, the proposed clearing is not likely to be at variance to this principle.

Principle i – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

The application area is not within a Public Drinking Water Source Area (Government of Western Australia 2021). There are no permanent or seasonal surface water bodies on AI. Investigative works are being undertaken to determine if any soil or groundwater contamination exists which will inform remediation and decommissioning planning. Remediation of contamination will be beneficial to the quality of the groundwater. Therefore, the proposed clearing is not at variance to this principle.

Principle j – Native vegetation should not be cleared if clearing of the vegetation is likely to cause or exacerbate the incidence of flooding.

Given the low rainfall and sandy soils, it is unlikely that the small areas of proposed clearing will increase the incidence of flooding on AI. Therefore, the proposed clearing is not likely to be at variance to this principle.

Planning and other matters

All works on AI are to be undertaken in accordance with the Varanus Island Hub Operations Environment Plan (State Waters) and Lease 1901/100.
Subsequent decommissioning activity on AI will be undertaken in accordance with a future DMIRS approved Environment Plan.

Please direct any queries to Patrick Becker, Senior Environment Advisor, at patrick.becker@santos.com

We look forward to continuing to work with you and remain available for further discussions.

Sincerely,

AMcGovern

Annette McGovern
Senior Environmental Advisor

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Attachment 1 – Application Area Map

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AIRLIE ISLAND CLEARING PERMIT

PROPOSED PERMIT AREA

Attachment 2 – Recent Vegetation Assessment Report

Santos Level 7, 100 St Georges Tce PERTH WA 6005	**Airlie Island Flora, Vegetation and Weed Monitoring, Annual Report 2021**
	Total number of pages to this document (incl. coversheet): 44
DOCUMENT TITLE: Airlie Island Flora, Vegetation and Weed Monitoring, Annual Report 2021	Santos DOCUMENT No: **SO-91-RI-20120** — Rev. 0 VENDOR DOCUMENT No: 569G-21-BISR-1Rev0_210526 — Rev. 0
CONTRACT / PURCHASE No: 4800003876	
DOCUMENT STATUS: INFORMATION ■ FOR REVIEW ☐ OTHER ☐ FOR APPROVAL ☐	EQUIPMENT TAG No: EQUIPMENT DATASHEET No:

REVISIONS TO QUADRANT DOCUMENT No:

Rev	Date	Reason for Issue
A	05/05/2021	Issued for Review
0	26/05/2021	Issued for Information

NOTES:

Santos Environmental Monitoring Program
Airlie Island Flora, Vegetation and Weed Monitoring
Annual Report
March 2021

Prepared for
Santos WA Energy Limited

Report Reference: 569G-21-BISR-1Rev0_210526

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Santos Environmental Monitoring Program
Airlie Island Flora, Vegetation and Weed Monitoring
Annual Report 2021

Prepared for
Santos WA Energy Limited

Job Number: 569G-21

Reference: 569G-21-BISR-1Rev0_210526

Santos Report Reference: SO-91-RI-20120

Revision Status

Rev	Date	Description	Author(s)	Reviewer
A	05/05/2021	Draft Issued for Client Review	N. Cadd D. Mihindukulasooriya S. Moore	A. Gove
0	26/05/2021	Final Issued for Information	S. Moore	L. Churchward

Approval

Rev	Date	Issued to	Authorised by	
			Name	Signature
A	05/05/2021	P. Becker	B. Lucas	[signature]
0	26/05/2021	P. Becker	S. Pearse	[signature]

Abbreviations

Abbreviation	Definition
AI	Airlie Island
cm	Centimetres
F	F-statistic
ha	Hectares
km	Kilometres
m	Metres
m^2	Metres squared
mm	Millimetres
P	Calculated probability
PERMANOVA	Permutation-based multivariate analysis of variance
PFC	Projected foliar cover
t	Pearson test t statistic
Santos	Santos WA Energy Limited
r	Correlation coefficient (Pearson test)
WSI	Water stress index

Executive Summary

Monitoring of flora, vegetation and weeds at Airlie Island is conducted to meet the requirements of regulatory conditions relevant to Santos WA Energy Limited's Lease 1901/100. Monitoring of nine previously established transects was undertaken from 15 to 17 March 2021.

The long-term data indicate no distinct trends over time for floristic composition or species richness. A significant long-term decline in vegetation cover was observed at both the Lease and Reserve areas. Cover was significantly associated with rainfall recorded in the 12 months prior to monitoring.

Weed cover has increased significantly at one transect located on the Reserve due to the proliferation of **Cenchrus ciliaris*. A notable increase in the distribution of the introduced mainland species *Dactyloctenium radulans* was recorded from opportunistic observations. This introduced species was recorded for the first time in 2015 along the track to the Jetty, and in 2021 had formed a dense population along the length of the track and close to the accommodation area, having also spread to the old turkey's nest.

Beyond the proliferation *D. radulans*, the 2021 monitoring results have demonstrated that there is no overall change to the vegetation on Airlie Island attributable to Santos' operations (care and maintenance).

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1 Introduction

1.1 Project Background

Airlie Island (AI) is a nature reserve vested under the *Conservation and Land Management Act 1984*, a portion of which is leased by Santos WA Energy Limited (Santos) for facilities associated with historic petroleum production (Lease 1901/100) (**Figure 1**). Airlie Island was first developed as an oil terminal for the North Herald and South Pepper fields by Western Mining Corporation Ltd in 1987. Since then, the AI terminal has been operated by five other companies: Novus West Australia Pty Ltd, Hadson Energy Ltd, Apache Energy Limited, Quadrant Energy and now Santos. Operations on AI ceased in March 2002 and Santos' activities on AI are now limited to care and maintenance.

Historic operations on AI had the potential to cause changes to vegetation, native flora and weeds. Monitoring of the flora and vegetation is conducted as per the *Airlie Island Flora, Vegetation and Weeds Monitoring Method Statement* (EA-00-RI-10058.10) (Santos WA Energy Australia Limited 2020) to meet regulatory requirements (**Table 1**). Flora and vegetation monitoring began in 1987 and continued on an annual basis until 2018. Monitoring was not undertaken during 2019 and 2020.

The purpose of this report is to present the monitoring results for 2021 in the context of regulatory requirements under Lease 1901/100 conditions.

1.2 Vegetation and Flora Overview

Airlie Island is located on the border of the Carnarvon and Fortescue Botanical Districts of the Eremaean Botanical Province (Beard 1975). Due to AI's small size (26 ha), isolation, simple habitat types, poor soils and hot, dry climate, AI supports relatively few species of vascular plants. A total of 40 taxa have been recorded since the monitoring program began in 2006. Vegetation associations were initially described by Astron Environmental Services (1988) and further detailed in the *Airlie Island Annual Vegetation Monitoring 2001* (Astron Environmental Services 2002).

The five vegetation types described for AI are:

- beach association
- foredune association
- grassland
- low shrubland
- open shrubland.

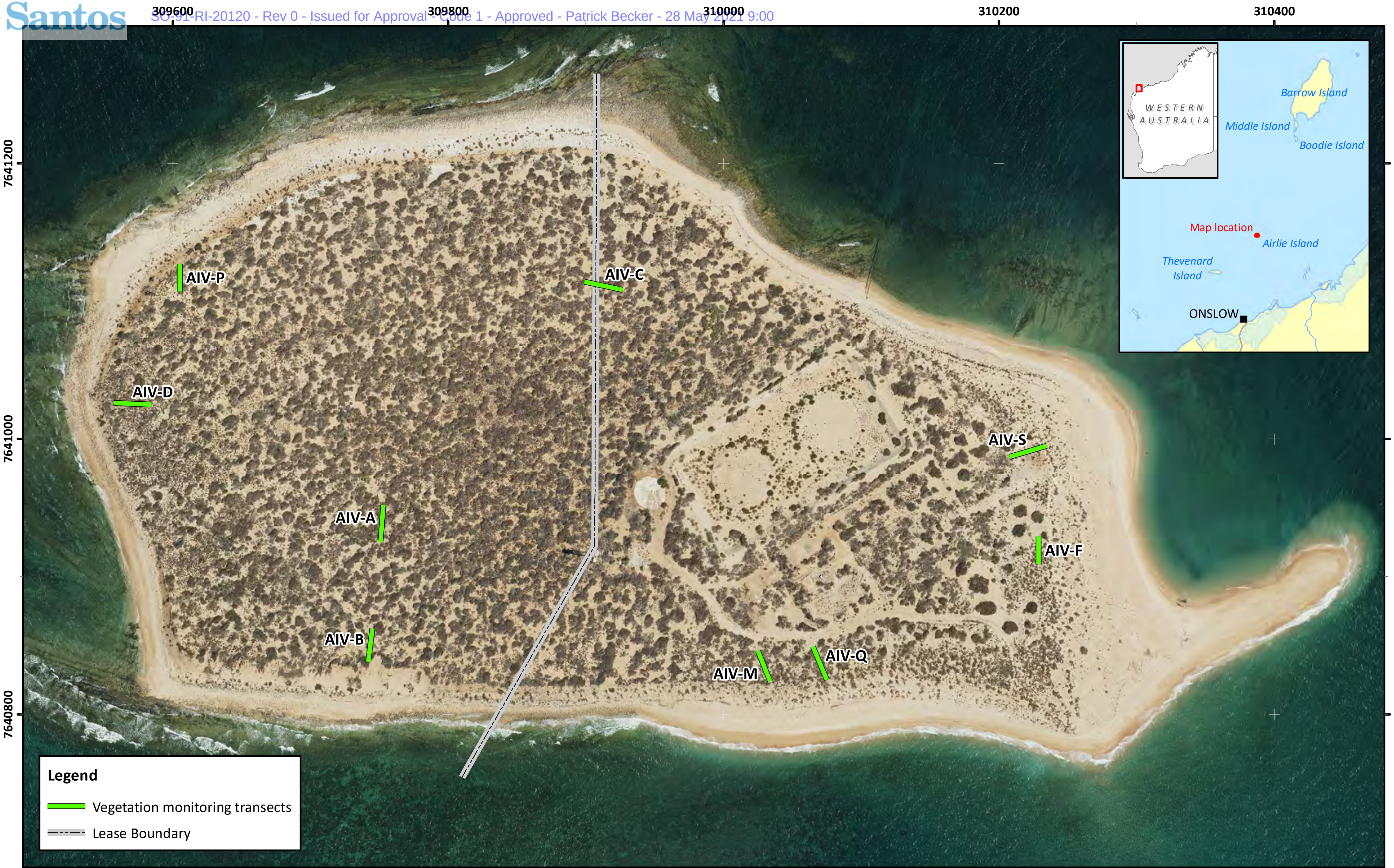
Of the 40 confirmed flora taxa recorded on AI, four are listed as weed species: **Cenchrus ciliaris*, **Aerva javanica, *Eragrostis minor* and **Flaveria trinervia*. There are also four native mainland species that have been introduced to AI: *Abutilon lepidum, Dactyloctenium radulans*, *Dysphania plantaginella* and *Ipomoea muelleri*.

None of the flora species recorded on AI are currently listed as a Threatened or Priority flora species (Department of Biodiversity, Conservation and Attractions 2020). Additionally, none are listed as a Weed of National Significance (Australian Weeds Committee 2012), or a declared pest plant in Western Australia under the *Biosecurity and Agriculture Management Act 2007* (Department of Primary Industries and Regional Development 2020).

Table 1: Regulatory conditions from Airlie Island Lease 1901/100 (Department of Conservation and Land Management 1991) relating to monitoring of flora and vegetation and how each requirement has been met.

Condition no.	Requirement	Evidence of requirement met
Clause 1(26)	THE Lessee shall carry out by its servants or independent consultants previously approved by the Lessor a continuous programme of investigation and research including annual monitoring studies of sample areas to ascertain the effectiveness of measures taken by the Lessee pursuant to approved proposals for rehabilitation protection and management of the environment. Data obtained from the monitoring studies shall be presented to the Lessor in a form suitable for statistical analysis by the Lessor.	The monitoring program as implemented and this report.
Clause 1(27)(a)	THE monitoring to be carried out under paragraph (26) hereof shall include:- (a) annual colour vertical aerial photography at a scale of 1:5,000 or larger of the entire Reserve to be flown along the same course each year.	**Figure 1** presented in this report.
Clause 1(27)(g)	THE monitoring to be carried out under paragraph (26) hereof shall include:- (g) the effects of unusual weather conditions including cyclones and droughts upon the flora fauna and environment of the Reserve.	Results and discussion of this report.
Clause 1(28)(d)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive. (d) investigations research and biological monitoring studies carried out by the Lessee as hereinbefore provided and any conclusions or findings thereon.	Final of this report.
Clause 1(28)(f)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive. (f) any further new or additional procedures which the Lessee may wish to suggest as being relevant or necessary to improve the management of the environment of the Reserve and to mitigate damage caused to that environment including, without limiting the generality of the foregoing, proposals to amend existing procedures if the monitoring carried out under paragraph (26) hereof shows that the Lessee's operations are having a detrimental effect on the Reserve's flora or fauna.	Santos annual report.

Condition no.	Requirement	Evidence of requirement met
Clause 1(29)	ANY observations of environmental concern resulting from the monitoring programme or otherwise shall be reported immediately to the Lessor.	Mainland flora species proliferation (refer to section 3.5)



Santos WA Energy Limited
Airlie Island Flora, Vegetation and Weeds Monitoring – Annual Report, March 2021

Figure 1: Location of vegetation monitoring transects on Airlie Island

Coordinate System: GDA 1994 MGA Zone 50

0 50 100 150 200 Metres

N

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Author: N. Cadd | Drawn: T. Pedersen | Date: 12-04-2021 | Figure Ref: 569G-21-BIDR-1RevA_210412_Fig01

2 Methods

2.1 Monitoring

2.1.1 Timing

With the exception of 2015 and 2021, monitoring surveys on AI have been conducted as dry season surveys, with the majority of monitoring taking place in September (**Table 2**). In 2015 the monitoring was conducted in May, after wet season rainfall, to maximise the identification of a wide suite of flora species, including ephemeral and annual species. However, in order to maintain consistency with historical monitoring, the 2016, 2017 and 2018 monitoring surveys were undertaken during the dry season. Monitoring in 2021 occurred from 15 to 17 March 2021 to coincide with other environmental monitoring programs on AI.

A summary of historical monitoring times and associated rainfall records is presented in **Table 2**. Rainfall values summarised here were recorded at Onslow and should be interpreted with caution. This table also includes the time since a particular quantity of rainfall (20 mm weekly rainfall) had fallen. This level of rainfall was considered sufficient to promote plant growth.

Table 2: Summary of historical survey timing, rainfall recorded in the 12 months prior to monitoring and the number of weeks since total weekly rainfall was 20 mm or greater.

Survey year	Survey commencement date	Annual rainfall (mm)	Weeks since weekly rainfall total greater than 20 mm
2006	13 October	401	19
2009	16 September	500	12
2010	8 November	42	72
2011	10 December	658	23
2012	9 September	120	13
2013	1 September	280	10
2014	20 September	102	20
2015	7 May	383	1
2016	1 October	237	13
2017	8 December	280	36
2018	29 September	170	16
2021	15 March	161	2

2.1.2 Field Methods

The monitoring survey for 2021 was undertaken by Astron Associate Botanist Vicki Long (Scientific flora license FB62000220-2) and Environmental Scientist Josh Collard (Scientific flora license FB62000205).

The field methodology combined the assessment of previously established transects and the opportunistic survey of annual and ephemeral flora species across the island. Data collected during the opportunistic survey were not included in the statistical analysis.

Nineteen transects have been established on AI since the monitoring program began in 1987. Over time some transects have been removed due to coastal erosion or the construction of new infrastructure, or intentionally removed as they were considered redundant to the monitoring program. New transects have been installed to replace some of these removed transects. Transect AIV-S was established in 2015 but was relocated (as close as possible to the original location) due to the removal of the flare tower in 2016. The highly disturbed nature of the area around AIV-S is likely to be reflected in the results of subsequent years.

Nine transects, established within five habitats, currently remain; all of which were monitored in 2021 (**Figure 1; Table 3**). Five transects are located within the Santos lease area ('Lease') (three in disturbed areas and two in undisturbed areas) and four are in undisturbed areas of the Department of Biodiversity, Conservation and Attractions managed (off-lease) lands ('Reserve') (**Table 3**). The locations of transects in the Lease and Reserve areas are designed to detect changes in vegetation inside and outside the lease area.

Table 3: Summary of Airlie Island monitoring transects in 2021.

Transect	Habitat	Vegetation type	Location	Disturbance
AIV-A	Inner island basin	Open shrubland	Reserve	Undisturbed
AIV-B	Hind dune	Low shrubland	Reserve	Undisturbed
AIV-C	Inner island ridge	Open shrubland	Lease	Disturbed
AIV-D	Elevated sand plain	Open grassland	Reserve	Undisturbed
AIV-F	Remnant foredune	Dune vegetation	Lease	Disturbed
AIV-M	Hind dune	Colonising vegetation	Lease	Undisturbed
AIV-P	Elevated sand plain	Low shrubland/open grassland	Reserve	Undisturbed
AIV-Q	Hind dune	Low shrubland	Lease	Undisturbed
AIV-S	Remnant foredune	Dune vegetation	Lease	Disturbed

Each transect was 25 m in length and 1 m wide, consisting of 25 contiguous 1 m by 1 m quadrats, and was located to provide a representative sample of a particular vegetation type. Within each 1 m^2 quadrat, the presence of all vascular flora species was recorded if the stem was located within the quadrat, while projected foliar cover (PFC) was recorded for all species overhanging the quadrat. The total number of plants present was counted for each species, including living and dead plants. PFC was estimated as a per cent value of the total quadrat area.

For species which produce underground rhizomes (such as *Sporobolus virginicus* and *Spinifex longifolius*), or where it was impossible to distinguish individual plants (such as *Cynanchum viminale* subsp. *australe*) only PFC was recorded.

A photograph of each transect monitored in 2021 is presented in **Appendix A**, and is compared with a photograph of the same transect taken in 2018 (the last monitoring survey).

2.2 Data Management and Statistical Analysis

The master data set containing all years of data was reviewed and updated in 2021 with the following changes made:

- historical data was reviewed and corrected where required
- *Euphorbia coghlanii* in all years was updated to *E. trigonosperma* and *Cleome viscosa* updated to *Arivela viscosa* due to updated taxonomic nomenclature at the time of the 2021 monitoring survey.

The statistical analysis methods were reviewed and updated in 2021 with the following variables tested for significant differences across time using linear models:

- species richness measured by the total number of native taxa recorded at each monitoring transect
- mean PFC of all native species recorded at each monitoring transect
- mean PFC of all native species recorded at each monitoring transect in the Reserve area
- mean PFC of all native species recorded at each monitoring transect in Lease area
- mean PFC of all weed species recorded at each monitoring transect.

Total PFC was calculated as the sum of all species within each quadrat, with the mean PFC then calculated for the transect. Model residuals were examined for normality. If residuals were found to be non-normal, transformations were attempted; if transformations were not effective, the statistical significance of the models was tested using permutation tests in the lmPerm package (Wheeler and Torchiano 2016).

Correlation tests were used to identify associations between species richness or vegetation cover, and the amount of rainfall recorded in the one, two, three, six and twelve months prior to monitoring. Additional tests were performed using the number of weeks since total weekly rainfall of 20 mm or more, and using a water stress Index (WSI) based on a method of Williams et al. (2012).

$$WSI = 0.5(z \times Rain\_3mo) - 0.5(z \times Tmax\_14d)$$

Where *Rain_3mo* is the cumulative rainfall (mm) over three months (90 days) prior to the survey date and *Tmax_14d* is the mean maximum daily temperature over the 14 days prior to the survey date. The Z score (z) is a dimensionless statistical measure indicating how many standard deviations (σ) an observation (x) is above or below the population mean (μ), defined as:

$$z = (x - \mu)/\sigma$$

Variables were examined for normality using Shapiro's Test of Normality. Variables that displayed a normal distribution were assessed using Pearson's Correlation tests while variables that were not normally distributed were assessed using Spearman's Correlation tests.

Using permutation-based multivariate analysis of variance (PERMANOVA) (Anderson et al. 2008), changes in floristic composition (quantified by total PFC of species) of each transect were examined separately. Similarity between each pair of quadrats was calculated using the Bray-Curtis similarity index with year as the fixed factor. When the overall effect of year was significant, differences in floristic composition between all pairwise combinations of years were examined using multiple comparisons tests. Analyses were completed using the vegan package in R (Dixon 2003, R Core Team 2019).

All statistical analyses were performed using R (Version 3.6.0) (R Core Team 2019). P values of all tests were reported to two or three decimal places depending on the level of significance. Complete series of non-significant results were generally reported to only two decimal places. Unless otherwise stated, statistical significance was determined as $P < 0.05$.

2.3 Limitations

When interpreting the data presented in this report, it should be considered that monitoring results from 2006 to 2014 and 2016 to 2018, relate to the state of flora and vegetation in the dry season (primarily September). Therefore, results from 2015 and 2021, which were respectively recorded in May and March, are likely to incorporate changes in vegetation related to wet season rainfall, such as a possible increased density of annual species. This contrast in environmental conditions should be considered when interpreting changes to vegetation.

Further caution should be taken when considering the correlation of monitoring results with rainfall data. There is no weather station located on AI and, as such, rainfall data is obtained from Onslow (station number 5017), which is the closest Bureau of Meteorology station. Onslow is 39 km from AI and given the localised nature of rainfall in the region, values recorded here are likely to vary from what was received at AI.

3 Results and Discussion

3.1 Climate and Weather

Daily weather observations recorded from Onslow Airport weather station (5017), located approximately 39 km south of AI, were used to describe local rainfall preceding the 2021 monitoring survey (Bureau of Meteorology 2021) (**Figure 2**). A total of 160.8 mm of rainfall was recorded in the 12 months prior to the monitoring survey, which was 143.3 mm below the long-term (1940 to 2020) mean of 304.2 mm (Bureau of Meteorology 2021). Rainfall received in the three months preceding the monitoring survey (123 mm) was 43.5 mm below the long-term mean of 166.5 mm for the same period; despite a significant rainfall event which occurred in early March 2021 (less than two weeks prior to the survey), in which 84.2 mm of rain was received (**Figure 2**). The mean annual rainfall for the duration of the monitoring period (2006 to March 2021) is 246.3 mm, but seasonal and annual variability is high (Bureau of Meteorology 2021) (**Figure 3**). Since 2016, total annual rainfall has been below average.

Field observations noted that in general, perennial native vegetation was in poor to average condition and had not yet fully recovered from the preceding dry years.

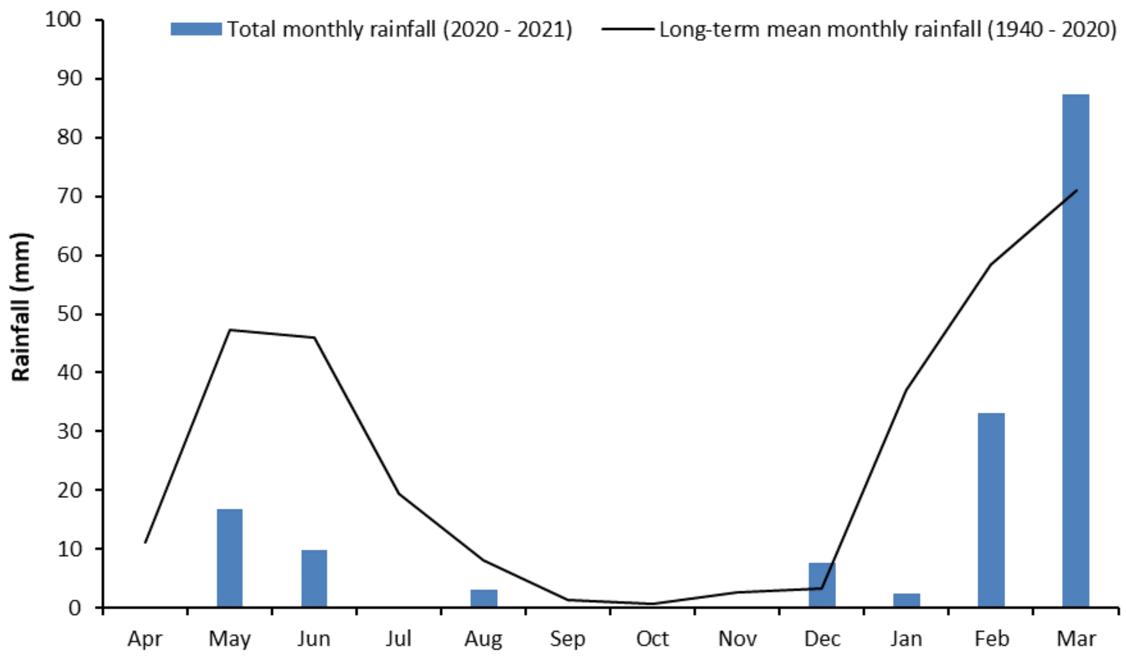

Figure 2: Monthly rainfall received at Onslow Airport (5017) in the 12 months preceding the March 2021 monitoring survey and the long-term (1940 to 2020) mean monthly rainfall. (Bureau of Meteorology 2021).

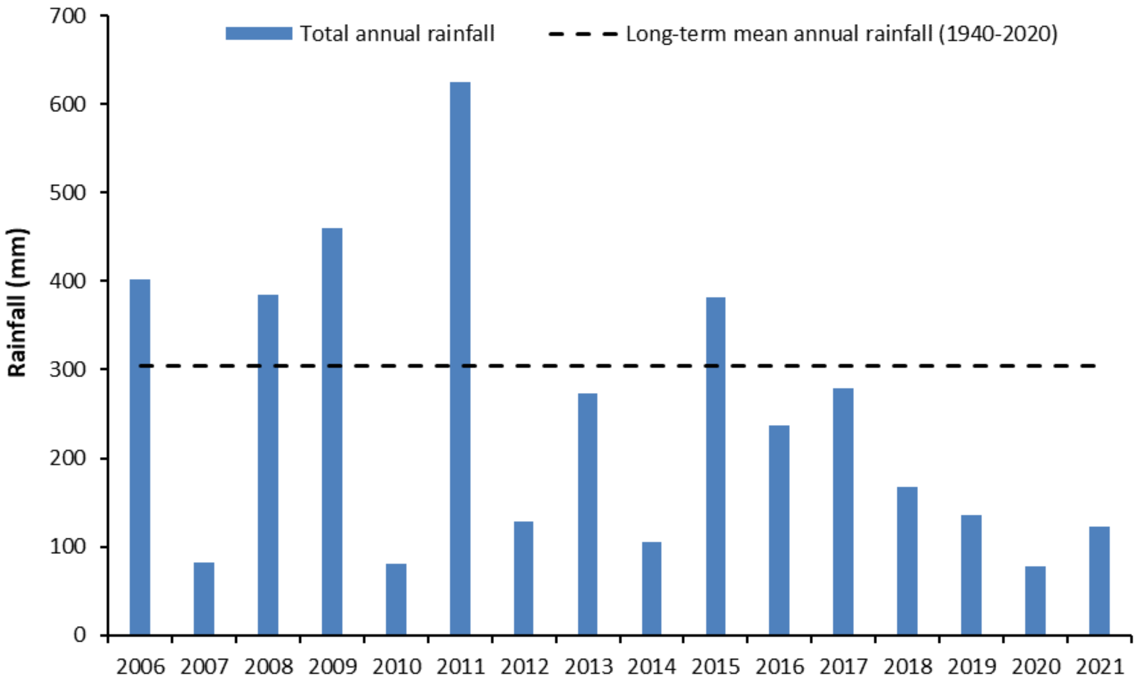

Figure 3: Total annual rainfall received at Onslow Airport (5017) for the duration of the monitoring program (2006 to March 2021), compared to the long-term (1940 to 2020) mean annual rainfall. (Bureau of Meteorology 2021).

3.2 Flora

There were 21 flora taxa from 11 families and 19 genera (including subspecies and varieties) recorded within the transects in 2021. The Poaceae family was the most dominant, with five species recorded, while *Acacia* and *Euphorbia* were the most species rich genera, each with two species recorded.

A list of all species recorded within transects and opportunistically on AI between 2006 and 2021, is presented in **Table B. 1, Appendix B**.

3.3 Species Richness and Floristic Cover

There has been no long-term trend in species richness ($F_{1,80}$ = 0.07, P = 0.80; **Table C.1, Appendix C**). Species richness fluctuated slightly until 2015 when the wet season survey and above average rainfall resulted in an increase in species richness for all transects except AIV-D (**Figure C.1**). Between 2018 and 2021, species richness increased in five transects, decreased in two transects, and remained stable in two transects. This may reflect the wet season survey timing and sufficient rainfall received six weeks prior to the survey to stimulate vegetation germination and growth. Species richness between 2006 and 2021 was statistically associated with the amount of rainfall recorded in the six months prior to transect monitoring (P = 0.04) and number of weeks since the last major rainfall event (P = 0.01; **Table C.2, Appendix C**). However, there was no significant association between species richness and the amount of rainfall recorded in the one, two, three, or 12 months prior to monitoring, nor with WSI (**Table C.2, Appendix C**).

There has been a significant long-term decline in the projected foliar cover of native species at AI ($F_{1,80}$ = 47.08, P < 0.001; **Table C.1, Appendix C**). When Lease and Reserve transects were assessed separately, a significant result was obtained for both Lease transects ($F_{1,49}$ = 15.97, P < 0.001; **Table**

C.1, Appendix C) and Reserve transects ($F_{1,45} = 32.06$, $P < 0.001$; **Table C.1, Appendix C**). Short-term native cover decline was particularly evident in the periods from 2009 to 2010, 2013 to 2014, and 2016 to 2017 (**Figure C.2, Appendix C**). Between 2018 and 2021, there was an increase in live native plant cover at seven transects and a decline in native plant cover at two transects. This may be attributed to wet season monitoring and preceding rainfall as native cover was significantly correlated with the amount of rainfall recorded in the 12 months prior to monitoring ($t = 2.45$, $r = 0.64$, $P = 0.03$; **Table C.2, Appendix C**). However, native cover between 2006 and 2021 was not statistically associated with the amount of rainfall recorded in the one, two, three, or six months prior to transect monitoring, nor with number of weeks since the last major rainfall event and WSI (**Table C.2, Appendix C**).

3.4 Floristic Composition

Floristic composition in 2021 was significantly different to that in 2018 in seven of the nine transects and across all habitats (**Table C.3, Figures C.4, C.5, C.8, C.9, C.10, C.11 and C.12, Appendix C**). Comparisons with the 2006 baseline composition indicate significant changes in proportional PFC in all eight transects (not including AIV-S, which was not established until 2015) (**Table C.3, Figures C.4, C.6, C.7, C.8, C.9, C.10, C.11 and C.12, Appendix C**). Three of the nine existing transects have consistently displayed significant floristic composition changes each year in comparison to 2021: AIV-A, AIV-C and AIV-Q (**Table C.3, Figures C.8, C.9 and C.10, Appendix C**). Hind dune transect AIV-B (undisturbed transect in the Reserve) has the most stable floristic composition over time (**Table C.3, Figure C.6, Appendix C**).

3.5 Detection and Monitoring of Weed Species

Four weed species have been previously detected during the monitoring surveys undertaken on AI: **A. javanica*, **C. ciliaris*, **E. minor* and **F. trinervia*. Three of these weed species, **A. javanica*, **C. ciliaris* and **E. minor* were recorded during the 2021 monitoring survey.

**Aerva javanica* was recorded opportunistically during the 2021 monitoring survey. It was located along the track to the top accommodation area as well as within the bund towards the eastern end of the island. Total numbers were low, with less than 2% cover noted.

The presence of **C. ciliaris* was recorded in transects AIV-A, AIV-B, AIV-C and AIV-M (**Figure C.3, Appendix C**). **Cenchrus ciliaris* has been recorded in AIV-A for every monitoring year since 2011 and in AIV-C every year since 2013 (**Figure C.9,Figure C.10**). The occurrence of **C. ciliaris* in transects AIV-A and AIV-C has increased since the 2018 monitoring survey, with a significant increase at transect AIV-A ($F_{1,80} = 5.46$, $P = 0.02$; **Figure C.1 and Figure C.3, Appendix C**). Mean weed cover at transect AIV-A increased from 0.2% in 2018 to 23.7% in 2021 (**Figure C.3, Appendix C**). The highest weed cover previously recorded at this transect was 3.1% in 2016. This undisturbed transect is located on the Reserve and the significant increase in cover cannot be attributed to Santos' operations (care and maintenance).

Transect AIV-B has not recorded the presence of **C. ciliaris* since 2006; mean cover was lower in 2021 (0.2%) compared to 2006 (1.2%). The presence of **C. ciliaris* in AIV-M in 2021 is a new occurrence. Mean cover in this transect was low at < 0.1%. Field observations indicate that **C. ciliaris* cover is dense in the "basin" area, however its occurrence in the *Eulalia aurea* tussock grassland towards the western end of the island and in the *Spinifex longifolius* beach dune grassland is low or absent.

Eragrostis minor* was recorded in transect AIV-C during the 2021 monitoring survey; recorded with low cover in only one quadrat. This species has not been recorded within this transect since 2016 (Figure C.10**). **Eragrostis minor* has previously been opportunistically recorded in 2017 and 2018.

Four native species introduced from the mainland (*A. lepidum*, *D. radulans*, *D. plantaginella* and *I. muelleri*) have been previously recorded during monitoring surveys on AI. Two of these mainland introductions, *A. lepidum* and *D. radulans* were recorded opportunistically in 2021.

Abutilon lepidum was originally recorded at the accommodation area in 2012, with opportunistic records identified during each monitoring survey since. During the 2021 monitoring survey, two individuals of this species were recorded at the accommodation area. *Abutilon lepidum* has never been recorded to have spread beyond this location.

Dactyloctenium radulans was first recorded on AI in 2015 along the track to the jetty. Further records were noted during the 2017 and 2018 monitoring surveys. During the 2021 monitoring survey, this species had formed a dense population which extended from the beach, along the access track to within 20 m of the accommodation area, as well as into the old turkey's nest.

Dysphania plantaginella was not recorded during the 2021 monitoring survey, however it is likely that the absence of this annual species was due to the timing of the survey. *Dysphania plantaginella* was initially recorded in 2017 and, in 2018 it was noted to have seeded and spread throughout the disturbed lease areas. *Ipomoea muelleri* was not recorded during the 2021 monitoring survey and has not been recorded on AI since 2003.

4 Conclusions

The long-term data indicate that there are no clear trends over time for floristic composition or species richness. Long-term decline in vegetation cover was evident within all transects, both on the Lease and Reserve areas. This is correlated with the amount of rainfall received in the 12 months prior to monitoring. Weed cover significantly increased in transect AIV-A due to the proliferation of **C. ciliaris*. Further, field observations noted an increase in the abundance and distribution of the introduced species *D. radulans* in the Lease area.

The 2021 monitoring results demonstrated that there have been no changes in composition of flora and vegetation on AI that can be attributed to Santos' operations (care and maintenance).

5 References

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Appendix A: Transect Photographs (March 2021 and September 2018)

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Plate 1: AIV-A in March 2021

Plate 2: AIV-A in September 2018

Plate 3: AIV-B in March 2021

Plate 4: AIV-B in September 2018

Plate 5: AIV-C in March 2021

Plate 6: AIV-C in September 2018

Plate 7: AIV-D in March 2021

Plate 8: AIV-D in September 2018

Plate 9: AIV-F in March 2021

Plate 10: AIV-F in September 2018

Plate 11: AIV-M in March 2021

Plate 12: AIV-M in September 2018

Plate 13: AIV-P in March 2021

Plate 14: AIV-P in September 2018

Plate 15: AIV-Q in March 2021

Plate 16: AIV-Q in September 2018

Plate 17: AIV-S in March 2021

Plate 18: AIV-S in September 2018

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Appendix B: Vascular Flora Species List

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Table B. 1: Vascular plant species recorded in monitoring transects and opportunistically on Airlie Island between 2006 and 2021.

Family	*Species*	2006	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2021
Amaranthaceae	**Aerva javanica*	-	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	-	X^{Op}	X^{Op}	X^{Op}
	Amaranthus undulatus	X	X	X^{Op}	X^{Op}	X^{Op}	-	X^{Op}	X	X	X^{Op}	X^{D}	X^{Op}
	Ptilotus villosiflorus	X	X	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X	X	X	-
Apocynaceae	*Cynanchum viminale* subsp. *australe*	-	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}
Asteraceae	*Angianthus cunninghamii*	X	X	-	X^{Op}	X^{Op}	X	X^{Op}	X^{Op}	X	X^{Op}	X^{Op}	-
	**Flaveria trinervia*	-	X^{Op}	-	X^{Op}	X^{Op,D}	X^{Op}	X^{D}	X^{Op}	-	X^{Op}	-	-
	Launaea sarmentosa	X	X	X	X	X	X^{Op}	X	X	X	X	X	X
Chenopodiaceae	*Atriplex isatidea*	-	X^{Op}	X^{Op}	X^{Op}	X^{Op}	-	X^{Op}	-	X^{Op}	X^{Op}	X^{Op}	X^{Op}
	#Dysphania plantaginella	-	-	-	-	-	-	-	-	-	X^{Op}	X^{Op}	-
	Rhagodia preissii subsp. *obovata*	X	X	X	X	X	X	X	X	X	X	X	X
	Salsola australis	X	X	X	X	X	X	X	X	X	X	X	X
	Threlkeldia diffusa	X	X	X	X	X	X	X	X	X	X	X	X
Cleomaceae	*Arivela viscosa*	X	X	X^{D}	X^{D}	X^{Op,D}	X^{Op}	X^{D}	X	X	X	X	X
Convolvulaceae	*Cuscuta victoriana*	X	X	-	X^{Op}	X^{Op}	-	X^{Op}	X	X	X^{Op}	X	X
	#Ipomoea muelleri	-	-	-	-	-	-	-	-	-	-	-	-
	Ipomoea pes-caprae	X	X	X	X	X	X^{Op}	X	X	X	X	X	X
Cyperaceae	*Cyperus bulbosus*	X	X^{Op,D}	X^{D}	X^{D}	-	-	X^{D}	X	-	X^{Op}	X^{D}	X
Euphorbiaceae	*Euphorbia drummondii*	X	X^{Op}	X^{D}	X^{Op}	-	X^{Op}	X^{Op}	X^{Op}	-	X^{Op}	-	-
	Euphorbia tannensis subsp. *eremophila*	X	X	X	X	X	X	X	X	X	X	X	X
	Euphorbia trigonosperma	X	X	X^{D}	X	X^{Op}	X	X	X	X	X	X	X
Fabaceae	*Acacia bivenosa*	X	X	X	X	X	X	X	X	X	X	X	X
	Acacia coriacea	X	X	X	X	X	X	X	X	X	X	X	X
	Acacia sclerosperma subsp. *sclerosperma*	-	-	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}	X^{Op}

Family	*Species*	2006	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2021
	Acacia sp.	-	-	-	-	-	-	-	-	X	-	-	-
	Rhynchosia minima	-	X[Op]	-	X[Op]	X[Op]	-	-	-	-	X[Op]	-	-
Goodeniaceae	*Scaevola crassifolia*	-	-	-	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]
	Scaevola spinescens	-	X[Op]	-	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]
Malvaceae	*#Abutilon lepidum*	-	X[Op]	-	-	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]
Nyctaginaceae	*Boerhavia schomburgkiana*	X	X	X	X	X	X	X	X	X	X	X	X
	Commicarpus australis	-	X[Op]	-	X[Op]	X[Op]	-	-	X[Op]	-	X[Op]	X[Op]	X[Op]
Poaceae	**Cenchrus ciliaris*	X	X	X	X	X	X	X	X	X	X	X	X
	#Dactyloctenium radulans	-	-	-	-	-	-	-	X[Op]	-	X[Op]	X[Op]	X[Op]
	**Eragrostis minor*	-	-	X[D]	-	-	-	X[D]	-	X	X[Op]	X[Op]	X
	Eulalia aurea	X	X	X	X	X	X	X	X	X	X	X	X
	Setaria dielsii	X	X	X[D]	X[Op]	X	X[Op]	X[D]	X	X	X[Op]	X[D]	X[Op]
	Spinifex longifolius	X	X	X	X	X	X	X	X	X	X	X	X
	Sporobolus virginicus	X	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	X[Op]	-	X[Op]	X[Op]
	Triraphis mollis	X	X	X[D]	X	X[Op]	X[Op]	X[D]	X[Op]	X	-	-	X
Portulacaceae	*Portulaca intraterranea*	X	X	X	X	X	X	X	X	X	X	X	X
Solanaceae	*Nicotiana occidentalis*	-	-	-	-	-	X[Op]	-	-	X[Op]	-	-	-
Zygophyllaceae	*Tribulus occidentalis*	-	X[Op]	X[D]	X[D]	X[Op]	X[Op]	X	X		-		X

[Op] indicates a species only identified opportunistically and not within any of the transects.

[D] indicates the species was only identified when dead.

# denotes mainland native species not indigenous to Airlie Island.

* denotes weed species.

Appendix C: Detailed Statistical Analyses

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1 Species Richness and Foliar Cover

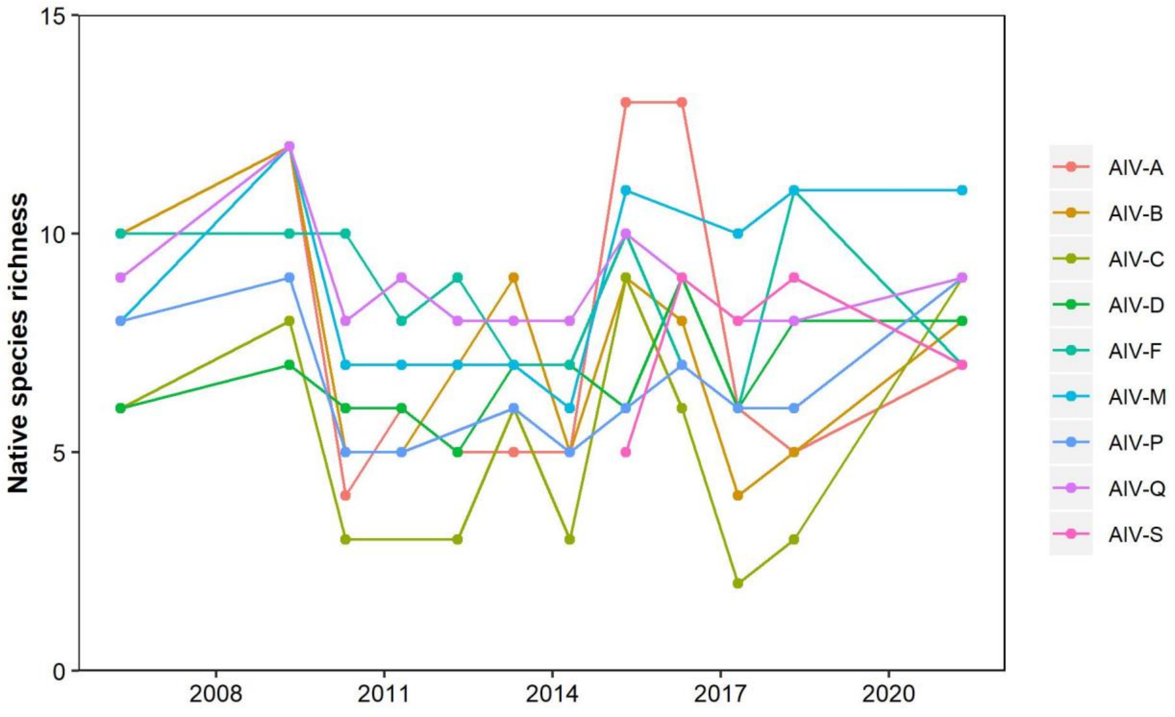

Figure C.1: Total native species richness at each transect from 2006 to 2021.

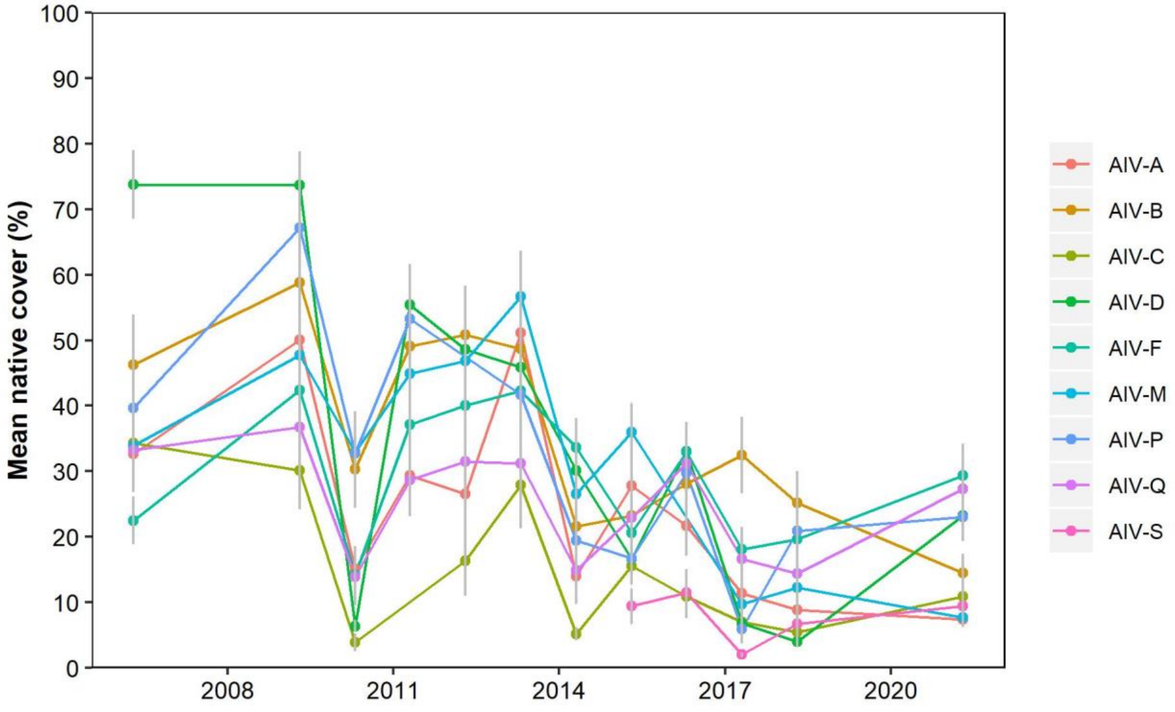

Figure C.2: Mean native species foliar cover (%) at each transect from 2006 to 2021. Error bars are standard error.

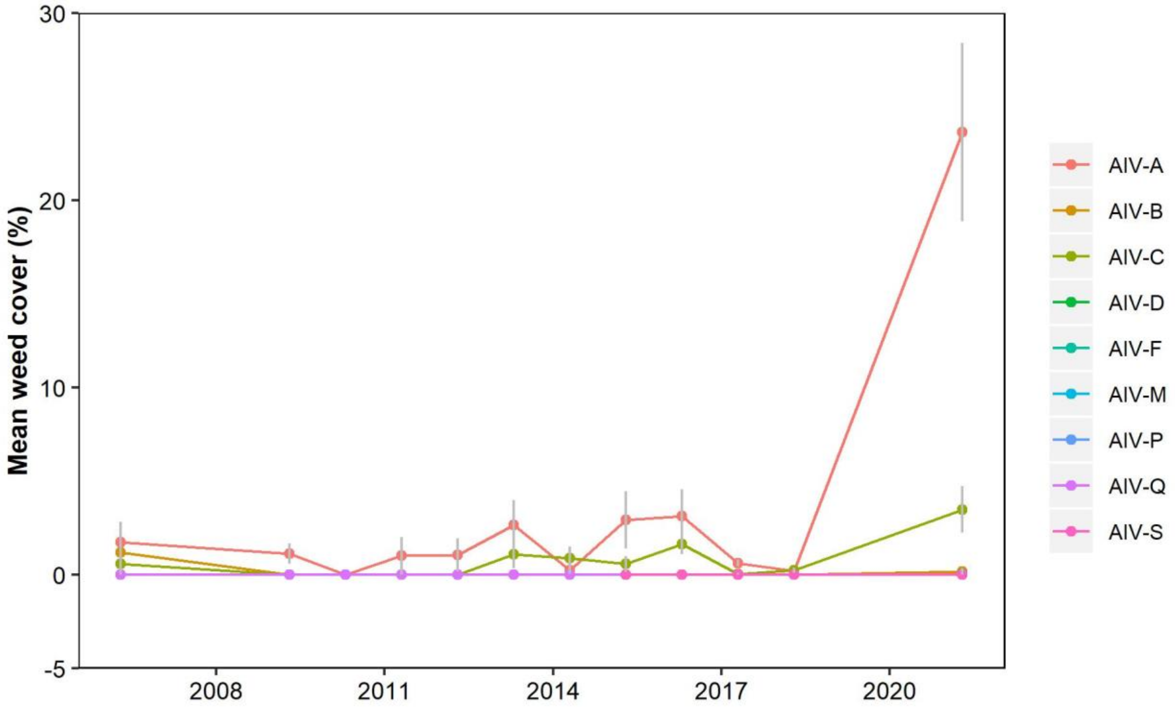

Figure C.3: Mean weed species foliar cover (%) at each transect from 2006 to 2021. Error bars are standard error.

Table C.1: Summary of statistical analysis results for long-term temporal changes in species richness and projected foliar cover (PFC) for all transects; significant results in bold; df = degrees of freedom; F = F statistic; P = calculated probability.

Variable	df	F	P	Slope
Species richness	1,80	0.07	0.80	n/a
Native PFC	1,80	47.08	**< 0.001**	↓
Lease area native PFC	1,49	15.97	**< 0.001**	↓
Reserve area native PFC	1,45	32.06	**< 0.001**	↓
Weed PFC	1,80	5.46	**0.02**	↑

Table C.2: Summary of results from correlation tests; significant results in bold; df = degrees of freedom, t = t statistic (for Pearson tests); S = S statistic (for Spearman tests); correlation coefficient r (for Pearson tests) or ρ (for Spearman tests); P = calculated probability.

Response variable	Predictor variable	Method	df	t/S	r/ρ	P
Species richness	Rainfall one month prior to monitoring	Spearman	10	264.81	0.07	0.82
Species richness	Rainfall two months prior to monitoring	Spearman	10	205.86	0.28	0.37
Species richness	Rainfall three months prior to monitoring	Spearman	10	148	0.48	0.11
Species richness	Rainfall six months prior to monitoring	Spearman	10	116	0.59	**0.04**
Species richness	Rainfall 12 months prior to monitoring	Pearson	10	1.55	0.44	0.15
Species richness	Weeks since total weekly rainfall > 20 mm	Spearman	10	484.73	-0.69	**0.01**
Species richness	Water stress index (WSI)	Pearson	10	164.00	0.43	0.17
PFC	Rainfall one month prior to monitoring	Spearman	10	428.25	-0.49	0.10
PFC	Rainfall two months prior to monitoring	Spearman	10	404.21	-0.41	0.18
PFC	Rainfall three months prior to monitoring	Spearman	10	266.00	0.07	0.83
PFC	Rainfall six months prior to monitoring	Spearman	10	256.00	0.10	0.75
PFC	Rainfall 12 months prior to monitoring	Pearson	10	2.46	0.61	**0.03**
PFC	Weeks since total weekly rainfall > 20 mm	Spearman	10	356.62	-0.25	0.44
PFC	WSI	Spearman	10	308	-0.08	0.81

2 Comparisons of Floristic Composition

2.1 Remnant Foredune

Floristic composition differed significantly over time for both remnant foredune transects: AIV-F and AIV-S (**Figure C.4, Figure C.5 and Table C.3**). At transect AIV-F, floristic composition in 2021 was significantly different to all other years except 2013 and 2017 (**Table C.3**). *Spinifex longifolius* has increased in dominance since 2006, with a decline in *Rhagodia preisii* subsp. *obovata* cover and an absence of *Ipomoea pes-caprae* and *Acacia coriacea* also contributing to the difference in floristic composition (**Figure C.4**).

Transect AIV-S was established in 2015 but relocated in 2016 when the flare tower was removed. While the transect was re-installed as close as possible to its original location, the area was initially highly disturbed, which is reflected in the low vegetation cover (**Figure C.2**). Prior to the disturbance, the transect was dominated by *Acacia bivenosa* and *Spinifex longifolius*. *Acacia bivenosa* is no longer present within the transect and, since disturbance, *S. longifolius* cover has declined, replaced with *Launaea sarmentosa, Salsola australis* and *I. pes-capra*e (**Figure C.5**).

2.2 Hind Dunes

Floristic composition has changed significantly over time for all hind dune transects: AIV-B, AIV-M and AIV-Q (**Figure C.6, Figure C.7, Figure C.8 and Table C.3**). In 2021, floristic composition at transect AIV-B was similar to 2014, 2015 and 2018 (**Table C.3**). *Acacia bivenosa* remains the dominant species in 2021 (**Figure C.6**). **Cenchrus ciliaris* was recorded again in 2021 after the first and only record in 2006, although weed cover was lower than 2006 (**Figure C.6**).

Floristic composition at transect AIV-M in 2021 was significantly different in 2021 to all other years except 2018 (**Table C.3**). The most notable change in 2021 is the decrease in cover of *A. bivenosa* and increase in *Euphorbia tannensis* subsp. *erempophila* cover (**Figure C.7**). *Spinifex longifolius* was first recorded in this transect in 2017 and has consistently increased each year since.

Floristic composition at transect AIV-Q in 2021 was significantly different to all other years (**Table C.3**). Since 2006, *R. preissii* subsp. *obovata* has replaced *Threlkeldia diffusa* as the most dominant species at this transect (**Figure C.8**). *Acacia bivenosa* has been one of the dominant species since 2009, however in 2021 cover of *A. bivenosa* had decreased substantially from previous years (**Figure C.8**). Both transects AIV-Q and AIV-M were planted with *A. bivenosa* seedlings in 2005 and it is possible that these plants did not establish as well as those occurring naturally on AI (V Long, Associate Botanist Astron, pers. comm., 27 April 2021). It was also noted in the field that the perennial shrubs across AI had not yet recovered from the preceding dry years.

2.3 Inner Island Basin

Floristic composition at the Inner Island Basin transect (AIV-A) was significantly different over time and to all previous years compared to 2021 (**Table C.3**). Transect AIV-A was dominated by **C. ciliaris* in 2021, with a decline in the previously dominant *A. bivenosa* and *Acacia coriacea* (**Figure C.9**). The dense cover of **C. ciliaris* has not impacted on species richness, which was consistent with previous years. However, **C. ciliaris* responds rapidly to rainfall and given the opportunity will readily outcompete other native perennial species. The decline in the dominance of native species such as *A. bivenosa* and *A. coriacea* may indicate a potential impact of **C. ciliaris*.

2.4 Inner Island Ridge

Floristic composition at the Inner Island Ridge transect (AIV-C) in 2021 was significantly different over time and to all previous years in 2021 (**Table C.3**). There has been a decline in the dominance of *A. coriacea* and an increase in **C. ciliaris* and the native annual species *Arivela viscosa*, both of which respond rapidly to rainfall (**Figure C.10**). An increase in **C. ciliaris* dominance may be contributing to a decline in *A. coriacea*.

2.5 Elevated Sand Plain

Floristic composition was significantly different over time at both Elevated Sand Plain transects: AIV-D and AIV-P. In 2021, AIV-D and AIV-P was significantly different to all previous years apart from 2016 (**Table C.3**). At transect AIV-D, *Eulalia aurea* remains the most dominant species, although cover has declined since 2006 (**Figure C.11**). There was an increase in *E. aurea* cover from previously low cover in 2017 and 2018; following sufficient rainfall in 2021, the cover of *E. aurea* has recovered after the preceding dry years (**Figure C.11**).

Transect AIV-P continues to be dominated by *A. bivenosa* with fluctuations in the dominance of other species over time (**Figure C.12**). This transect also had a recovery of *E. aurea* in 2021 after a decline in 2018 (**Figure C.12**).

Table C.3: Overall temporal change and pairwise comparisons per transect calculated using PERMANOVA analysis. Numbers in cells are the P-values; significant results in bold.

Habitat	Remnant foredune		Hind dune			Inner island basin	Inner island ridge	Elevated sand plain	
Transect	**AIV-F**	**AIV-S**	**AIV-B**	**AIV-M**	**AIV-Q**	**AIV-A**	**AIV-C**	**AIV-D**	**AIV-P**
All years	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.006**	**0.001**
2006 vs. 2021	**0.001**	--[a]	**0.03**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
2009 vs. 2021	**0.001**	--[a]	**0.001**	**0.002**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
2010 vs. 2021	**0.001**	--[a]	**0.006**	**0.002**	**0.005**	**0.001**	**0.001**	**0.001**	**0.001**
2011 vs. 2021	**0.01**	--[a]	**0.001**	**0.002**	**0.001**	**0.001**	--[b]	**0.001**	**0.001**
2012 vs. 2021	**0.01**	--[a]	**0.004**	**0.002**	**0.001**	**0.001**	**0.001**	**0.001**	--[c]
2013 vs. 2021	0.07	--[a]	**0.002**	**0.001**	**0.002**	**0.001**	**0.001**	**0.001**	**0.005**
2014 vs. 2021	**0.001**	--[a]	0.08	**0.003**	**0.001**	**0.001**	**0.001**	**0.02**	**0.001**
2015 vs. 2021	**0.001**	0.25	0.44	**0.001**	**0.001**	**0.001**	**0.001**	**0.04**	**0.001**
2016 vs. 2021	**0.002**	**0.001**	**0.04**	--[d]	**0.004**	**0.001**	**0.001**	0.23	0.05
2017 vs. 2021	0.63	0.06	**0.004**	**0.001**	**0.005**	**0.001**	**0.001**	**0.001**	**0.001**
2018 vs. 2021	**0.004**	**0.001**	0.09	0.08	**0.004**	**0.001**	**0.001**	**0.001**	**0.002**

[a] established in 2015

[b] not monitored in 2011.

[c] not monitored in 2012.

[d] not monitored in 2016.

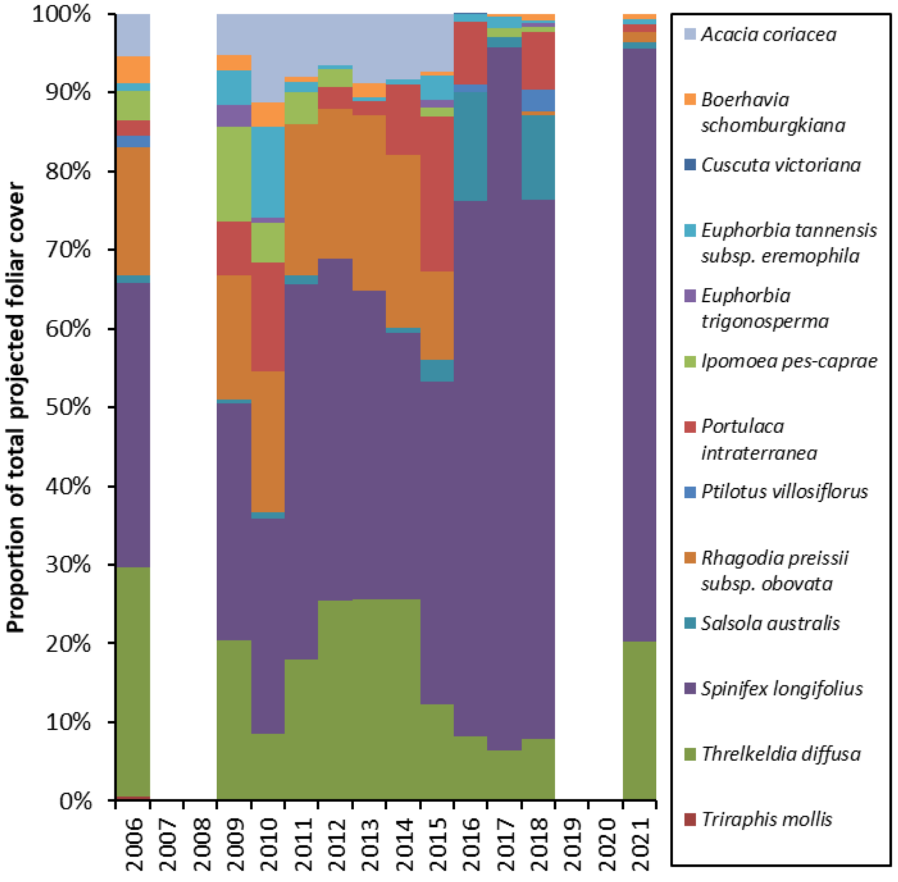

Figure C.4: Proportion of total projected foliar cover for each species between 2006 and 2021 for remnant foredune transect AIV-F.

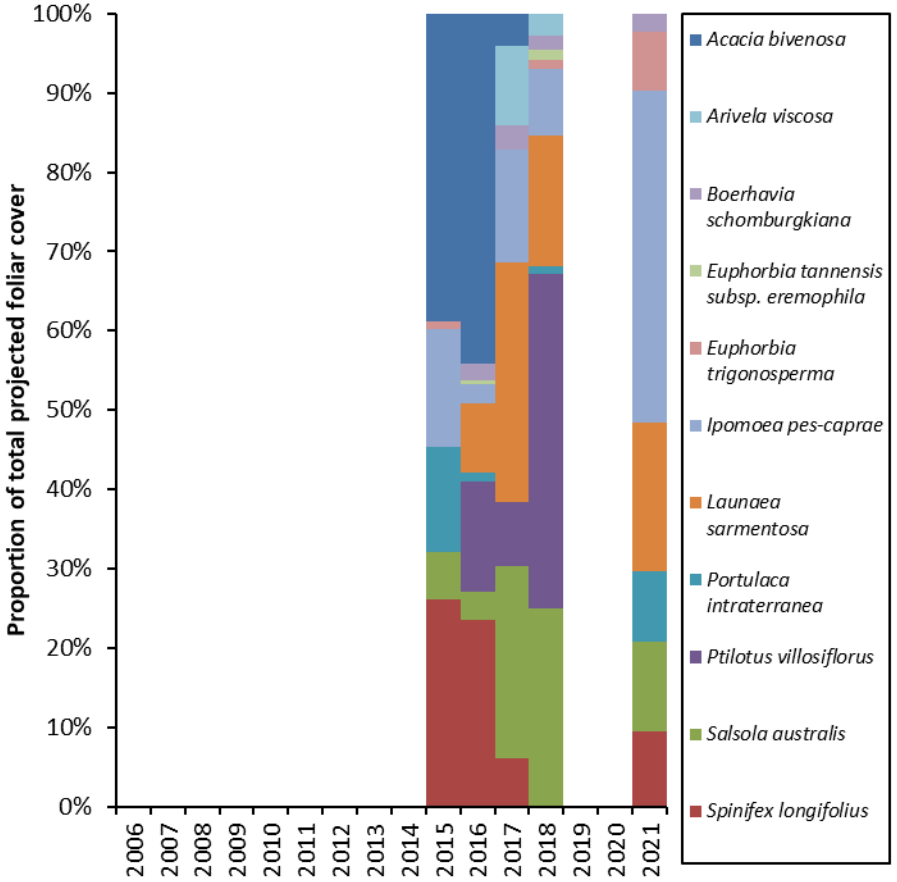

Figure C.5: Proportion of total projected foliar cover for each species between 2006 and 2021 for remnant foredune transect AIV-S.

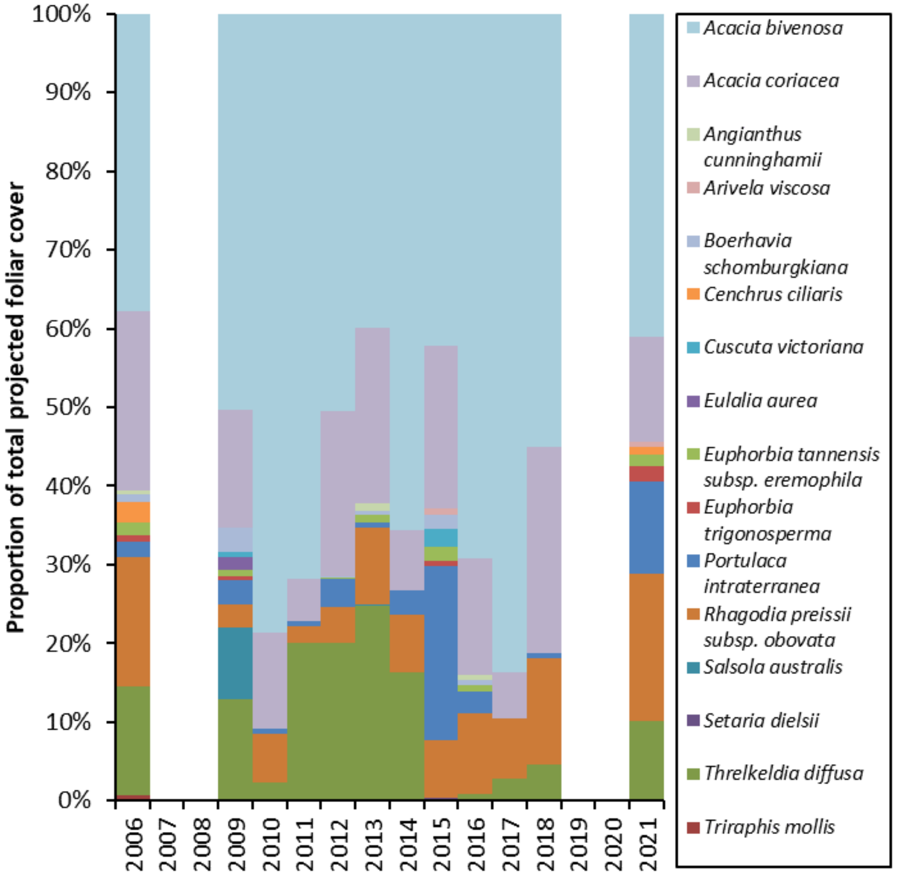

Figure C.6: Proportion of total projected foliar cover for each species between 2006 and 2021 for hind dune transect AIV-B.

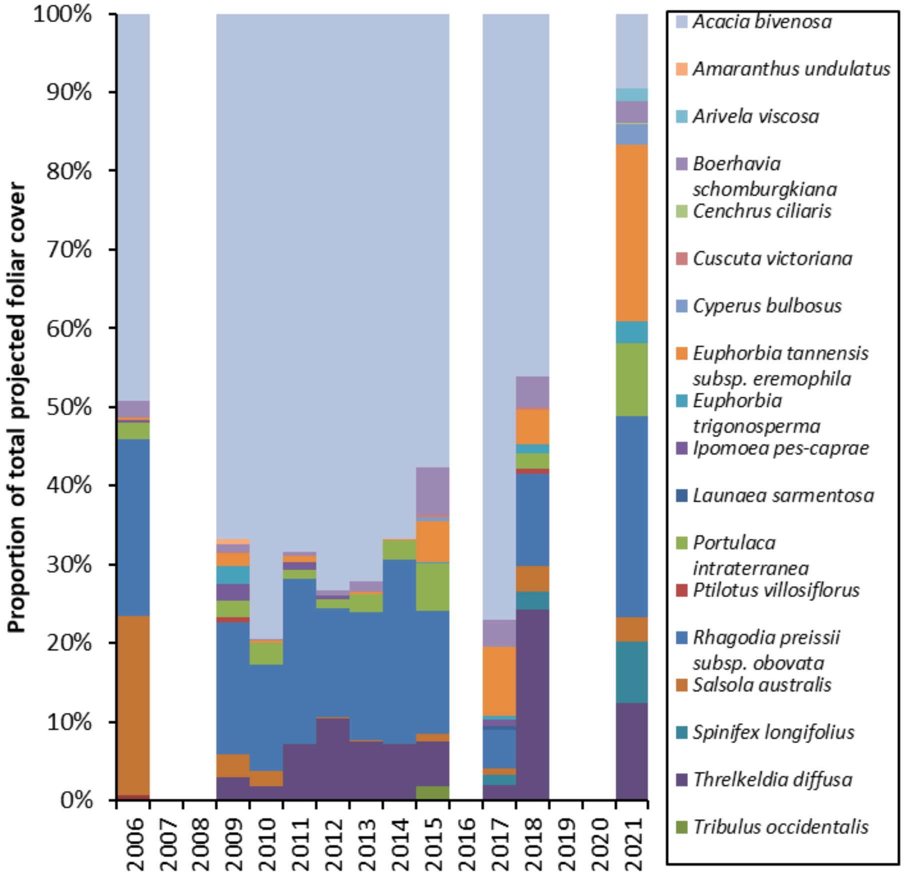

Figure C.7: Proportion of total projected foliar cover for each species between 2006 and 2021 for hind dune transect AIV-M.

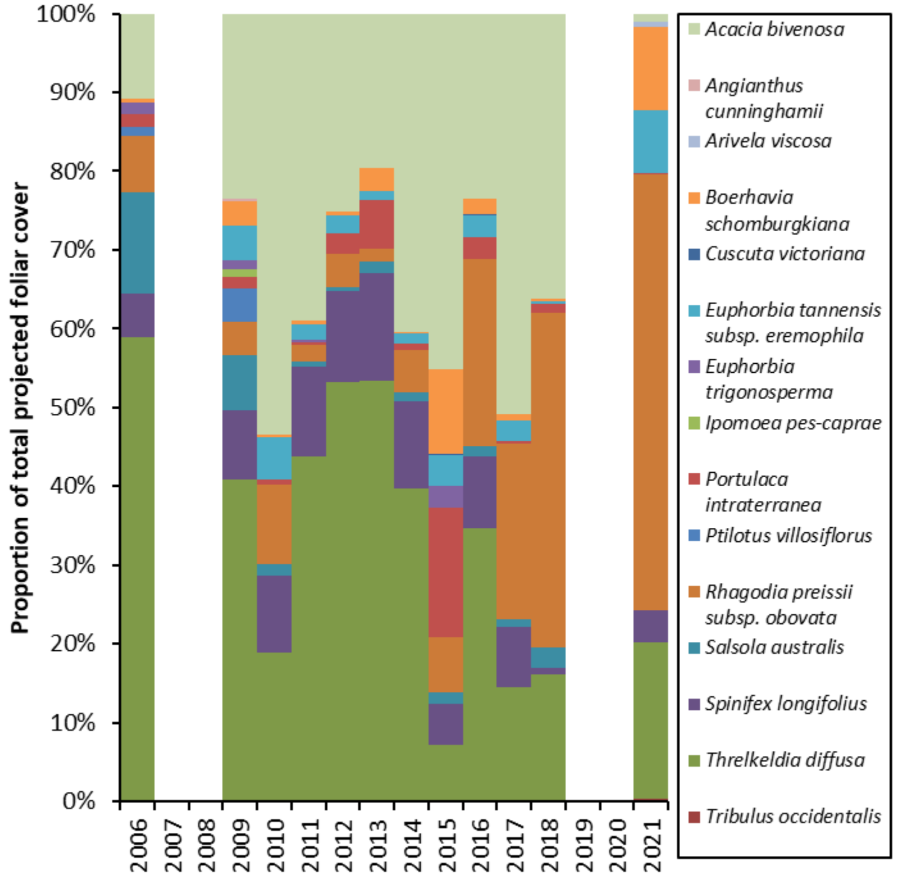

Figure C.8: Proportion of total projected foliar cover for each species between 2006 and 2021 for hind dune transect AIV-Q.

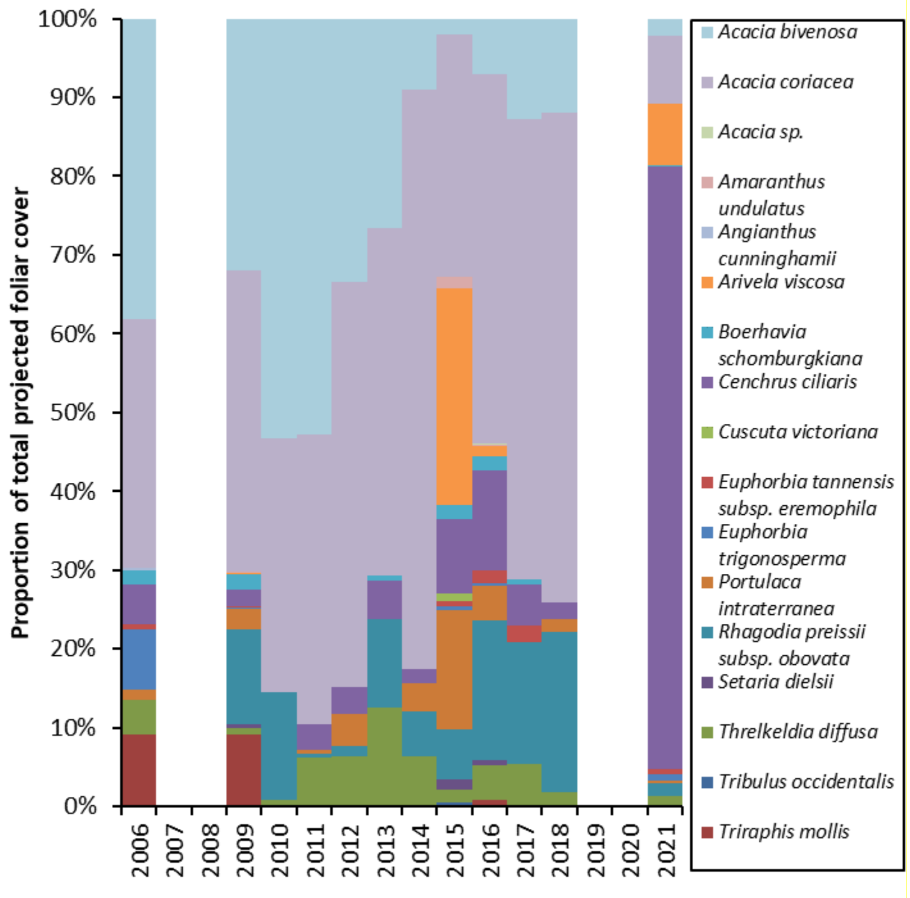

Figure C.9: Proportion of total projected foliar cover for each species between 2006 and 2021 for inner island basin transect AIV-A.

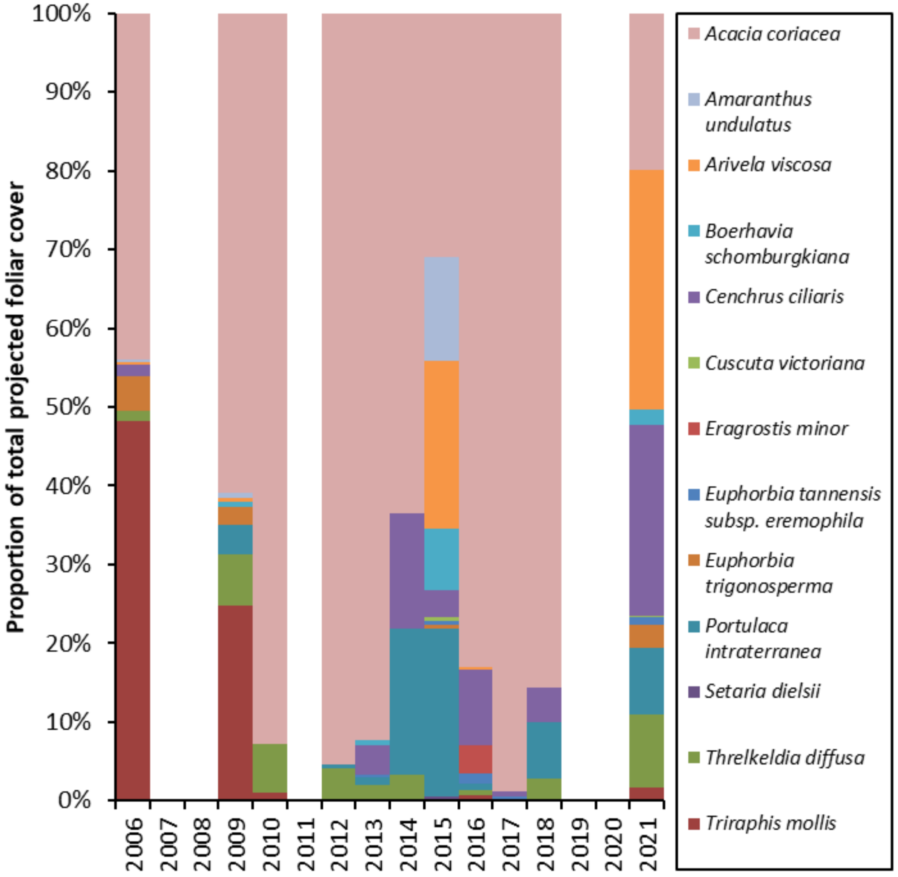

Figure C.10: Proportion of total projected foliar cover for each species between 2006 and 2021 for inner island ridge transect AIV-C.

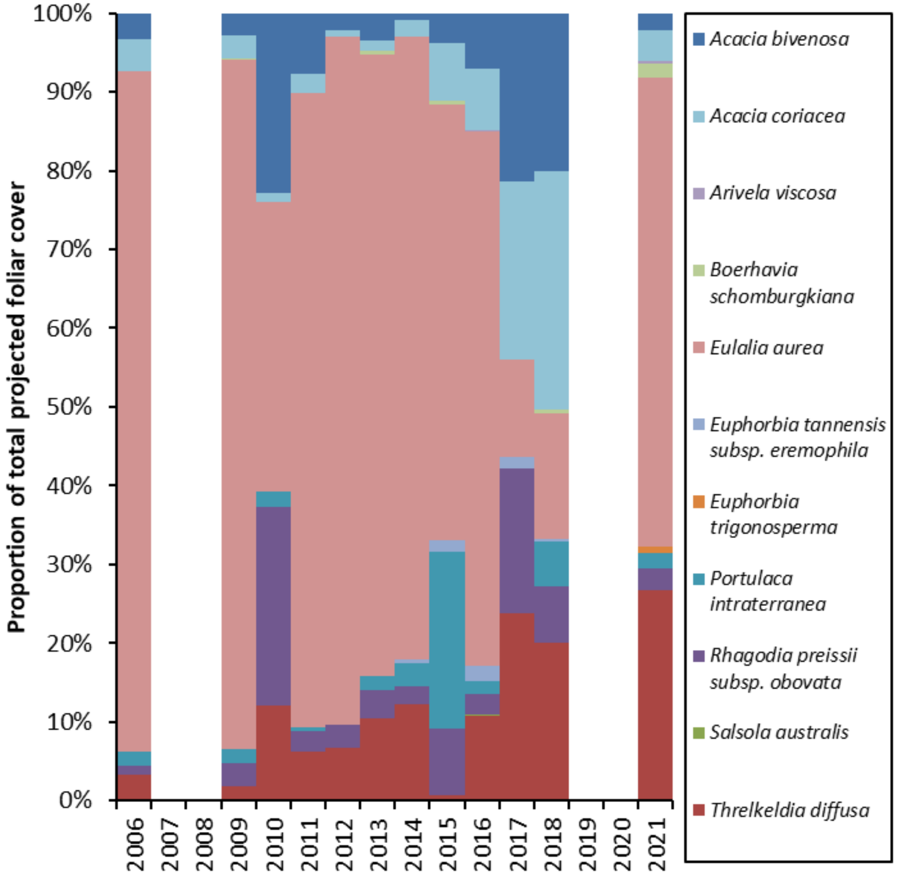

Figure C.11: Proportion of total projected foliar cover for each species between 2006 and 2021 for elevated sand plain transect AIV-D.

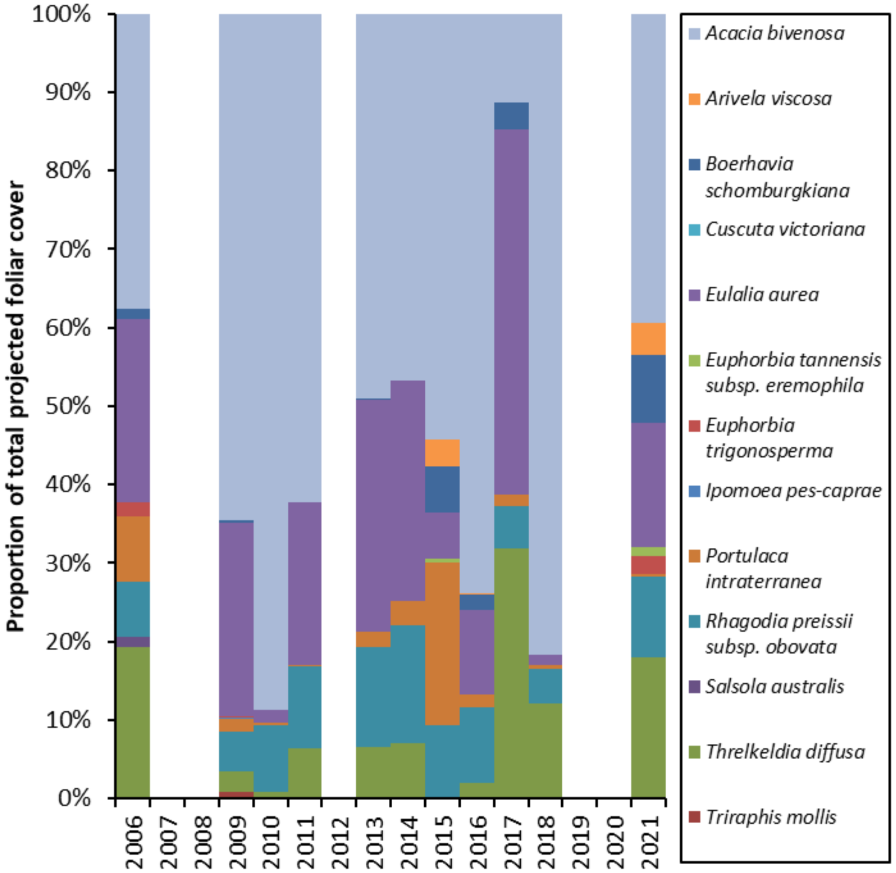

Figure C.12: Proportion of total projected foliar cover for each species between 2006 and 2021 for elevated sand plain transect AIV-P.

Attachment 3 – Recent Fauna Monitoring Reports

Santos Level 7, 100 St Georges Tce PERTH WA 6005	**Varanus and Airlie Islands Seabird Monitoring Annual Report 2021**
	Total number of pages to this document (incl. coversheet): 52
DOCUMENT TITLE: Varanus and Airlie Islands Seabird Monitoring Annual Report 2021	Santos DOCUMENT No: **SO-91-RI-20121** — Rev. 0 VENDOR DOCUMENT No: 569M-21-BISR-1Rev0_210614 — Rev. 0
CONTRACT / PURCHASE No: 4800003876	
DOCUMENT STATUS: INFORMATION ■ FOR REVIEW ☐ OTHER ☐ FOR APPROVAL ☐	EQUIPMENT TAG No: EQUIPMENT DATASHEET No:

REVISIONS TO QUADRANT DOCUMENT No:

Rev	Date	Reason for Issue
A	26/05/2021	Issued for Review
0	14/06/2021	Issued for Information

NOTES:

Environmental Monitoring Program
Varanus and Airlie Islands Seabird Monitoring
Annual Report
2021

Prepared for
Santos WA Energy Limited

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Report Reference: 569M-21-BISR-1Rev0_210614
Santos WA Energy Ltd Report Reference: SO-91-RI-20121

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Environmental Monitoring Program
Varanus and Airlie Islands Seabird Monitoring
Annual Report
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Prepared for
Santos WA Energy Limited

Job Number: 569M-21

Reference: 569M-21-BISR-1Rev0_210614

Santos WA Energy Ltd Report Reference: SO-91-RI-20121

Revision Status

Rev	Date	Description	Author(s)	Reviewer
A	26/05/2021	Draft Issued for Client Review	J. Johnston	A. Gove
0	14/06/2021	Final Issued for Information	J. Johnston	A. Gove

Approval

Rev	Date	Issued to	Authorised by	
			Name	**Signature**
A	26/05/2021	P. Becker	B. Lucas	[signature]
0	14/06/2021	P. Becker	B. Lucas	[signature]

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Abbreviations

Abbreviation	Definition
AIC	Akaike Information Criteria
Astron	Astron Environmental Services Pty Ltd
DBCA	Department of Biodiversity, Conservation and Attractions
GAM	Generalised additive model
HD	High Definition
m	Metres
MS	Ministerial Statement
RPA	Remotely Piloted Aircraft
Santos	Santos WA Energy Limited
SD	Standard deviation
SOI	Southern Oscillation Index
SSTA	Sea surface temperature anomaly

Executive Summary

Monitoring of seabird colony nesting habitat and the number of breeding pairs on Varanus and Airlie Islands (potential impact islands), and five control islands (Abutilon, Beacon, Bridled, Parakeelya and Serrurier), is conducted annually to meet the requirements of regulatory conditions relevant to Varanus Island Leases 1902 and 2064 and Airlie Island Lease 1901/100. Six seabird species are targeted as part of the program: Bridled Terns, Silver Gulls, Crested Terns, Lesser Crested Terns, Roseate Terns and Pied Cormorants. Santos WA Energy Limited was compliant with the lease conditions with regard to seabird monitoring in 2021. Wedge-tailed Shearwaters are monitored as part of a separate program.

The 2021 monitoring results showed the number of Bridled Tern and Silver Gull breeding pairs encountered during the surveys were low, with Bridled Terns having the lowest estimates since monitoring began in 2006, with the exception of Beacon Island for which no meaningful data were recorded. Low estimates are likely due to the timing of the surveys, rather than a true reflection of the number of breeding pairs present in 2021. The timing of survey execution was late in the season as chicks had fledged on all islands. This was due to delayed mobilisation because of COVID-19 lockdown restrictions and rainfall events.

No Bridled Terns were recorded nesting on Airlie (potential impact), Serrurier and Bridled Islands (controls) in 2021. Bridled Terns have historically been recorded nesting in small numbers on Varanus (potential impact) and Beacon (control) Islands, where there has been a historical decline and no change over time, respectively. Two Bridled Tern breeding pairs were recorded in 2021, following two seasons of no records on Varanus Island. It is unknown why numbers have declined on Varanus Island, but it has always had very low numbers and Varanus Island may provide marginal breeding habitat for this species. The control islands have recorded larger breeding numbers of Bridled Terns which have shown a similar trend in breeding numbers over time, with a recent decrease since 2017/2018. The recent decrease observed on Abutilon and Bridled Islands may be due in part to some of the monitoring transects no longer being located within the mapped nesting habitat for Bridled Terns on these islands, which were moved in 2021 to within mapped habitat. In addition, the low numbers of breeding Bridled Terns recorded in 2021, which are not likely to be an accurate estimate due to survey limitations, may also have contributed to this apparent decrease.

Silver Gulls were recorded nesting on Airlie Island (potential impact) as well as Serrurier Island (control) in 2021. Silver Gulls have previously been recorded breeding intermittently on Airlie Island in 2019, 2017, 1991 and 1987/88. Limited available nesting habitat due to high numbers of breeding birds in some seasons may cause some Silver Gulls to breed on islands, such as Airlie Island, not routinely exploited for nesting. Silver Gulls were not observed nesting on Varanus (potential impact) and Bridled (control) islands in 2021. Beacon (control) Island has shown no change in Silver Gull breeding numbers over time. Silver Gull breeding numbers on the other control islands showed a similar significant trend: increase in numbers from 2013 before declining in recent seasons. Except for the impact of a Silver Gull Control Program that was instigated in 2006 for several seasons, the number of breeding Silver Gulls are likely to reflect natural variation and not attributable to Santos operations.

Pied Cormorants were recorded on Abutilon and Beacon Islands (controls) in 2021 and were recorded nesting in larger numbers than previous years on Beacon Island. Crested Terns and Lesser Crested Terns were recorded nesting on Airlie Island (potential impact), Abutilon and Serrurier Islands (controls) in 2021, as well as a rocky islet south of Beacon Island. Crested Terns were recorded nesting on Abutilon (control) and Airlie (potential impact) Islands in their highest numbers since monitoring began in 2006. Lesser Crested Terns were recorded on Airlie Island (potential impact) in 2021 for the first time since monitoring began in 2006.

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1 Introduction

Santos WA Energy Limited (Santos) has held the lease on Varanus and Airlie Islands since 27 November 2018. Santos operations on Varanus Island (**Figure 1**) have the potential to affect seabirds nesting within Department of Biodiversity, Conservation and Attractions (DBCA) reserve tenure on the Lowendal Islands. Monitoring of seabirds is conducted annually as per the Environmental Monitoring Program *Varanus and Airlie Islands Seabirds and Shearwater Monitoring Method Statement* ((Quadrant Energy Australia Limited 2018), EA-00-RI-10058.01) to meet regulatory requirements (**Table 1**). Seabirds are defined as "*those birds associated with the sea and deriving most of their food from it and typically breeding colonially, excluding raptors*" (Surman and Nicholson 2014). Wedge-tailed Shearwaters are considered seabirds; however, monitoring for this species is undertaken as a separate monitoring program.

Seabird colonies have been monitored in relation to operational activities within the Lowendal group of islands and Airlie Island (potential impact) and Serrurier Island (control) since 2006 and no impacts to breeding seabirds attributable to operational activities have been detected during monitoring undertaken to date (Astron Environmental Services 2017, 2018, 2019, 2020).

Breeding patterns of Bridled Terns have varied greatly between islands. Bridled Terns have historically only been recorded nesting in very small numbers on Varanus (potential impact) and Beacon (control) Islands, where there has been no change over time to date (Astron Environmental Services 2020). Bridled Tern breeding numbers on all other control islands with larger numbers have shown an increase recently (Astron Environmental Services 2020). The exception to this is Abutilon Island (control), which showed a significant decrease in Bridled Tern breeding numbers in recent seasons (Astron Environmental Services 2020).

Breeding pairs of Silver Gulls have recently been recorded on Airlie Island in 2017 and 2019 (Astron Environmental Services 2017, 2019). Previous records of breeding Silver Gulls have been in 1988 and 1991 on Airlie Island. Reasons for the recent breeding records are unclear, but it may be due to growth in numbers of Silver Gulls on nearby islands where breeding is known to occur; this growth could have resulted in limited nesting availability on these islands causing birds to find alternative nesting habitat on Airlie Island (Astron Environmental Services 2017).

The nomadic tern and cormorant species appear to utilise a consistent subset of islands and vary their nesting location within this subset of islands each season (Astron Environmental Services 2017, 2018, 2019, 2020), with the highest number of Crested and Lesser Crested Terns recorded breeding on Varanus Island in 2019 than the previously estimated number (Astron Environmental Services 2019). Pied Cormorants, Crested Terns and Lesser Crested Terns were recorded nesting on Beacon Island in larger numbers in 2020 than previous years (Astron Environmental Services 2020).

The purpose of this report is to present the monitoring results for the 2021 season in the context of regulatory requirements under DBCA Lease 1902, 2064 and 1901/100 conditions (**Table 1**).

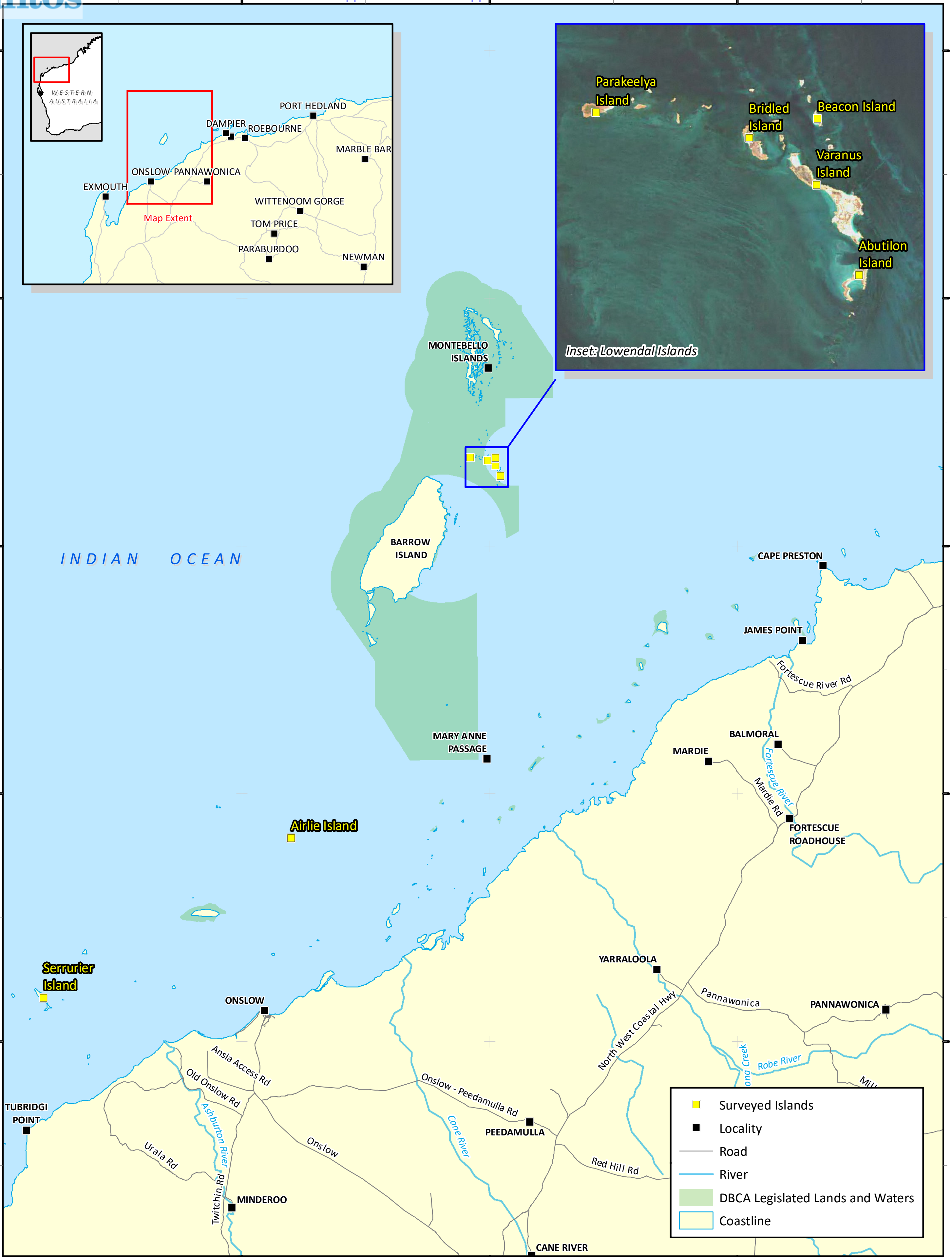
Table 1: Regulatory conditions relating to monitoring of seabirds on Varanus and Airlie Islands and how each requirement has been met. MS = Ministerial Statement; DBCA = Department of Biodiversity, Conservation and Attractions.

Regulatory Document	Condition No.	Requirement	Evidence of requirement met
Varanus Island			
Harriet VI Lease 1902 and East Spar VI Lease 2064	1.28	THAT the Lessee shall, in the EP referred to in clause 1(18), identify and map seabird nesting areas inside and immediately outside the adjacent boundary of the Demised Premises. Except for the purpose of the monitoring referred to in clause 1 (30) the Lessee shall not approach or enter any seabird nesting areas on the Island whether inside or outside the Demised Premises.	This report.
	1.29	THE Lessee shall in respect of the matters referred to in clause 1 (18) and which are the subject of proposals approved as hereinbefore provided, carry out by its employees, agents or independent consultants previously approved by the Lessor a continuous plan of investigation and research including monitoring studies of sample areas to ascertain the effectiveness of its EP and the measures taken by the Lessee pursuant to such approved proposals for rehabilitation protection and management of the environment. Data obtained from the monitoring studies shall be presented annually to the Lessor as suitably analysed data, and in a form suitable for statistical analysis by the Lessor, if required.	This report.
	1.30(ai)	THE monitoring to be carried out under clause 1 (29) shall include: (a) (i) annual colour vertical aerial photography at a scale of 1:25,000 or larger of the entire Island	Figures in this report.
	1.30(aii)	THE monitoring to be carried out under clause 1 (29) shall include: (a) (ii) a summary of weather reporting for the reporting period;	Results and discussion of this report.
	1.30(aiii)	THE monitoring to be carried out under clause 1 (29) shall include: (a) (iii) digitised map of the Demised Premises to be provided annually suitable for ArcView which includes shorebird and seabird nesting habitats	Figures in this report.

Regulatory Document	Condition No.	Requirement	Evidence of requirement met
Harriet VI Lease 1902 and East Spar VI Lease 2064	1.30(e)	THE monitoring to be carried out under clause 1 (29) shall include: annual sea bird breeding colonies monitoring and burrows in wedge-tailed shearwater colonies using a method approved by the Lessor (acting reasonably);	The monitoring program as implemented, this report and supplied data. Wedge-tailed Shearwaters are monitored separately.
	1.30(i)	THE monitoring to be carried out under clause 1 (29) shall include: the effects of unusual weather conditions including cyclones and droughts upon the fauna, flora, and environment of the Island, with methods approved by the Lessor	The monitoring program as implemented, this report and supplied data.
	1.30(j)	THE monitoring to be carried out under clause 1 (29) shall include: counts and details of any fauna mortality resulting from the Lessee's operations on the Demised Premises	Santos' incident reporting system.
	1.31(d)	THAT the Lessee shall on 9 May in each year during the Term submit a written report to the Lessor and the Minister for Mines and Petroleum containing full particulars (commercially sensitive information excluded) of the following: (d) investigations research and biological monitoring studies carried out by the Lessee under clause 1 (30) as hereinbefore provided and any conclusions or findings thereon	This report.
	1.31(e)	THAT the Lessee shall on 9 May in each year during the Term submit a written report to the Lessor and the Minister for Mines and Petroleum containing full particulars (commercially sensitive information excluded) of the following: (e) time series analysis of results from monitoring studies from preceding years in order to analyse trends over time	This report.
Airlie Island			
Airlie Lease 1901/100	1(26)	THE Lessee shall carry out by its servants or independent consultants previously approved by the Lessor a continuous programme of investigation and research including annual	This report.

Regulatory Document	Condition No.	Requirement	Evidence of requirement met
		monitoring studies of sample areas to ascertain the effectiveness of measures taken by the Lessee pursuant to approved proposals for rehabilitation protection and management of the environment. Data obtained from the monitoring studies shall be presented to the Lessor in a form suitable for statistical analysis by the Lessor.	
	1(27)(c)	THE monitoring to be carried out under paragraph (26) hereof shall include: (c) counts of, and measurements of the breeding success of, sea birds in breeding colonies on the Reserve and on an undisturbed island situated nearby	The monitoring program as implemented, this report and supplied data. Wedge-tailed Shearwaters are monitored separately.
	1(27)(g)	THE monitoring to be carried out under paragraph (26) hereof shall include: (g) the effects of unusual weather conditions including cyclones and droughts upon the flora fauna and environment of the Reserve	The monitoring program as implemented, this report and supplied data.
	1(27)(h)	THE monitoring to be carried out under paragraph (26) hereof shall include: (h) counts and details of any fauna mortality resulting from the Lessee's operations on the Reserve	Santos' incident reporting system.
	1(28)(d)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive. (d) investigations research and biological monitoring studies carried out by the Lessee as hereinbefore provided and any conclusions or findings thereon;	This report.
Airlie Lease 1901/100	1(28)(f)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive.	This report.

Regulatory Document	Condition No.	Requirement	Evidence of requirement met
		(f) any further new or additional procedures which the Lessee may wish to suggest as being relevant or necessary to improve the management of the environment of the Reserve and to mitigate damage caused to that environment including, without limiting the generality of the foregoing, proposals to amend existing procedures if the monitoring carried out under paragraph (26) hereof shows that the Lessee's operations are having a detrimental effect on the Reserve's flora or fauna.	
	1(29)	ANY observations of environmental concern resulting from the monitoring programme or otherwise shall be reported immediately to the Lessor.	Not required; no concern noted for 2021 reporting period.



Santos WA Energy Limited

Environmental Monitoring Program – Varanus and Airlie Islands Seabird Monitoring Annual Report 2021

Figure 1: Regional location

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Author: J. Johnston	Date: 05-05-2021	Datum: GDA 1994 - Projection: MGA Zone 50
Drawn: C. Dyde	Figure Ref: 569M-17-BIDR-1RevA_170623_Fig01_Locn	0 10 20 30 40 50 Km N

2 Methods

2.1 Monitoring

The timing of monitoring is based on the breeding phenology of seabirds and monitoring effort is detailed in **Table 2**. Monitoring was conducted under DBCA licence FO25000003-4 held by Astron Environmental Services.

Table 2: Summary of monitoring effort for the seabird monitoring program in 2021.

Survey	Personnel	Survey dates	Target species	Islands surveyed
1	Aaron Gove & Daenia Dundon	10 – 15 March 2021	Bridled Terns Silver Gulls	Varanus (potential impact) Abutilon (control) Bridled (control) Parakeelya (control)
2	Matthew Love & Ashley Innes	30 March 2021	Crested Terns Lesser Crested Terns Roseate Terns Pied Cormorants	Varanus (potential impact) Abutilon (control) Beacon (control) Bridled (control) Parakeelya (control)
3	Chris Surman & Sam Gray	11 – 14 December 2020 19 – 20 March 2021	Bridled Terns Silver Gulls Crested Terns Lesser Crested Terns Roseate Terns Pied Cormorants	Airlie (potential impact) Serrurier (control)

The monitoring methods used to calculate nesting habitat and breeding numbers differed depending on the species.

2.1.1 Bridled Terns and Silver Gulls

Nesting habitat for Bridled Terns and Silver Gulls was mapped using a handheld Global Positioning System by walking the perimeter of the observation area to count each species' nests.

The number of breeding seabirds on each island was estimated by counting the number of active nests along 100 m by 10 m transects (**Figure A.1** to **Figure A.5**; **Appendix A**). The number of monitoring transects varied according to the size of the breeding colony. However, it was generally two transects per species on each island, with the exception of only one Bridled Tern transect on each of Varanus and Beacon Islands, and three Bridled Tern transects on Parakeelya Island (**Table B.; Appendix B**). Two Bridled Tern transects, one on Abutilon Island (BT-ABU-B) and one on Bridled Island (BT-BRI-B), were moved following recommendations to do so in 2020, as the old transects were outside the most recently mapped nesting habitat. The estimate of the number of breeding pairs for Bridled Terns and Silver Gulls was based on the nest densities within the monitoring transects extrapolated out to the total nesting habitat area.

Nesting habitat and the number of breeding pairs for Bridled Terns and Silver Gulls is provided by Pendoley Environmental collected during the Wedge-tailed Shearwater monitoring program on Airlie (potential impact) and Serrurier (control) Islands.

2.1.2 Pied Cormorants and Easily Disturbed Tern Species

The nesting habitat for the easily disturbed species Pied Cormorants, Crested Terns and Lesser Crested Terns, was mapped using photographs taken from a Remotely Piloted Aircraft (RPA), except for Airlie and Serrurier Islands, where nesting habitat and the number of breeding pairs is provided by Pendoley Environmental collected during the Wedge-tailed Shearwater monitoring program.

Reconnaissance conducted by Astron personnel whilst surveying the islands for Bridled Terns and Silver Gulls or from the vessel during the second field survey, identified Crested and Lesser Crested Terns roosting on Abutilon Island and rocky islets south of Beacon Island. Reconnaissance, including a complete foot search on Varanus Island, confirmed that no nesting was identified on Bridled, Parakeelya or Varanus Islands; therefore, they were not surveyed by RPA. Crested Terns and Lesser Crested Terns were confirmed nesting on Abutilon Island and islets south of Beacon Island, and Pied Cormorants were confirmed nesting on Abutilon and Beacon Islands. Complete image capture of Abutilon Island, Beacon Island and the small rocky islet south of Beacon Island were surveyed using RPA on 30 March 2021.

Terra Drone personnel, Ashley Innes, conducted the aerial survey in conjunction with Astron using two multi-copter RPAs (Inspire 2 and Phantom 4 Pro) attached with a High Definition (HD) camera (X4S). Images of the breeding colonies were captured by conducting an autonomous imaging survey (**Photograph 1 and Photograph 2**). The RPA was able to operate within 40 m above the birds without any noticeable disturbance, capturing planar and oblique visuals of the breeding colony. Images taken from the autonomous flight were mosaicked and georeferenced to produce a single image (**Photograph 3**).

Systematic counts of the number of breeding birds from the images captured by RPA were undertaken using the open-source cross-platform desktop geographic information system application QGIS (https://www.qgis.org/).

2.2 Statistical Analysis

Data analysis was undertaken using the statistical package R (R Core Team 2016). A generalised additive model (GAM) was fitted to the Bridled Tern and Silver Gull data using the R package *mgcv* (Wood 2006) to examine temporal trends in breeding colony size across islands. The Pied Cormorants and other tern species were not analysed for temporal trends due to their nomadic breeding habit, i.e., they move nesting sites each year making it difficult to examine temporal trends in numbers.

The general approach was to test whether all islands could be modelled using a single curve, or whether islands required individually fitted curves; the latter would indicate that all species of select seabirds were responding differently across islands. The best statistical model was selected by minimising the Akaike Information Criteria (AIC) value and ensuring that all included variables (islands) made a significant contribution to the model based on the value of the F statistic ($P < 0.05$).

Analysis on the number of breeding pairs for Pied Cormorants, Crested Terns, Lesser Crested Terns and Roseate Terns was not conducted due to their nomadic breeding habit. Instead, qualitative analysis is undertaken to determine whether they are observed nesting on islands, they have historically not been recorded or if they have been absent from an island for a long period of time (> 10 years).

2.3 Limitations of the Study

The following limitations were experienced during the first field survey:

- Beacon Island could not be accessed during the first field visit to survey for Bridled Terns and Silver Gulls due to bad weather preventing personnel transfer. Beacon Island was surveyed during the second field visit (30 March 2021) However, it was too late to record any meaningful data for Bridled Terns and Silver Gulls.

- The survey for Bridled Terns and Silver Gulls was executed late in the season as both the Bridled Terns and Silver Gulls had fledged on all islands. This was due to delay in mobilisation because of COVID-19 lockdown restrictions and rainfall events.

These are considered major limitations for the 2021 monitoring program as the number of breeding Bridled Terns and Silver Gulls is estimated using the density of active nests and extrapolating it across the mapped habitat. The density of active nests was extremely low in 2021 due to the high number of apparently empty nests. This is because both species had fledged much earlier in the season and there was little sign left in the nests to determine if they had been previously occupied, and nests were subsequently recorded as empty.

There were no limitations experienced in the field during the second survey. However, Crested and Lesser Crested Terns tend to nest together in the same colony, and it is not possible to distinguish between the species from the images captured by RPA. A proportion of the two species nesting within the colony is estimated by an observer using binoculars. This proportion is then applied to the total count of breeding birds, to obtain an estimate of both Crested and Lesser Crested Terns. The birds are harder to identify on some habitat types from the images capture by RPA. For example, on very rocky substrate or heavy vegetation; however, it is possible by manually counting rather than automated detection, which has been trialled on the data previously. These are not considered limitations of the program and it is unlikely to affect the calculated breeding numbers.

Photograph 1: Image of part of the Crested Tern and Lesser Crested Tern breeding colony on rocky islet south of Beacon Island captured during the RPA survey. Note the difference in the ease of detection of terns on sandy substrate vs rocky substrate.

Photograph 2: Image of part of the Pied Cormorant breeding colony on Beacon Island captured during the RPA survey.

Photograph 3: Single mosaicked image produced from the autonomous flight flown over seabird breeding colonies on Beacon Island.

3 Results and Discussion

3.1 Climate Data

Mean annual Southern Oscillation Index (SOI) and sea surface temperature anomaly (SSTA) were calculated from publicly available data as they are indicative of regional oceanographic conditions and therefore, potential indicators of the number of seabirds breeding each season (as discussed in the following sections). The mean annual SOI and SSTA between 1994 and 2020 are shown in **Figure 2**. The 2021 season (i.e. previous year of 2020) was considered to be a neutral year based on the annual SOI. The season for the corresponding breeding pair numbers within **Figures 4 and 5** are classified according to their annual SOI into neutral, La Niña or El Niño years.

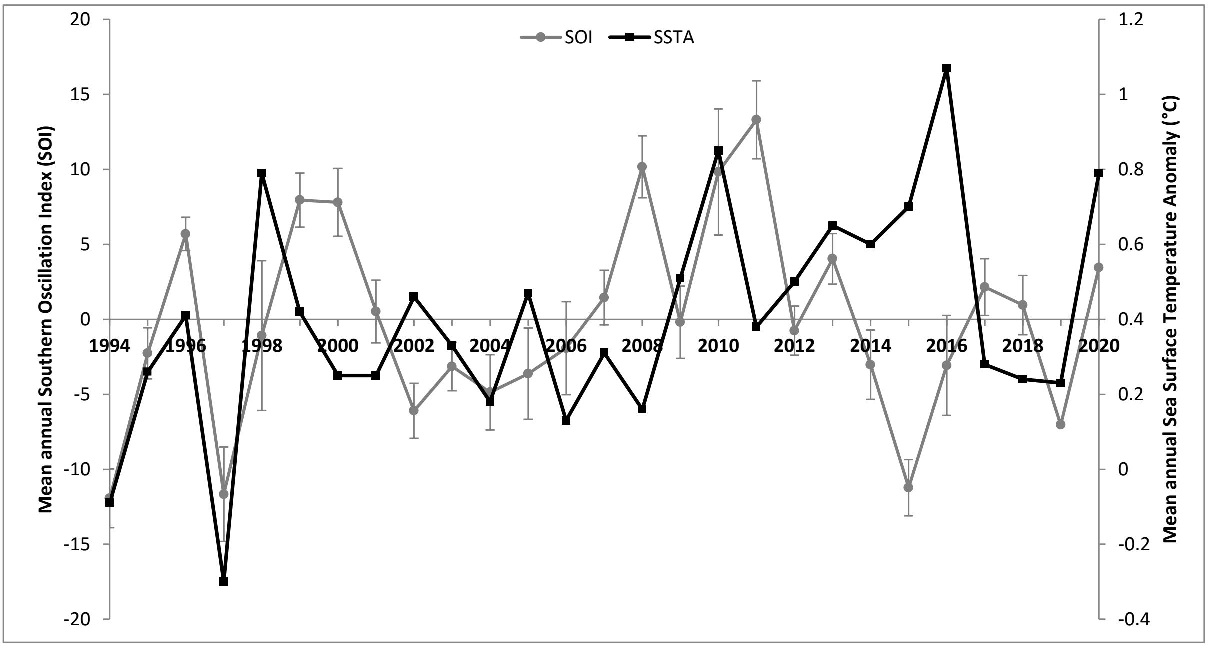

Figure 2: Mean annual Southern Oscillation Index (SOI) and sea surface temperature anomaly (SSTA) for the Australian region (from 1994 to 2020) (Source: Bureau of Meteorology).

3.2 Nesting Habitat

The area of potential nesting habitat available for each target seabird species in 2021 is detailed in **Table 3** and shown in **Figure A.1** to **Figure A.5** (**Appendix A**). The composition of breeding seabird species (based on the estimated number of breeding pairs) on each of the monitored islands in 2021 is shown in **Figure 3**.

Table 3: Size of seabird nesting habitat and breeding pair estimates on each island in 2021.NR = Not recorded/no meaningful data collected.

Species	Island	Area of potential nesting habitat (ha)	Estimate of no. breeding pairs (2020)	Range for no. of breeding pairs from previous surveys (2009 – 2021)
Bridled Tern (*Onychoprion anaethetus*)	Airlie	0	0	0
	Varanus	0	2	0 - 51
	Abutilon	6.1	31	31 - 4,286
	Beacon	0.8	0	20 - 260

Species	Island	Area of potential nesting habitat (ha)	Estimate of no. breeding pairs (2020)	Range for no. of breeding pairs from previous surveys (2009 – 2021)
	Bridled	3.3	0	0 - 5,603
	Parakeelya	5.7	75	75 - 9,476
	Serrurier	0	0	0
Silver Gull (*Chroicocephalus novaehollandiae*)	Airlie	1.0	66*	0 - 66
	Varanus	0	0	0
	Abutilon	2.9	88	45 – 1,471
	Beacon	0.8	0	11 - 175
	Bridled	4.4	0	0 - 1,591
	Parakeelya	4.3	152	54 – 2,080
	Serrurier	5.1	314*	314
Crested Tern (*Thalasseus bergii*)	Airlie	0.2	220	0 - 220
	Varanus	0	0	0 – 19,557
	Abutilon	0.8	16,157	0 – 16,157
	Beacon	0	0	0 – 8,725
	Bridled	0	0	0
	Parakeelya	0	0	0
	Serrurier	0.7	10	10
Lesser Crested Tern (*Thalasseus bengalensis*)	Airlie	0.2	10	0 - 10
	Varanus	0	0	0 - 688
	Abutilon	0.8	97	0 - 900
	Beacon	0	0	0 - 459
	Bridled	0	0	0
	Parakeelya	0	0	0
	Serrurier	0.7	1	1
Pied Cormorant (*Phalacrocorax varius*)	Airlie	0	0	0
	Varanus	0	0	0 - 617
	Abutilon	0.03	96	0 - 205
	Beacon	0.05	353	0 - 353
	Bridled	0	0	0 - 392
	Parakeelya	0	0	0
	Serrurier	0	0	N/A

*These are summary counts of birds on the island, not the number of breeding pairs.

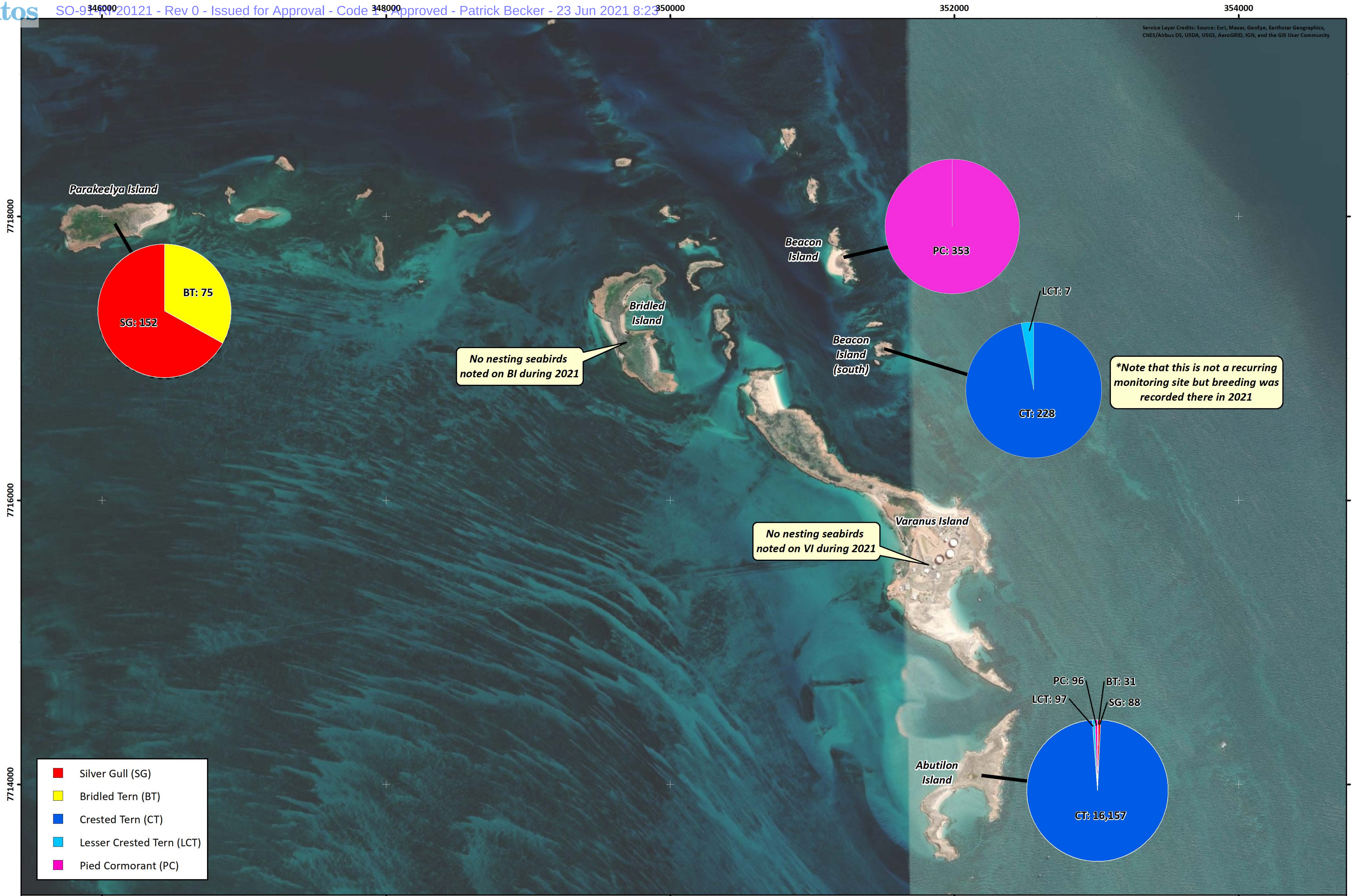

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Figure 3: Composition and proportion of seabird breeding pairs on each of the monitored islands in 2021

Scale: 1:24,000 at A3
Coordinate System: GDA 1994 MGA Zone 50
Metres
0 250 500 750 1,000

N

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Author: J. Johnston | Drawn: C. Dyde | Date: 03-06-2021 | Figure Ref: 569M-21-BIDR-1Rev0_210603_Fig03_BreedPairs

3.3 Breeding Colony Size

3.3.1 Bridled Terns

The estimated number of breeding pairs of Bridled Terns on each island monitored in 2021 were the lowest estimates since monitoring began in 2006 (**Table 3**). This is likely due to the timing of the surveys. The survey was too late in the season as the Bridled Tern chicks had fledged on all islands. Once they have left their nests it is too difficult to discern previously occupied nests during that season, and the number of occupied nests is the variable used to calculate the number of breeding pairs. This was due to delayed mobilisation because of COVID-19 lockdown restrictions and rainfall events.

No Bridled Terns were recorded nesting on Airlie (potential impact), Beacon, Serrurier and Bridled Islands (controls) in 2021. Breeding patterns for Bridled Terns varied between islands. Bridled Terns breed on Varanus (potential impact) and Beacon Island (control) in smaller numbers compared to the other control islands: Abutilon, Bridled and Parakeelya Islands. The control islands with larger Bridled Tern numbers (Abutilon, Bridled and Parakeelya) showed large annual fluctuations in the number of breeding pairs present. Abutilon, Bridled and Parakeelya Islands showed a similar trend over time with a slight decrease from 2006 to 2013 before increasing until 2018 and declining in recent seasons (**Figure 4**). This trend was considered significant for Abutilon Island only (P = 0.03). The decrease observed on Abutilon and Bridled Islands may be due in part to one of the monitoring transects on each of these islands no longer being located within the main nesting Bridled Tern colonies; they were originally established in the more minor colonies on the island. Hence, is likely to have resulted in an underestimate of breeding pairs across the islands. In addition, the low numbers of breeding Bridled Terns recorded in 2021, which are not likely to be an accurate estimate as per the limitations described in **Section 2.3**, may also have contributed to this apparent decrease.

The GAMs for the islands with fewer Bridled Tern pairs indicated no change over time for Beacon Island (control) (P = 0.29) and a significant decline for Varanus Island (potential impact) (P = 0.001) (**Figure 4**), where historically few pairs have nested on these islands. A linear model also showed a similar significant decrease in Bridled Tern numbers on Varanus Island (potential impact) ($F_{`1,13}$ = 16.4, P = 0.001). It is unknown why numbers have declined on Varanus Island, but it has always had very low numbers and Varanus Island may be considered marginal breeding habitat for this species. The entire island was surveyed in 2021 and two fledglings were recorded, suggesting that two breeding pairs were present in 2021, which is an increase from zero recorded during the previous two seasons.

Studies have shown that the diet and reproductive performance of some seabirds shows a strong relationship with the flow of the Leeuwin Current (Dunlop et al. 2002; Nicholson 2002; Surman, Nicholson, and Santora 2012). La Niña conditions (non El Niño years), which are characterised by a positive SOI, stronger Leeuwin Current flow and warmer sea surface temperatures (and larger SSTA), generally lead to more prey availability, and are correlated with a positive effect upon the breeding success of a number of seabird species (Dunlop et al. 2002; Nicholson 2002; Surman, Nicholson, and Santora 2012). Analysis using GAM indicated there was a significant relationship between the number of Bridled Tern breeding pairs and SSTA (r^2 = 0.49, P < 0.0001) but not the mean annual SOI (r^2 = 0.36, P = 0.12) for the period 2006 until 2021.

As would be predicted, the number of breeding pairs generally increased with increasing SSTA, particularly when SSTA was high, indicating an influence of more localised oceanographic conditions. The number of breeding pairs also increased with increasing SOI, but once SOI values became positive, the number of breeding pairs began to decrease, although not considered significant. Reasons for this are unclear; however, seabirds have been shown to also have poor breeding years under La Niña conditions, and not just during probable ENSO events, with breeding parameters showing a decoupling from the strong negative influence of large-scale (ENSO) oceanographic conditions (Surman, Nicholson, and Santora 2012). In addition, in recent years, SOI and SSTA do not appear to be positively correlated (see **Figure 2**), which has historically been the case. Bridled Terns may also be buffered to some extent against climate-induced changes in oceanic productivity due to diverse prey types and the availability of resources supplied by the benthic food chains (Dunlop and Surman 2012). Due to changes in ocean climate and associated shifts in marine productivity, Bridled Terns have been able to expand their distribution and large growth in colonies further south have been reported over the last 20 years (Dunlop and Surman 2012).

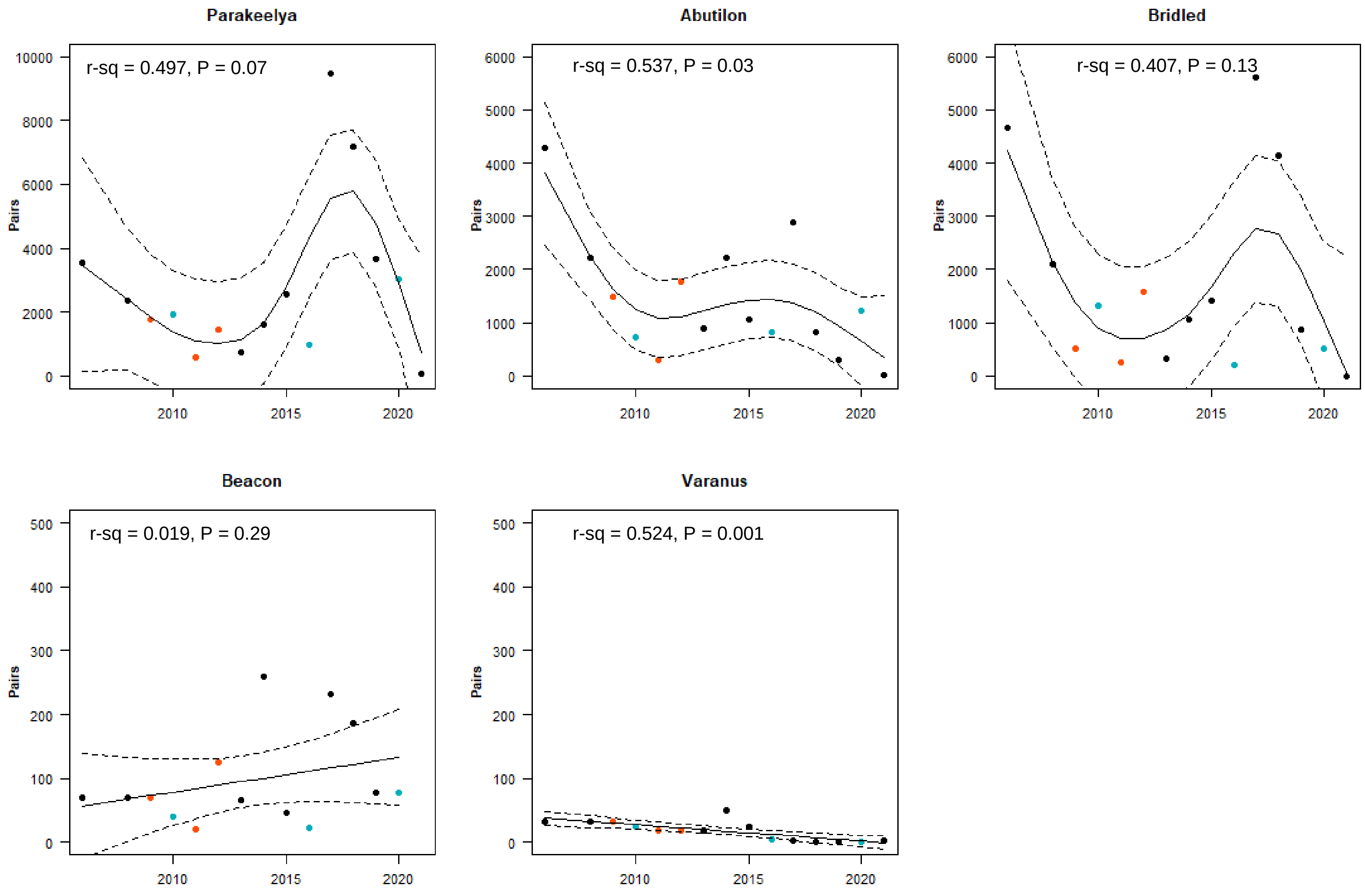

Figure 4: Change in the number of Bridled Tern breeding pairs over time. Blue dots represent La Niña years, orange dots El Niño years and black dots neutral years. Solid lines represent the fitted GAM models and dotted lines represent the 95% confidence limits. Note that the y-axis changes for islands.

3.3.2 Silver Gulls

The estimated number of breeding pairs of Silver Gulls on each island monitored in 2021 were low but within previous estimates recorded since monitoring began in 2006, with the exception of Beacon Island where no meaningful data were recorded (**Table 3**). This was again likely due to the timing of the surveys. The survey was too late in the season as the Silver Gull chicks had fledged on all islands, and once they have left their nests, it is too difficult to discern previously occupied nests during that season. This was due to delay in mobilisation because of COVID-19 lockdown restrictions and rainfall events.

Silver Gulls were recorded nesting on Airlie Island (potential impact) as well as Serrurier Island (control). This monitoring program previously recorded Silver Gulls breeding on Airlie Island in 2019 and 2017, and there have been other historical records of breeding Silver Gulls from 1987/88 and 1991 (Department of Parks and Wildlife 2017). It is unknown why they are recorded breeding intermittently on Airlie Island. Silver Gull populations have increased in size over the last 50 years and available nesting grounds appear to be a limiting factor to population increases (Auman, Meathrel, and Richardson 2008; Smith and Carlile 1992). Limited available nesting habitat due to high numbers of breeding birds during certain seasons may cause some Silver Gulls to breed on islands not routinely exploited for nesting.

No Silver Gulls were recorded breeding on Varanus Island (potential impact). Beacon Island (control) has shown no change in Silver Gull breeding numbers over time ($P = 0.08$) (**Figure 5**). Bridled and Parakeelya Islands (controls) have shown a significant increase in numbers from 2013, before declining in recent seasons ($P = 0.005$ and $P = 0.01$, respectively) (**Figure 5**). Silver Gull breeding numbers followed a similar trend on Abutilon Island (control), but with a less marked decrease in recent seasons ($P = 0.26$) (**Figure 5**). A Silver Gull Control Program was instigated in 2006 for a number of years in response to a rapid expansion of the population and potential detrimental effects on other seabird and marine turtle nesting populations (Surman 2006), and decreased numbers for several years post-2006 (**Figure 5**). However, numbers of Silver Gulls during the past ten years are likely to reflect natural variation.

GAM analysis indicated there was no significant relationship between Silver Gull breeding numbers and SOI or SSTA. The number of Silver Gull breeding pairs showed an increasing trend with increasing SSTA, similar to Bridled Terns; however, the trend was not statistically significant. This indicates that the warmer sea surface temperatures (and larger SSTA) that leads to more prey availability may have had a positive effect upon the breeding success of Silver Gulls. The reason this trend is not significant may be due to the Silver Gull's diet, as it can also prey on terrestrial species such as frogs, birds and mammals, as well as exploiting human-derived foods (Higgins and Davies 1996; Smith, Carlie, and Louwerse 1991), which are not influenced by oceanographic conditions.

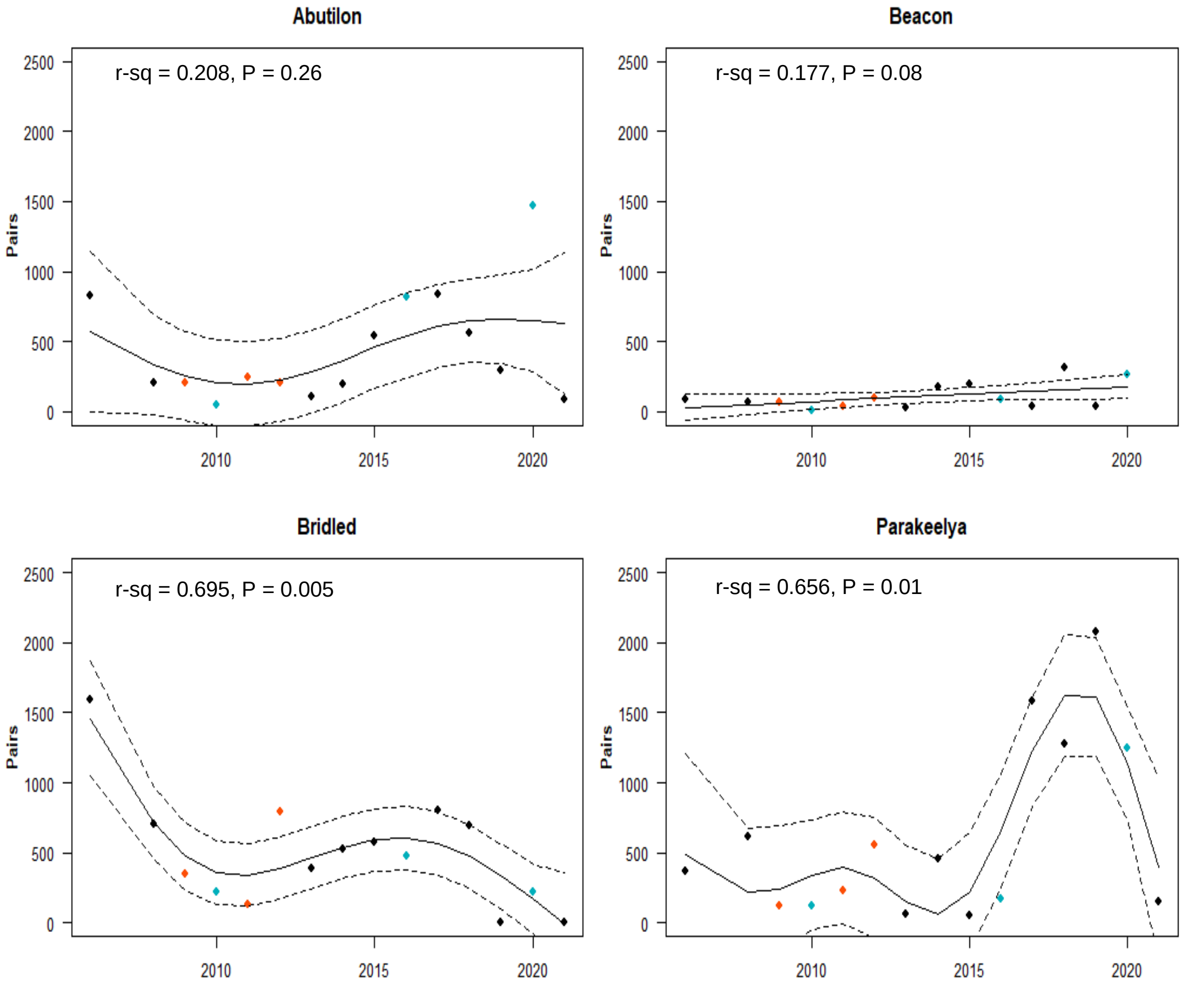

Figure 5: Change in the number of Silver Gull breeding pairs over time. Varanus Island is not shown as Silver Gulls have not been recorded on this island. Blue dots represent La Niña years, orange dots El Niño years and black dots neutral years. Solid lines represent the fitted GAM models and dotted lines represent the 95% confidence limits. Note that the y-axis changes for islands.

3.3.3 Tern and Cormorant Species

Although the tern and cormorant species are considered nomadic breeders, they appear to utilise a consistent subset of islands and vary their nesting location within this subset each season (**Table A. 1; Appendix A**). For example, Lesser Crested Terns tend to nest on Abutilon, Beacon and Varanus Islands, whereas Pied Cormorants tend to nest on Abutilon, Bridled and Varanus Islands.

Crested and Lesser Crested Terns were recorded breeding on Airlie Island (potential impact), Abutilon and Serrurier Islands (controls) in 2021, with Crested Terns recorded in higher numbers than previously estimated on Abutilon (control) and Airlie (potential impact) Islands, with 16,157 and 220 breeding pairs observed, respectively. It is also the first time Lesser Crested Terns have been recorded nesting on Airlie Island (potential impact) since monitoring began in 2006. Lesser Crested Terns were estimated to make up only 0.6% of the breeding colony on Abutilon Island, 4.3% on Airlie Island and 9% on Serrurier Island. At the time of the survey the terns appeared to be incubating their eggs and no chicks had hatched. Crested and Lesser Crested Terns were not recorded nesting on any of the other monitored islands; however, they were observed nesting on a rocky islet south of Beacon Island with 228 Crested Tern pairs and seven Lesser Crested Tern pairs recorded breeding.

Ninety-six Pied Cormorant nests were recorded on Abutilon Island in 2021. Pied Cormorants were also recorded breeding in higher numbers than previously estimated on Beacon Island, with 353 nests observed.

3.4 Other Seabird and Shorebird Species

A list of other shorebird and seabird species recorded during the 2021 monitoring period on Varanus and Airlie Islands is provided in **Table A. 2** (**Appendix A**).

4 Conclusions

Santos was compliant with the lease conditions at Varanus and Airlie Islands as outlined in **Table** 1 with regard to seabird monitoring in 2021. Wedge-tailed Shearwaters are monitored as part of a separate monitoring program. The 2021 monitoring results showed the number of Bridled Tern breeding pairs were the lowest estimates since monitoring began in 2006, with the exception of Beacon Island for which no meaningful data were recorded. The estimated number of breeding pairs of Silver Gulls on each island monitored in 2021 were low but within previous estimates recorded since monitoring began in 2006, except for Beacon Island where no meaningful data were recorded. This is likely due to the timing of the surveys, rather than a true reflection of the number of breeding pairs present in 2021. The survey was too late in the season as chicks had fledged on all islands, and once they have left their nests, it is too difficult to discern nests occupied during the 2021 season. This was due to delay in mobilisation because of COVID-19 lockdown restrictions and rainfall events.

No Bridled Terns were recorded nesting on Airlie (potential impact), Serrurier and Bridled Islands (controls) in 2021. Bridled Terns breed in very small numbers on Varanus Island (potential impact) and Beacon Island (control) compared to the other control islands: Abutilon, Bridled and Parakeelya Islands. These marginal Bridled Tern breeding islands indicated no change over time for Beacon Island (control) and a decline for Varanus Island (potential impact), although two Bridled Tern breeding pairs were recorded in 2021, following two seasons of no breeding pairs. The control islands with larger Bridled Tern numbers (Abutilon, Bridled and Parakeelya) showed large annual fluctuations in the number of breeding pairs present. Abutilon, Bridled and Parakeelya Islands showed a similar cyclical trend over time, with a recent decrease since 2017/2018. The recent decreases observed on Abutilon and Bridled Islands may be due in part to some of the monitoring transects no longer being located within the mapped nesting habitat for Bridled Terns on these islands, hence, resulting in an underestimate of breeding numbers across the island. These transects were moved in 2021 to within mapped nesting habitat. In addition, the low numbers of breeding Bridled Terns recorded in 2021, which are not likely to be an accurate reflection of the actual number of breeding pairs, may also have contributed to this apparent decrease.

Silver Gulls were recorded nesting on Airlie Island (potential impact) as well as Serrurier Island (control). Silver Gulls have previously been recorded breeding intermittently on Airlie Island in 2019, 2017, 1991 and 1987/88. Limited available nesting habitat due to high numbers of breeding birds during certain seasons may cause some Silver Gulls to breed on islands, such as Airlie and Serrurier Islands, not routinely exploited for nesting. Silver Gulls were not observed nesting on Varanus (potential impact) and Bridled (control) islands. Beacon (control) Island has shown no change in Silver Gull breeding numbers over time. The other control islands exhibited similar trends in Silver Gull breeding numbers with an increase in numbers from 2013, before declining in recent seasons; this trend was significant for Bridled and Parakeelya Islands only. A Silver Gull Control Program was instigated in 2006 for several years in response to a rapid expansion of the population (Surman 2006) and decreased numbers for several years post-2006; however, numbers of Silver Gulls during the past ten years are likely to reflect natural variation.

Pied Cormorants were recorded on Abutilon and Beacon Islands (controls) in 2021 and were recorded nesting in larger numbers than previous years on Beacon Island (control). Crested and Lesser Crested Terns were recorded breeding on Airlie Island (potential impact), Abutilon and Serrurier Islands (controls) in 2021, as well as a rocky islet south of Beacon Island. The tern and cormorant species are nomadic breeders, and they generally appear to utilise a consistent subset of islands, varying their nesting location within this subset of islands each season.

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Appendix A: Summary of Results

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Figure A.1: Seabird nesting habitat recorded on Abutilon Island in 2021

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Author: J. Johnston	Date: 08-06-2021	Datum: GDA 1994 - Projection: MGA Zone 50
Drawn: C. Dyde	Fig Ref: 569M-21-BIDR-1Rev0_210608_FigA1_ABU_Seabird	0 50 100 150 200 Metres N

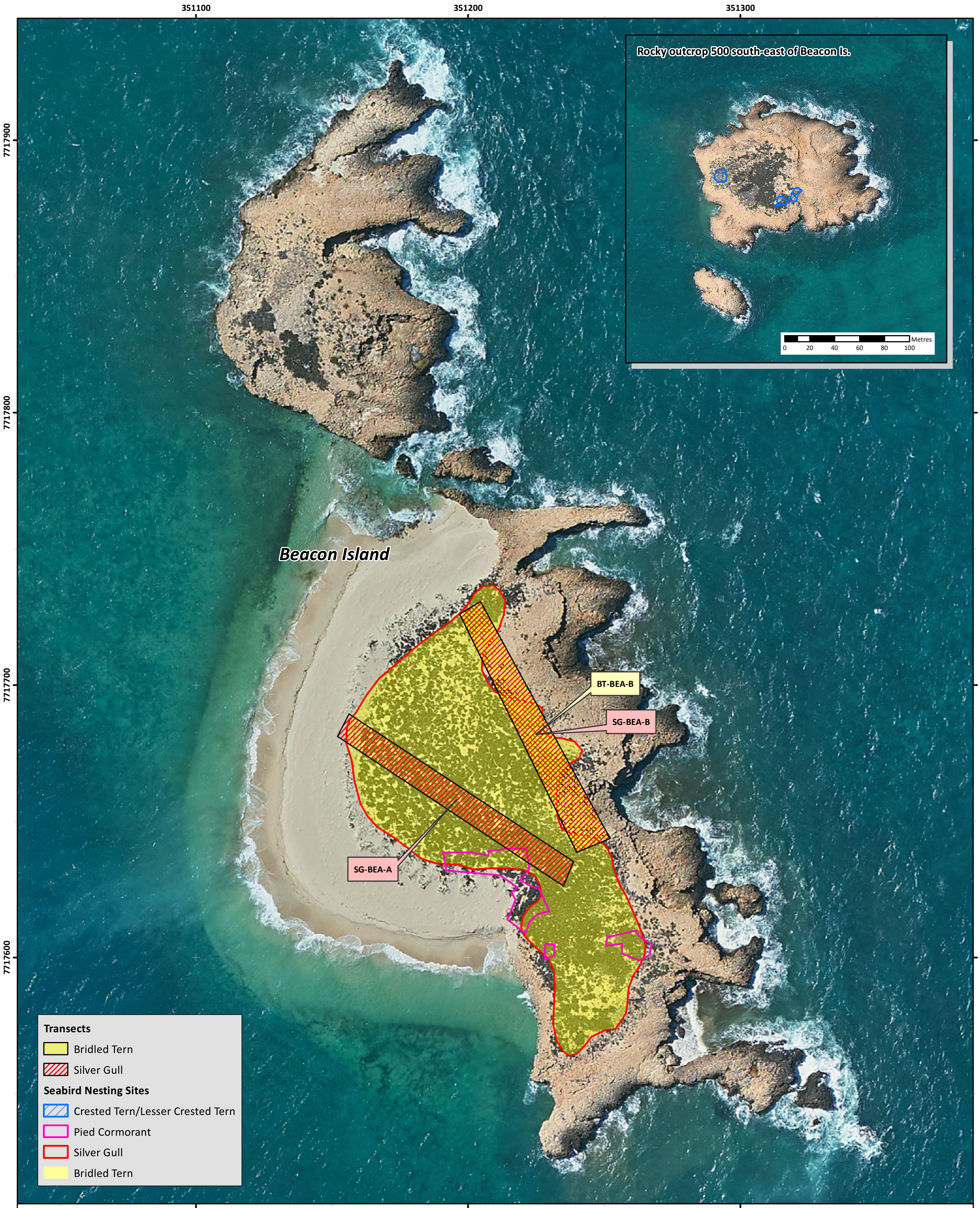

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Figure A.2: Seabird nesting habitat recorded on Beacon Island in 2021

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Author: J. Johnston	Date: 05-05-2021
Drawn: C. Dyde	Fig Ref: 569M-21-BIDR-1RevA_210505_FigA2_BEA_Seabird

Datum: GDA 1994 - Projection: MGA Zone 50

Metres 0 20 40 60 80 100

N

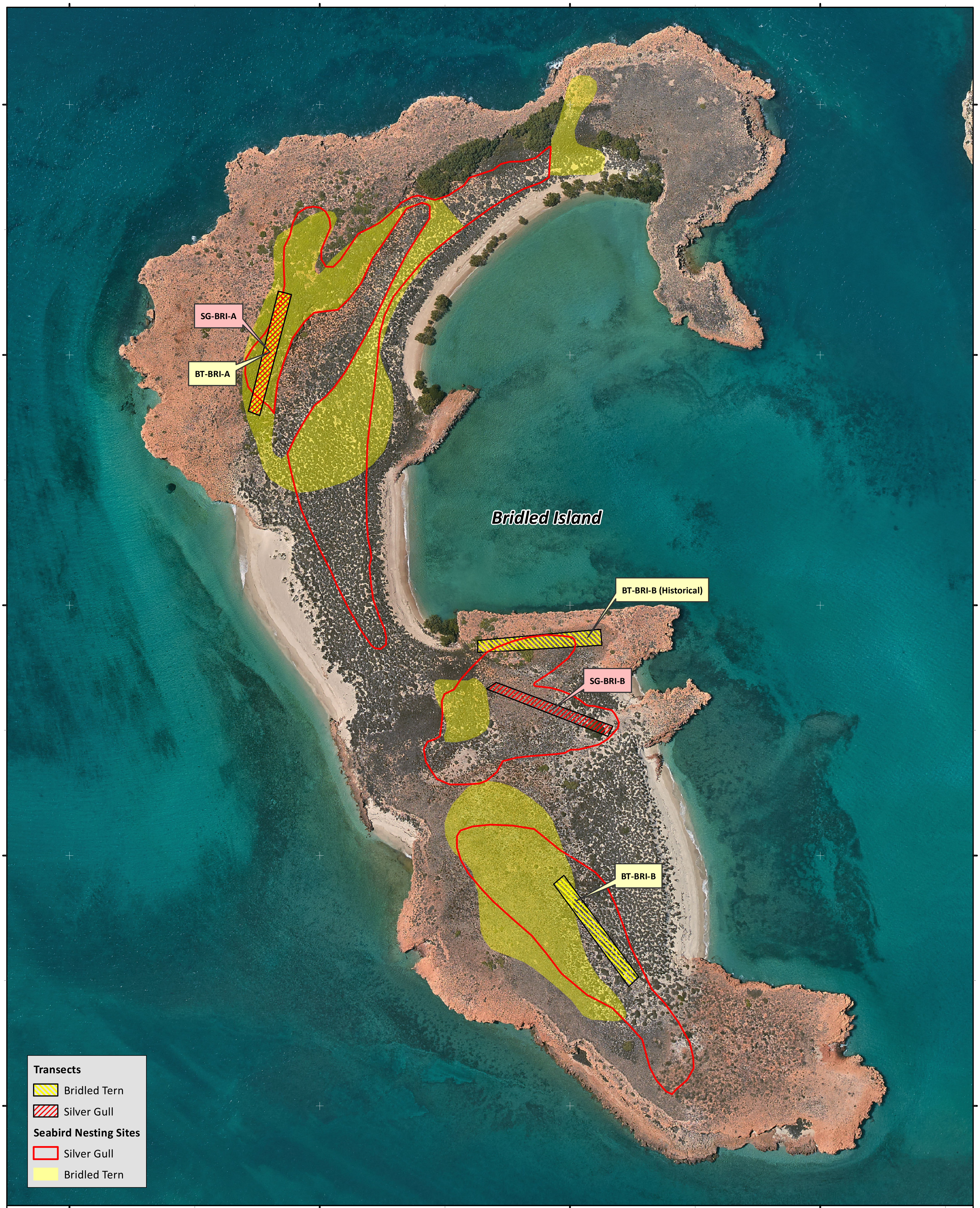

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Figure A.3: Seabird nesting habitat recorded on Bridled Island in 2021

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Author: J. Johnston	Date: 08-06-2021	Datum: GDA 1994 - Projection: MGA Zone 50
Drawn: J. Manninen	Fig Ref: 569M-21-BIDR-1Rev0_210608_FigA3_BRI_Seabird	0 50 100 150 200 Metres N

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Figure A.4: Seabird nesting habitat recorded on Parakeelya Island in 2021

Author: J. Johnston | Drawn: J. Manninen | Date: 05-05-2021 | Fig Ref: 569M-21-BIDR-1RevA_210505_FigA4_PAR_Seabird

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Figure A.5: Seabird nesting habitat recorded on Varanus Island in 2021

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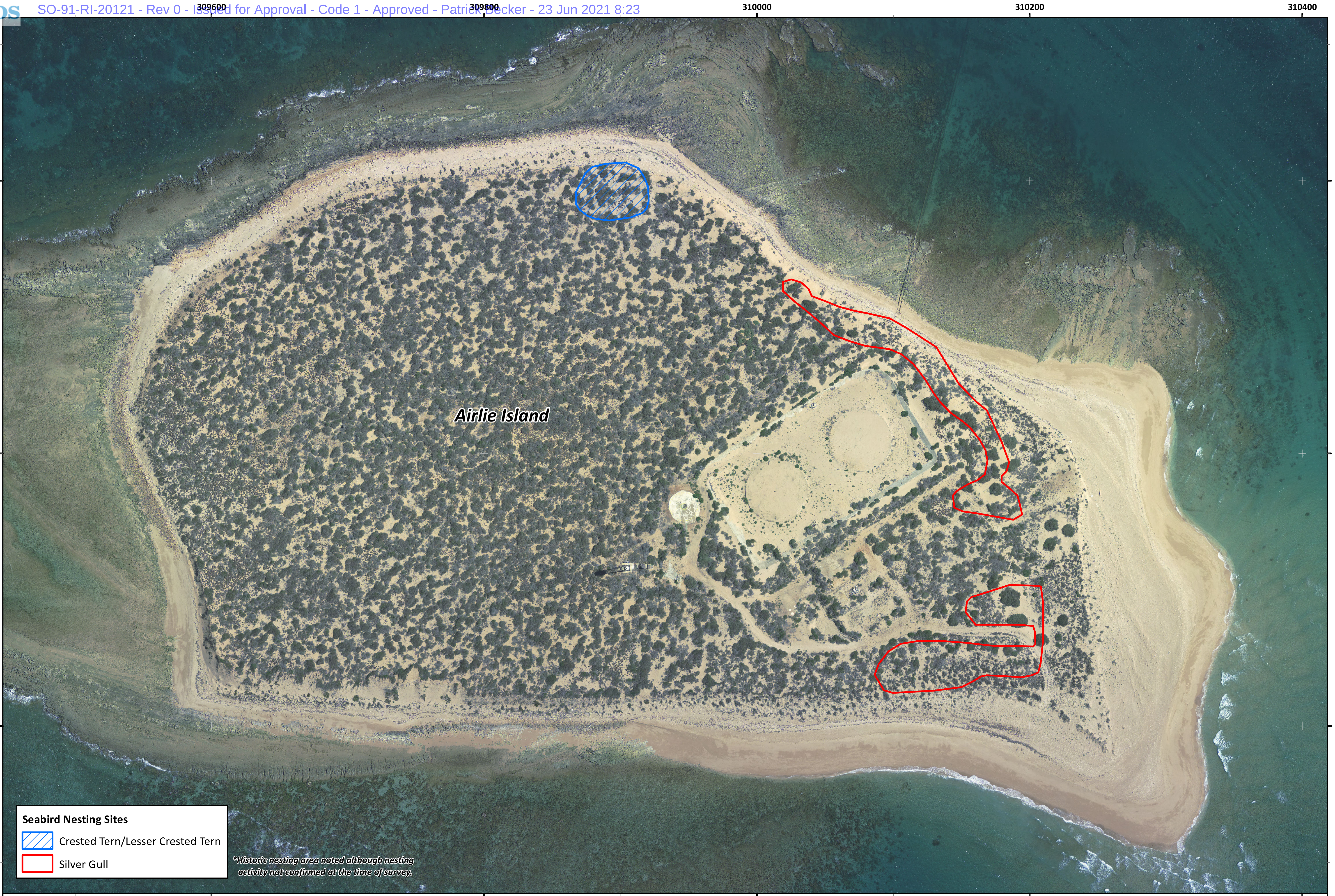
Author: J. Johnston	Date: 05-05-2021	Datum: GDA 1994 - Projection: MGA Zone 50; Metres 0 100 200 300 400 500; N
Drawn: C. Dyde	Fig Ref: 569M-21-BIDR-1RevA_210505_FigA5_VAR_Seabird	



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Environmental Monitoring Program - Varanus and Airlie Islands Seabird Monitoring Annual Report, 2021

Figure A.6: Seabird nesting habitat recorded on Airlie Island in 2021

Author: J. Johnston | Drawn: C. Dyde | Date: 13-05-2021 | Figure Ref: 569M-21-BIDR-1RevA_210512_FigA6_AIR_Seabird

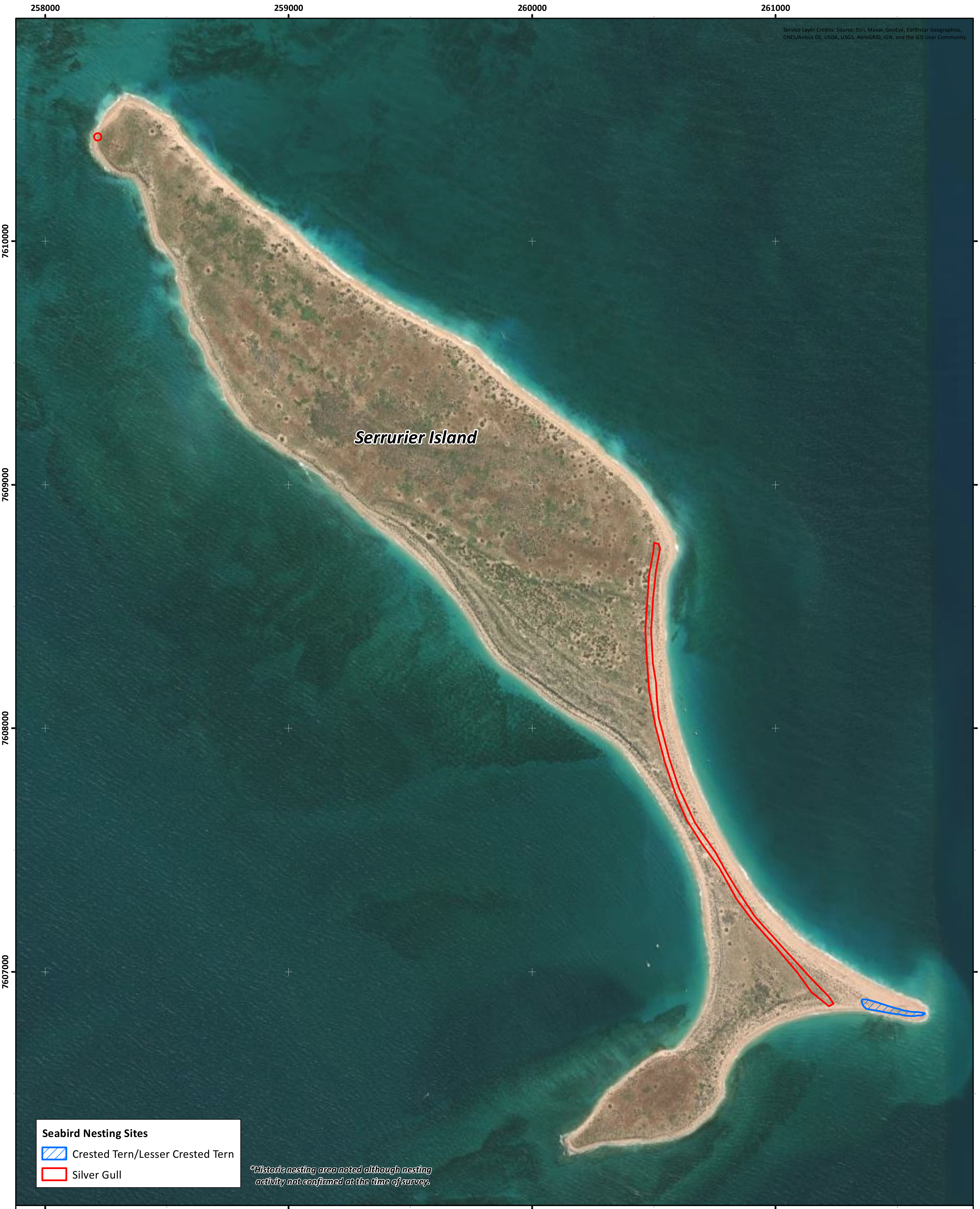

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Figure A.7: Seabird nesting habitat recorded on Serrurier Island in 2021

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Author: J. Johnston	Date: 13-05-2021
Drawn: C. Dyde	Fig Ref: 569M-21-BIDR-1RevA_210512_FigA7_SERR_Seabird

Datum: GDA 1994 - Projection: MGA Zone 50

0 200 400 600 800 1,000 Metres

N

Table A. 1: The location of breeding colonies of non-site faithful seabirds between 2005 and 2021.

Species	Island	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Crested Tern	Airlie															✓		
	Abutilon		✓	✓		✓	✓								✓			✓
	Beacon	✓		✓	✓	✓		✓	✓	✓				✓			✓	✓[1]
	Bridled																	
	Parakeelya						✓											
	Varanus			✓	✓				✓	✓			✓		✓	✓		
Lesser Crested Tern	Airlie																	
	Abutilon		✓	✓		✓	✓											✓
	Beacon				✓	✓		✓		✓				✓			✓	✓[1]
	Bridled																	
	Parakeelya																	
	Varanus			✓	✓				✓				✓		✓	✓		
Pied Cormorant	Airlie																	
	Abutilon		✓			✓	✓					✓		✓				✓
	Beacon																✓	✓
	Bridled		✓															
	Parakeelya																	
	Varanus								✓							✓		
Roseate Tern	Airlie																	
	Abutilon																	
	Beacon				✓													
	Bridled																	
	Parakeelya																	
	Varanus																	

[1]Recorded on rocky islet south of Beacon Island.

Table A. 2: Other seabird (not nesting) and shorebird species recorded during the 2021 seabird monitoring program.

Species name	Common name	Conservation status (EPBC Act, BC Act, DBCA Priority Fauna List)	Observation type	Abundance
Varanus Island				
Eastern Reef Egret	*Egretta sacra*		Individual(s)	2
Striated Heron	*Butorides striatus*		Individual(s)	1
Eastern Osprey	*Pandion cristatus*	MI, MI	Individual(s), nest	2
Pied Cormorant	*Phalacrocorax varius*		Individual(s)	20
Pied Oystercatcher	*Haematopus longirostris*		Individual(s)	1
Sooty Oystercatcher	*Haematopus fuliginosus*		Individual(s)	2
Beach Stone-curlew	*Esacus magnirostris*		Individual(s)	5
Common Sandpiper	*Actitis hypoleucos*	MI, MI	Individual(s)	2
Ruddy Turnstone	*Arenaria interpres*	MI, MI	Individual(s)	8
Bar-tailed Godwit	*Limosa lapponica*	MI, MI	Individual(s)	1
Greater Sand Plover	*Charadrius leschenaultii*	VU & MI, VU & MI	Individual(s)	1
Grey-tailed Tattler	*Tringa brevipes*		Individual(s)	2
Abutilon Island				
Common Sandpiper	*Actitis hypoleucos*	MI, MI	Individual(s)	1
Eastern Reef Egret	*Egretta sacra*		Individual(s)	1
Eastern Osprey	*Pandion cristatus*	MI, MI	Individual(s)	1
Bridled Island				
Pied Cormorant	*Phalacrocorax varius*		Individual(s)	4
Eastern Reef Egret	*Egretta sacra*		Individual(s)	1
Parakeelya Island				
Pied Cormorant	*Phalacrocorax varius*		Individual(s)	5
Airlie Island				
Crested Tern	*Thalasseus bergii*	MI, MI	Individual(s)	968 (220 nests)
Lesser Crested Tern	*Thalasseus bengalensis*		Individual(s)	51 (10 nests)
Asiatic Common Tern	*Sterna hirundo*	MI, MI	Individual(s)	55
Roseate Tern	*Sterna dougallii*	MI, MI	Individual(s)	126
Ruddy Turnstone	*Arenaria interpres*	MI, MI	Individual(s)	21
Greater Sand Plover	*Charadrius leschenaultii*	VU & MI, VU & MI	Individual(s)	5
Eastern Reef Egret	*Egretta sacra*		Individual(s)	2
Pied Oystercatcher	*Haematopus longirostris*		Individual(s)	4
White-bellied Sea-eagle	*Haliaeetus leucogaster*		Individual(s)	1
Eastern Osprey	*Pandion cristatus*	MI, MI	Individual(s), nest	2

Species name	Common name	Conservation status (EPBC Act, BC Act, DBCA Priority Fauna List)	Observation type	Abundance
Beach Stone-curlew	*Esacus magnirostris*		Individual(s)	2
Whimbrel	*Numenius minutus*		Individual(s)	3
Grey-tailed Tattler	*Tringa brevipes*		Individual(s)	8
Common Sandpiper	*Actitis hypoleucos*	MI, MI	Individual(s)	2
Lesser Sand Plover	*Charadrius mongolus*	EN & MI, EN & MI	Individual(s)	5
Sanderling	*Calidris alba*	MI; MI	Individual(s)	2
Silver Gull	*Chroicocephalus novaehollandiae*		Individual(s)	127 (nests present)
Bridled Tern	*Onychoprion anaethetus*	MI; MI	Individual(s)	1
Serrurier Island				
Eastern Osprey	*Pandion cristatus*	MI, MI	Individual(s)	6 (2 nests)
Eastern Reef Egret	*Egretta sacra*		Individual(s)	5
Beach Stone-curlew	*Esacus magnirostris*		Individual(s)	6
Silver Gull	*Chroicocephalus novaehollandiae*		Individual(s)	364 (nesting)
Common Sandpiper	*Actitis hypoleucos*	MI, MI	Individual(s)	2
Ruddy Turnstone	*Arenaria interpres*	MI, MI	Individual(s)	3
Grey-tailed Tattler	*Tringa brevipes*		Individual(s)	3
White-bellied Sea-eagle	*Haliaeetus leucogaster*		Individual(s)	1 (nest)
Pied Cormorant	*Phalacrocorax varius*		Individual(s)	10
Common Sandpiper	*Actitis hypoleucos*	MI, MI	Individual(s)	1
Asiatic Common Tern	*Sterna hirundo*	MI, MI	Individual(s)	6
Crested Tern	*Thalasseus bergii*	MI, MI	Individual(s)	10
Lesser Crested Tern	*Thalasseus bengalensis*		Individual(s)	1

EPBC Act – *Environment Protection and Biodiversity Conservation Act 1999*; BC Act – Western Australian *Biodiversity and Conservation Act 2016*; DBCA - Department of Biodiversity, Conservation and Attractions; MI – Migratory, VU – Vulnerable.

Appendix B: Monitoring Transect Descriptions

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Table B.1: Description of seabird monitoring transects.

Island	Transect	Habitat	Photo
Abutilon Island	BT/SG-ABU-A	*Spinifex longifolius* grassland on sand dunes	
	BT/SG-ABU-B	*Rhagodia* shrubland and *Spinifex longifolius* grassland on sand dunes	
Beacon Island	SG-BEA-A	*Spinifex longifolius* grassland on sand dunes	No photo available
	BT/SG-BEA-B	*Spinifex longifolius* grassland on sand dunes and *Rhagodia* shrubland on rocky outcropping	No photo available
Bridled Island	BT/SG-BRI-A	Dense *Sarcostemma viminale* shrubland on shallow soils and exposed bedrock	

Island	Transect	Habitat	Photo
	BT-BRI-B	Sparse *Ptilotus* shrubland over annuals in sand basin	
	SG-BRI-B	Sparse *Sarcostemma viminale* shrubland over *Ptilotus nobilis* on rocky outcropping	
Varanus Island	BT-VAR-A	Stunted tussock grassland over open herbland on exposed bedrock	

Island	Transect	Habitat	Photo
Parakeelya Island	BT/SG-PAR-A	*Rhagodia* and *Sarcostemma viminale* shrubland over grasses on shallow soils and exposed bedrock	
	BT/SG-PAR-B	*Rhagodia* and *Sarcostemma viminale* shrubland over low heath on shallow soils and exposed bedrock	
	BT-PAR-C	*Sarcostemma viminale* shrubland over low heath and grasses on shallow soils and exposed bedrock	

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Total number of pages to this document (incl. coversheet)	27

DOCUMENT TITLE:

AIRLIE ISLAND TURTLE MONITORING: ANNUAL REPORT 2021/22

SANTOS DOCUMENT No:	Rev.
7931-650-REP-0020	**0**

VENDOR DOCUMENT No:	Rev.
J06050	0

CONTRACT / PURCHASE No: 4800006290

DOCUMENT STATUS:

- INFORMATION ☐
- FOR REVIEW ☐
- OTHER ☐
- FOR APPROVAL ■

EQUIPMENT TAG No.:

EQUIPMENT DATASHEET No.:

NOTES:

REVISIONS TO SANTOS DOCUMENT No:

Rev	Date	Reason for Issue
A	12/04/2022	Issued for Review
B	18/05/2022	Issued for Review
0	27/05/2022	Issued for Approval

SANTOS LTD

SANTOS ENVIRONMENTAL MONITORING PROGRAM: AIRLIE ISLAND TURTLE MONITORING: ANNUAL REPORT 2021/22

Prepared by

Pendoley Environmental Pty Ltd

For

Santos Pty Ltd

27 May 2022

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DOCUMENT CONTROL INFORMATION

TITLE: SANTOS ENVIRONMENTAL MONITORING PROGRAM: AIRLIE ISLAND TURTLE MONITORING ANNUAL REPORT 2021/22

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Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		04/04/2022	J. Kelly
Rev IA	Technical Review	06/04/2022	07/04/2022	L. Peel/P. Whittock
Rev A	Client review	12/04/2022	06/05/2022	B. Pace
Rev B	Address client comments	18/05/2022	26/05/2022	B. Pace
Rev 0	Final report issued	27/05/2022		

Printed:	27 May 2022
Last saved:	27 May 2022 02:16 PM
File name:	P:\06 Projects\J06 Santos (Apache Energy, Quadrant))\2021_22 Santos\05 Programs\03 AI Turtles & WTS\05 Technical Reports\Turtle\Rev0_PENV\J06050 - Airlie Island Turtle Monitoring Report 2021-22 Rev0.docx
Author:	Jade Kelly/Lauren Peel/Paul Whittock
Project manager:	Dr Lauren Peel
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Airlie Island Marine Turtle Monitoring Program 2021/22
Client	Santos Limited
Client representative:	Ben Pace
Report number:	J06050
Cover photo:	West coast of Airlie Island (facing south).

EXECUTIVE SUMMARY

Santos Ltd (Santos) are the current titleholders of Crown Lease 1901/100 on Airlie Island (AI) managed by the Department of Biodiversity, Conservation and Attractions (DBCA).

Since facilities on AI are non-operational, opportunistic marine turtle monitoring effort has been executed in alignment with other environmental monitoring scopes. This 2021/22 season represents the third consecutive season using this monitoring strategy. Although systematic monitoring has not historically been conducted, anecdotal evidence and sporadic monitoring of marine turtle nesting activity has been undertaken and reported on AI.

Two field surveys of seven days each were conducted during the 2021/22 nesting season at AI. The first in December 2021, to coincide with peak nesting period of flatback and green turtles in the region and the end of the hawksbill turtle nesting period, and the second in March 2022, to coincide with the peak hatching period of flatback and green turtles and the end of the hatching period of hawksbill turtles. The field surveys involved an overnight track census of adult turtle nesting activity, recording hatchling orientation indices for emerged nests (i.e. hatchling nest fans), and undertaking excavations of hatched nests to determine incubation success.

A total of 84 turtle tracks were recorded at AI during 2021/22 survey effort, with all nesting activity recorded during the first field survey. The overnight track census survey showed that flatback turtles were the most frequent nesters, followed by hawksbill turtles and a lower number of green turtles (*n* = 65, 15, and 4 total tracks, respectively).

One hawkbill nest was opportunistically excavated during Field Survey 1. This clutch was considered complete and had a high incubation success (hatch and hatchling emergence success = 90.7 and 88.7 % of 97 eggs, respectively). Despite the level of nesting activity recorded during the first field survey, the observation frequency of hatched nests during Field Survey 2 was low, with four nest fans recorded in total over both surveys (FS1 = 3 fans, FS2 = 1 fan). The cause of this low number of observations is unknown but was not likely due to the timing of the survey, which occurred during the known peak period of hatching for flatback and green turtles. No evidence of hatchling disorientation or misorientation was identified from recorded nest fans.

Overall, Santos was found to be compliant with the Airlie Lease 1901/100 conditions with regards to marine turtle monitoring in 2021/22.

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Glossary

AI: Airlie Island

BoM: Bureau of Meteorology

DBCA: Department of Biodiversity, Conservation and Attractions

FB: Flatback turtle

GPS: Global Positioning System

GR: Green turtle

n: sample size

PENV: Pendoley Environmental

StDev: Standard deviation

VI: Varanus Island

HK: Hawksbill turtle

TI: Thevenard Island

1 INTRODUCTION

Santos Ltd (Santos) are the current titleholders of Crown Lease 1901/100 on Airlie Island (AI) managed by Department of Biodiversity, Conservation and Attractions (DBCA).

Since facilities on AI are non-operational, opportunistic marine turtle monitoring effort has been executed in alignment with other environmental monitoring scopes. This 2021/22 season represents the third consecutive season using this monitoring strategy. Monitoring was conducted during the 2021/22 turtle nesting season in accordance with the *Varanus Island and Airlie Island Turtle Monitoring Method Statement* (EA-00-RI-10058.03) (Santos 2020) to meet regulatory requirements associated with Lease 1901/100 (**Table 1**). A literature review undertaken in 2015 identified existing marine turtle monitoring records from AI, which were comprised of sporadic surveys and ad hoc observations of turtle nesting activity on the island (PENV 2015). Results are summarised in **Appendix A**.

1.1 Scope of Work and Objectives

The purpose of this report is to present results of marine turtle monitoring on AI for the 2021/22 season in the context of regulatory requirements under DBCA Lease 1901/100 conditions for AI. Regulatory conditions, and details on how this report meets these conditions, are provided in **Table 1**.

Table 1: Regulatory conditions relating to monitoring of marine turtles at Airlie Island (Airlie Lease 1901/100).

Condition number	Requirement	Evidence of requirement being met	
		2021/2022 Work Scope	Section
Airlie Lease 1901/100			
1(26)	Conduct monitoring to ascertain the effectiveness of measures taken for rehabilitation, protection and environmental management.	Nest counts and distribution Hatchling orientation	3.2, 3.3, 3.4
1(27)(f)	Monitoring shall include counts and distribution of turtle nests and nesting turtles, and any disturbance thereof as a result of operations.	Nest counts and distribution	3.2
1(27)(g)	Examine the effects of any unusual weather conditions upon the fauna on the island	Climate data	3.1
1(27)(h)	Provide counts and details of any fauna mortality resulting from the operations.	None reported	N/A
1(28)(d)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive. (d) investigations research and biological monitoring studies carried out by the Lessee as hereinbefore provided and any conclusions or findings thereon;	This report	N/A
1(28)(f)	THAT the Lessee shall on the twenty second day of June in each year during the Term submit a brief written report to the Lessor and the Minister for Mines containing particulars of items and (a), (b), (c) and (e) below and every third year (commencing 1990) the Lessee shall submit a comprehensive report containing particulars of items (a) to (f) below inclusive. (f) any further new or additional procedures which the Lessee may wish to suggest as being relevant or necessary to improve the management of the environment of the Reserve and to mitigate damage caused to that environment including, without limiting the generality of the foregoing, proposals to amend existing procedures if the monitoring carried out under paragraph (26) hereof shows that the Lessee's operations are having a detrimental effect on the Reserve's flora or fauna.	None identified	N/A
1(29)	ANY observations of environmental concern resulting from the monitoring programme or otherwise shall be reported immediately to the Lessor.	None reported	N/A

2 METHODOLOGY

2.1 Monitoring Survey Effort

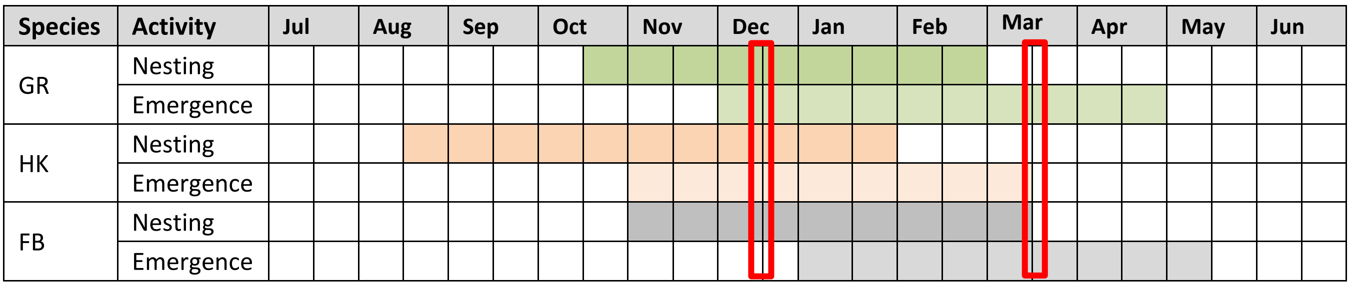
Marine turtle monitoring was conducted at AI (**Figure 1**) in line with the *Varanus Island and Airlie Island Turtle Monitoring Method Statement* (EA-00-RI-10058.03) (Santos 2020) as outlined in **Table 2**. All monitoring was conducted under DBCA Licence TFA 2020-0126-3, issued to, and managed by, Pendoley Environmental (PENV). Field surveys were conducted over a seven-day monitoring period to ensure sufficient track census data and spatial distribution of nesting activity were recorded as per AI Lease conditions.

Field Survey 1 (FS1) was conducted between the 10th and 16th December 2021, overlapping with peak nesting of flatback, green, and hawksbill turtles (**Table 3**). Field Survey 2 (FS2) was conducted between the 14th and 20th March 2022, overlapping with peak hatching of flatback and green turtles and the end of the hawksbill hatching period (**Table 3**). Field monitoring during FS2 did not commence until 15th March 2022 due to logistical delays and constraints.

Table 2: Work scopes to monitor marine turtle parameters on Airlie Island.

Turtle life stage	Work scope	Parameters
Adult nesting females	Track census of nesting females	Nesting abundance Spatial distribution of nesting
Hatchlings on the beach	Hatchling orientation	Hatchling emergence spread angle Hatchling emergence offset angle (from most direct line to the ocean)
	Opportunistic clutch excavation	Spatial distribution of nests Clutch size Hatching success Hatchling emergence success

Table 3: Approximate temporal scale of annual marine turtle activity and field survey timing. Red box indicates approximate timing of executed field survey. FB = flatback turtle; GR = green turtle; HK = hawksbill turtle.



J06050 Airlie Island Marine Turtle Monitoring 2021/22

Figure 1: Location of Airlie Island.

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Date: 12/05/2022
Drawing File Ref: PENV-J06050-1147-B
Coordinate System: GDA 1994 MGA Zone 50

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2.2 Work Scopes

2.2.1 Adult Nesters

Nesting beaches were patrolled for nesting marine turtles once daily between ~06:00 and ~16:00 hours. Track census was performed in accordance with the *Varanus Island and Airlie Island Turtle Monitoring Method Statement* (EA-00-RI-10058.03) (Santos 2020) and PENV's *Track Census and Snapshot Survey Standard Operating Procedure* (PENV 2021a). A snapshot (line-in) survey was conducted on Day 1 of each field survey to identify turtle tracks prior to the commencement of the census survey. Marine turtle species and resulting nesting activity category (false crawl, attempt, or nest) were determined using track and nest characteristics, including track width, shape and orientation of flipper marks, tail drag marks, movement of sand, morphology and depth of nest pit and associated mound (Eckert et al. 1999). Each track, including coordinates in decimal degrees, were recorded directly into a field tablet. All identified tracks were marked to avoid being recounted on subsequent days. The track census was repeated each day during the field survey.

2.2.1.1 Data Analysis

Nest density within a 20 m radius was calculated for all species combined using the heatmap tool in QGIS 3.6. The heatmap was generated using a Kernel Density Estimation and a quartic interpolation function with a 20 m search radius. This function and search radius were selected based on the moderately dispersed distribution of successful nests across the nesting habitat at AI. Mean ± StDev overnight track counts were calculated using nesting activity counts excluding the snapshot survey for all species separately. No further statistical analyses were undertaken due to small sample sizes.

2.2.2 Incubation Success

Clutch excavation was conducted in accordance with the *Varanus Island and Airlie Island Turtle Monitoring Method Statement* (EA-00-RI-10058.03) (Santos 2020) and PENV's *Incubation Success Standard Operating Procedure* (PENV 2021b).

Turtle hatchling emergences were confirmed via direct sighting of either individual hatchlings emerging from the sand or the presence of a depression in the sand (i.e. nest cone) and associated hatchling track fan. All excavations were conducted by hand with extreme caution to avoid disturbance to either live hatchlings within the clutch or to developing embryos that may not yet have hatched. Any unhatched eggs found during excavation were carefully checked to confirm mortality prior to opening. Where possible, the contents of the egg chamber were counted and sorted into hatched eggs (empty eggshells which are more than 50 % intact), live hatchlings, dead hatchlings, yolkless eggs, eggs with no discernible embryo, eggs with partially developed embryo, eggs with fully developed embryo and small egglets (usually about 2 cm in diameter). Data was recorded directly into a field tablet.

2.2.2.1 Clutch Fate

Classification of each clutch was undertaken via assessment of clutch contents at excavation. Classification was made as follows:

- Complete = If a clutch was successfully excavated.

- Disturbed (predator) = If evidence of disturbance was present at the surface of the nest (e.g. predator tracks, broken eggshells) and the total egg count was lower than expected for the species.
- Disturbed (mixed) = If a clutch count was more than 15 eggs larger than expected based on the average clutch size for the species.
- Lost = If a clutch could not be located; either due to sand movement or complete excavation by other nesting turtles.
- Inundation = Assessed based on the location of the clutch relative to the most recent spring high-tide line and the proportion of partially and fully developed embryos relative to hatched eggs.

2.2.2.2 Data Analysis

Hatch success was calculated by dividing the number of hatched eggs by the overall clutch size. Hatchling emergence success (the percentage of hatchlings successfully leaving the nest) was calculated by subtracting the hatched egg count with the number of live and dead hatchlings encountered within the egg chamber and then dividing by the overall clutch size.

2.2.3 Hatchling Orientation

Hatchling orientation was conducted in accordance with the *Varanus Island and Airlie Island Turtle Monitoring Method Statement* (EA-00-RI-10058.03) (Santos 2020) and PENV's *Hatchling Orientation Monitoring Standard Operating Procedure* (PENV 2020).

A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch (defined by a depression in the sand from which the hatchling tracks were seen to emerge). The coordinates of the nest were recorded in decimal degrees with a handheld GPS. A sighting compass was used to measure the bearing along the outside arms of emergent hatchling tracks (vectors A and B) and the shortest distance to the ocean (vector X; **Figure 2**). Bearings were taken at either the point where the track crossed the high tide line, or five metres from the clutch emergence point (whichever distance was shortest).

2.2.3.1 Data Analysis

An angle of spread was calculated as the angle between vectors A and B. The offset angle was determined by calculating the angle between the most direct line to the ocean (X) and the bearing bisecting the spread angle (vector C; **Figure 2**). Hatchlings were categorised as displaying no, moderate, or severe disorientation or misorientation depending on the size of the spread and offset angle.

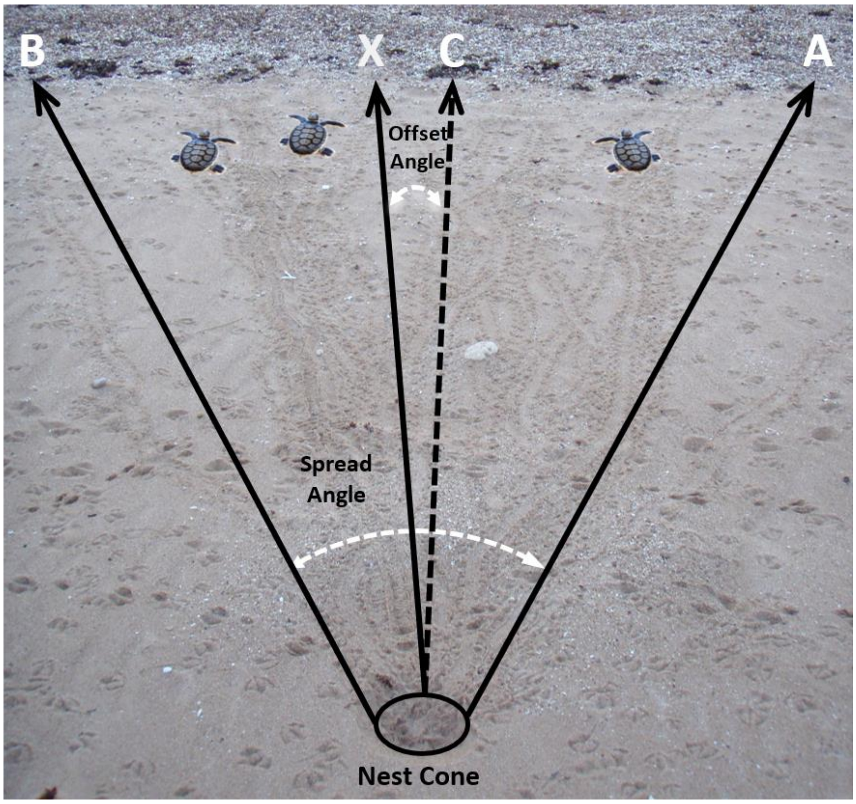


Figure 2: Hatchling orientation indices and emergence spread and offset angles. Spread angle: measure of dispersion; Offset angle: measure of deviation from the most direct route toward the ocean.

2.2.4 Climate Data

Rainfall and air temperature data for Thevenard Island (TI weather station; BoM Ref: 005084) was accessed from the Bureau of Meteorology (BoM) website on the 17th and 29th March 2022 and used as a proxy for climatic conditions on AI. TI is situated approximately 20 km south southwest of AI.

2.3 Monitoring Survey Limitations

Since the inter-nesting period for flatback, green, and hawksbill turtles is estimated at 14 days (Whittock et al. 2014; Walcott et al. 2012; Carr et al. 1974) the survey duration (7 days) prevents all females nesting within a given year from being detected during the survey period. Although the data allows comparison of the number of nests between different species during the survey period, indices of abundance or population size cannot be determined.

3 RESULTS

3.1 Climate Data

The mean daily maximum air temperature at TI during the field season (10th December 2021 – 20th March 2022) was 34.5 ± 2.4 °C. Rainfall in this period only occurred over three days and totalled 2.4mm (**Figure 3**). The daily minimum and maximum temperature, and rainfall for the field survey period, and the month preceding the field survey, is shown in **Figure 3**. No cyclone events were recorded during the 2021/22 season.

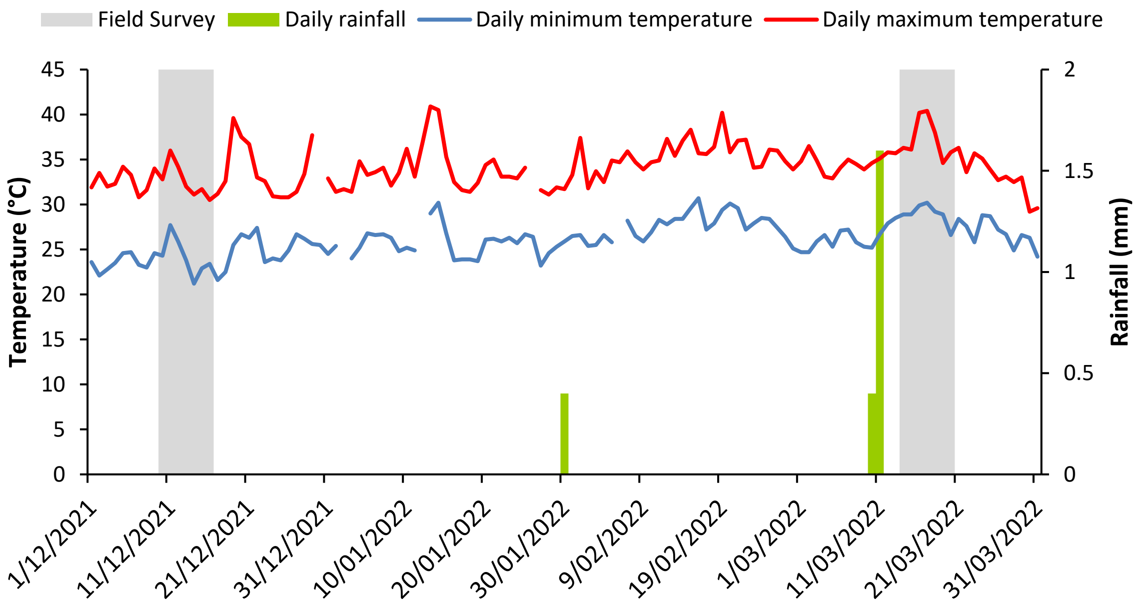


Figure 3: Minimum and maximum air temperature (°C) and rainfall (mm) at Thevenard Island for the 2021/22 marine turtle field surveys (shaded grey) (Source: BoM 2022).

3.2 Adult Nesters

A total of 84 turtle tracks were recorded on AI during FS1. No turtle tracks were recorded during FS2. The number of tracks for different nesting activity categories counted during FS1, including the snapshot day, is summarized in **Figure 4**. The total number of tracks counted for the different marine turtle species on each subsequent census day is shown in **Figure 5**.

When excluding the snapshot data, the mean number of overnight track counts during FS1 was 7.2 ± 2.0 for flatback turtles, 1.0 ± 1.3 for hawksbill turtles and 0.5 ± 0.8 for green turtles, over six census nights and excluding the snapshot day (total tracks per species on census days = 43, 6 and 3, respectively). When all species were combined, the mean number of overnight track counts was 8.7 ± 2.4. Results of the track census survey are provided in **Appendix B**.

During the track census effort, a total of 15 nests were identified during the 2021/22 season, with nest density being greatest on the north-eastern beach of AI (**Figure 6**).

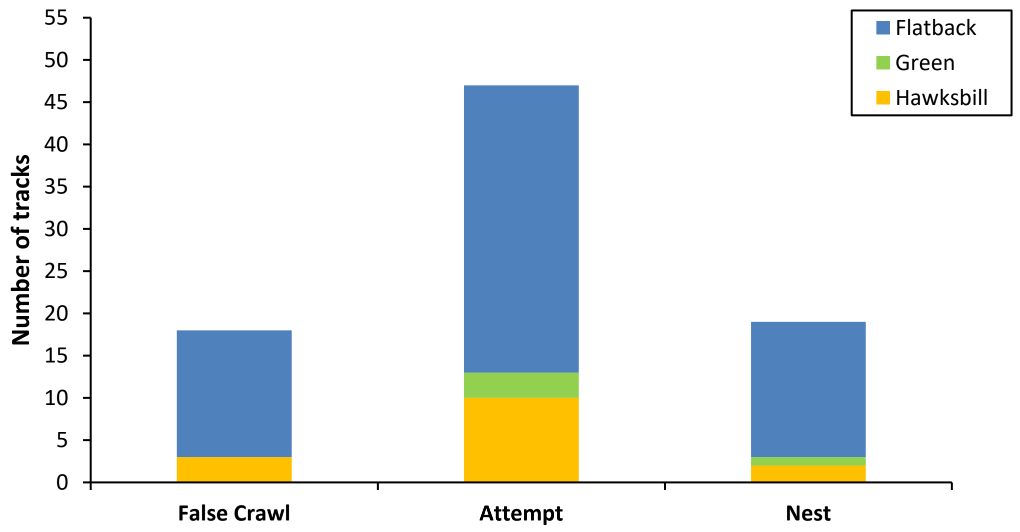


Figure 4: Track counts for different nesting activity for flatback, green, and hawksbill turtles on Airlie Island in 2021/22 (including snapshot survey).

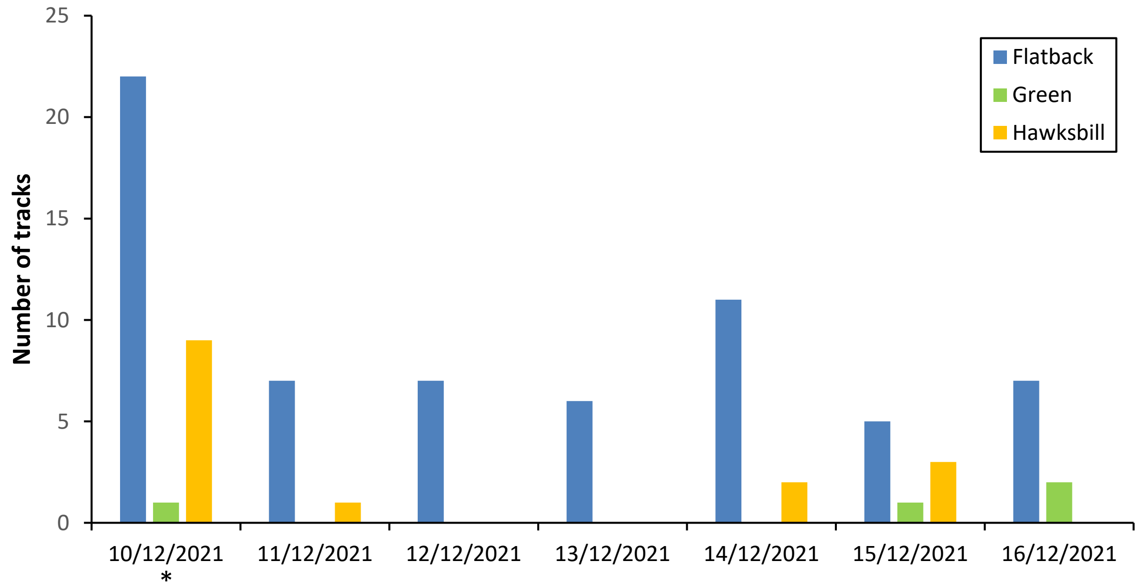
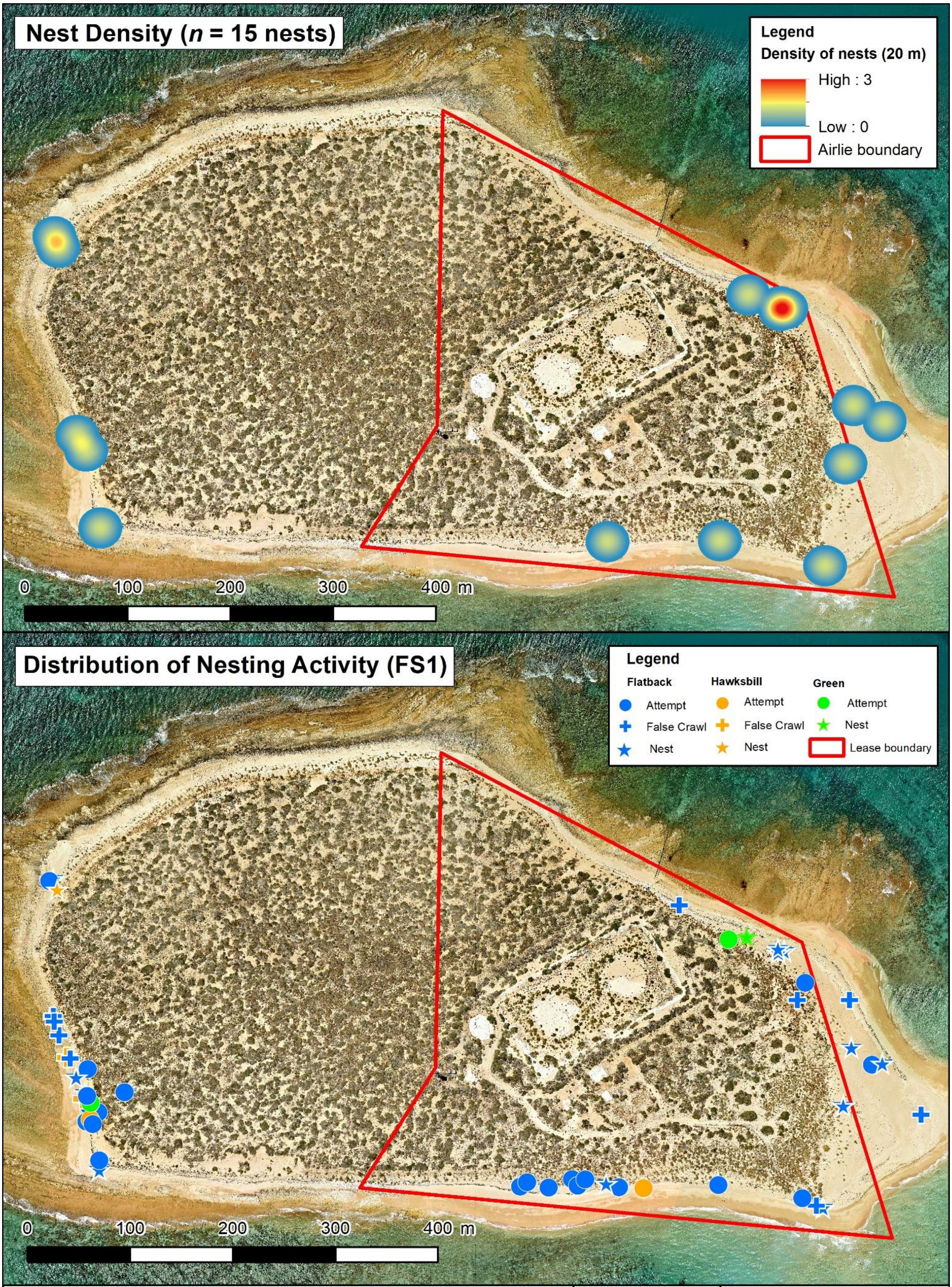


Figure 5: Total track counts of flatback, green, and hawksbill turtles for each survey day during FS1 on Airlie Island in 2021/22. *Indicates snapshot survey.

3.3 Incubation Success

One hawksbill nest was recorded and excavated during FS1. The incubation success was considered high (hatching success = 90.7 %; emergence success = 88.7 %). The fate of this clutch was considered complete. One green turtle nest was identified for excavation in FS2, however, attempts to locate and excavate the clutch were unsuccessful.



J06050 Airlie Island MarineTurtle Monitoring 2021/22

Figure 6: Nest density and distribution of nesting activity at Airlie Island in 2021/22, excluding snapshot survey.

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Date: 16/05/2022
Drawing File Ref: PENV-J06050-1148-B
Coordinate System: GDA 1994 MGA Zone 50

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3.4 Hatchling Orientation

Three hatchling nest fans (two hawksbill, one of unknown species) were recorded during FS1, and one green turtle hatchling nest fan was recorded during FS2 (**Figure 7**). The nest fan indices are shown in **Table 4**. There was no evidence of disorientation or misorientation within any of the measured fans.

Table 4: Nest fan indices for marine turtle nests recorded at AI during two field surveys (FS) in the 2021/22 season.

Field Survey	Species	Spread angle (°)	Offset Angle (°)
FS1	Hawksbill	38	2
FS1	Unknown	49	10
FS1	Hawksbill	55	12
FS2	Green	30	3

J06050 Airlie Island Marine Turtle Monitoring 2021/22

Figure 7: Hatchling fans recorded during Airlie Island Marine Turtle Monitoring in 2021/22.

Drawn: J.Kelly
Date: 16/05/2022
Drawing File Ref:
PENV-J06050-1154-B
Coordinate System: GDA 1994 MGA Zone 54

PENDOLEY ENVIRONMENTAL

4 DISCUSSION

Santos was compliant with the Airlie Lease 1901/100 conditions with regards to marine turtle monitoring in 2021/22, as outlined in **Table 1**. The 2021/22 marine turtle survey effort at AI did not detect any impact to marine turtles from Santos activities.

When including the snapshot data, three species of marine turtle were found to nest on AI: flatback, green, and hawksbill turtles. The overnight track census survey showed that flatback turtles at the time of survey were the most frequent nesters, followed by a lower number of hawksbill and green turtles (*n* = 65, 15, and 4 total tracks, respectively).

Marine turtle nesting activity was primarily situated on the south-west, south-east and north-east sides of AI. Very low activity was observed on the north-west side of the island (**Figure 6**). The selection of nesting habitat by marine turtles is known to be influenced by numerous factors including olfactory cues (i.e. smell; Carr 1972; Hays et al. 2003), low-frequency sound such as surf noise, magnetic fields (Lohmann & Lohmann 1993, 1996), offshore currents and the presence of offshore reefs and rocks (Hughes 1974; Mortimer 1995; Marcovaldi & Laurent 1996). At AI, the presence of an offshore shallow reef and rocks in the nearshore area on the north-west side of the island likely restricted access to nesting habitat, resulting in the very low nesting activity.

Although direct comparison with historic data is difficult, owing to the sporadic nature of surveys and methodological differences, the number of flatback turtle tracks encountered during the December 2021 initial snapshot survey was lower than track census surveys conducted in December 2009 and 2010 and higher than 2019 and 2020 (**Appendix A**). Although low sample size, green turtle tracks recorded during the current survey exceeded the numbers recorded in the December surveys in 2009, 2010, but were lower compared to 2019 and 2020 December surveys (**Appendix A**). The number of hawksbill tracks encountered during the December 2021 initial snapshot survey exceeded the number recorded in the December surveys in 2009, 2010 and 2020, though was lower than December surveys in 2019. Survey effort to-date has identified marine turtle species nesting activity and indication of favourable nesting locations on Airlie Island, although further monitoring will be required to better understand nesting activity trends of marine turtle species at AI.

Despite the extent of nesting activity recorded during FS1, only one clutch was able to be detected and successfully excavated during FS2. The cause for the low detection frequency of hatched nests is unknown but was not likely due to the timing of the survey, which occurred during the known peak period of hatching for flatback and green turtles (see **Table 3**). Instead, it is possible that weather conditions - including a small amount of rainfall (**Figure 3**) and high wind speeds – hindered detection of hatchling tracks and/or nests cones. Where nest fans could be recorded, however, no evidence of hatchling disorientation or misorientation was identified.

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Appendix A: Summary of historic marine turtle monitoring and sightings at Airlie Island

Table A1: Details of all available marine turtle observations at Airlie Island. G = green turtle, H = hawksbill turtle, F = flatback turtle, L = loggerhead turtle, NS = marine turtle observation not resolved to species. Source: PENV (2015) and references therein.

Year	Month	Species Observed					Description of Observation(s)	Comments
		G	H	F	L	NS		
1987/88	Jul/Aug 87	✓	✓				Tracks on western end of island	
	Aug 87 - Feb 88	✓	✓				60 tracks observed (green and hawksbill combined) Green turtle mating in shallows off east end, Nov 87.	At peak season 4-6 turtles would come ashore to nest on most evenings
	Sep 87		✓				Eggs found on south beach	
	Jan 88					✓	Hatchlings observed by construction workers	
1988/89	June 88	✓					Carapace of immature turtle found beneath Sea Eagle perch	W 160 mm x L 200 mm
	Oct 88 - Feb 89	✓	✓				126 tracks (69 hawksbill & 57 green). Hawksbill tracks confined to west end of island; Green tracks predominantly on east and south beaches, plus 4 females recorded on NW corner.	Tracks recorded during 5 visits to Airlie over a 4-month period during the summer
	May 89	✓					Green track on south beach	
	Jul 89	✓					Green tracks recorded on SE beach in the lease area	
	Sep 89	✓					Carapace of immature turtle found on SW corner	W 190 mm x L 220 mm, identified as immature green [*not clear by whom*]
1990	Jul 90	✓					Dead adult green found on NE sand plain	
	90 - 91	✓	✓				The few records available for the 1990/91 season indicate that numbers of both species were very low. There did not appear to be any nests dug on the eastern beach, and only a few tracks were recorded on the western end of the island.	
1991	Dec					✓	No nesting observed, but 13 tracks recorded on west end of island, and 5 tracks on south beach	More visits were made by turtles in the 1991-92 season than during the previous season, but difficult to estimate visitation frequency without regular monitoring
1999	Sep	✓			✓		1 loggerhead observed digging on western end of island Greens mating in shallow waters on island east side	
	Not clear but pre-Dec						Anecdotal evidence that flatbacks and the occasional loggerhead may also use Airlie however these observations are yet to be confirmed	
	Dec	✓	✓	✓			6 hawksbills, 2 flatbacks, and 1 green turtle tagged	1 week tagging trip, first confirmation of flatback use of island All new turtles, no previous tag records

Year	Month	Species Observed					Description of Observation(s)	Comments
		G	H	F	L	NS		
								1 flatback returned twice after being tagged, so 4 flatback observations No records of any of these turtles in WA tag database since (checked Oct 2015) Turtles observed to nest in daylight hours just as much as night
2004	Mar - Apr			✓		✓	Single swimming hatchlings observed swimming from the direction of Airlie Island on each of two nights from a vessel traversing between Airlie Island and the drilling rig Ensco 56 located WSW of Airlie Island. 1 large adult green(?) turtle observed on two separate nights in the waters between Airlie and Ensco 56. Ample evidence of past turtle nesting activity (including depressions left by adults and tracks) observed during an investigation of Airlie's beaches Fresh hatchling tracks observed from 1 nest 150 m west of the old jetty (south beach).	Both hatchlings likely to be flatbacks, but only one was positively identified. Both were likely to have originated from the emerged nest observed on the island.
2006	Dec	✓				✓	32 tracks observed over 5 nights, during island wide surveys	Photographic evidence of green turtles, but not clear if all tracks relate to only greens.
2009/10	Oct 09	✓	✓	✓			Snapshot tracks: 4 x F, 3 x H, 1 x G; Census over 4 nights: 1 x F track	
	Dec 09			✓			Snapshot tracks: 58 x F; Census over 1 night: 2 x F track	
	Jan 10	✓	✓	✓			Snapshot tracks: 39 x F, 9 x H, 9 x G; Census over 4 nights: 8 x F track	
	Feb - Mar 10	✓		✓			Snapshot tracks: 26 x F, 1 x G; Census over 3 nights: 1 x F track	
2010	Oct		✓				Snapshot tracks: 8 x H; Census over 5 nights: 4 x H track	
	Dec			✓			Snapshot tracks: 116 x F; Census over 1 nights: 2 x F track	
2019/20	Dec	✓	✓	✓			Snapshot tracks: 17 x F, 12 x G, 50 x H Census over 6 nights: 42 x F, 5 x G, 6 x H	
2020/21	Dec	✓	✓	✓			Snapshot tracks: 9 x F, 3 x G, 2 x H. Census over 6 nights: 40 x F, 14 x G, 0 x H	
	Mar	✓					Snapshot tracks: 1 x G. Census over 6 nights: No tracks recorded.	
2021/22	Dec	✓	✓	✓			Snapshot tracks: 22 x F, 1 x G, 9 x H Census over 6 nights: 43 x F, 3 x G, 6 x H	
	Mar						Snapshot tracks: No tracks recorded. Census over 5 nights: No tracks recorded.	

Appendix B: Airlie Island track census results 2021/22

Table B1: Marine turtle nesting activity records for Airlie Island during Field Survey 1 in 2021/22.

FIELD SURVEY 1					
Nesting Activity	Date	Flatback	Green	Hawksbill	Total
Attempt	10/12/2021*	13	1	8	22
	11/12/2021	2	0	0	2
	12/12/2021	5	0	0	5
	13/12/2021	1	0	0	1
	14/12/2021	5	0	1	6
	15/12/2021	2	1	1	4
	16/12/2021	6	1	0	7
	Total	34	3	10	47
False Crawl	10/12/2021*	5	0	1	6
	11/12/2021	3	0	1	4
	12/12/2021	1	0	0	1
	13/12/2021	3	0	0	3
	14/12/2021	2	0	0	2
	15/12/2021	0	0	1	1
	16/12/2021	1	0	0	1
	Total	15	0	3	18
Nest	10/12/2021*	4	0	0	4
	11/12/2021	2	0	0	2
	12/12/2021	1	0	0	1
	13/12/2021	2	0	0	2
	14/12/2021	4	0	1	5
	15/12/2021	3	0	1	4
	16/12/2021	0	1	0	1
	Total	16	1	2	19
Overall Total		65	4	15	84

* snapshot survey

Table B2: Marine turtle nesting activity records for Airlie Island during Field Survey 1 in 2021/22.

FIELD SURVEY 2					
Nesting Activity	Date	Flatback	Green	Hawksbill	Total
Attempt	15/03/2022*	0	0	0	0
	16/03/2022	0	0	0	0
	17/03/2022	0	0	0	0
	18/03/2022	0	0	0	0
	19/03/2022	0	0	0	0
	20/03/2022	0	0	0	0
	Total	0	0	0	0
False Crawl	15/03/2022*	0	0	0	0
	16/03/2022	0	0	0	0
	17/03/2022	0	0	0	0
	18/03/2022	0	0	0	0
	19/03/2022	0	0	0	0
	20/03/2022	0	0	0	0
	Total	0	0	0	0
Nest	15/03/2022*	0	0	0	0
	16/03/2022	0	0	0	0
	17/03/2022	0	0	0	0
	18/03/2022	0	0	0	0
	19/03/2022	0	0	0	0
	20/03/2022	0	0	0	0
	Total	0	0	0	0
Overall Total		0	0	0	0

* snapshot survey

Attachment 4 – Santos TL/2 Petroleum Licence

STATE OF WESTERN AUSTRALIA

Petroleum (Submerged Lands) Act 1982

RENEWAL OF PRODUCTION LICENCE TL/2 (R1)

I, WILLIAM LEE TINAPPLE, Executive Director Petroleum Division in the Department of Mines and Petroleum, the Delegate of the Minister for Mines and Petroleum for the State of Western Australia, pursuant to the provisions of *the Petroleum (Submerged Lands) Act 1982*, grant a renewal of Petroleum Production Licence TL/2 (R1) in respect of the blocks described hereunder to:

Apache Oil Australia Pty Ltd
100 St George's Tce, PERTH WA 6000

Pan Pacific Petroleum (South Aust) Pty Ltd
Level 3, 88 Walker Street NORTH SYDNEY NSW 2060

Santos (BOL) Pty Ltd
Ground Floor 60 Flinders Street ADELAIDE SA 5000

Tap (Shelfal) Pty Ltd
Level 1, 47 Colin St, WEST PERTH WA 6005

The term of the Petroleum Production Licence is to have effect for a period of twenty-one (21) years from the date of grant.

The grant will be subject to the conditions set out hereunder and to the licensee at all times complying with the provisions of the Act and of any regulations for the time being in force under the Act and all directions given to the licensee under the Act.

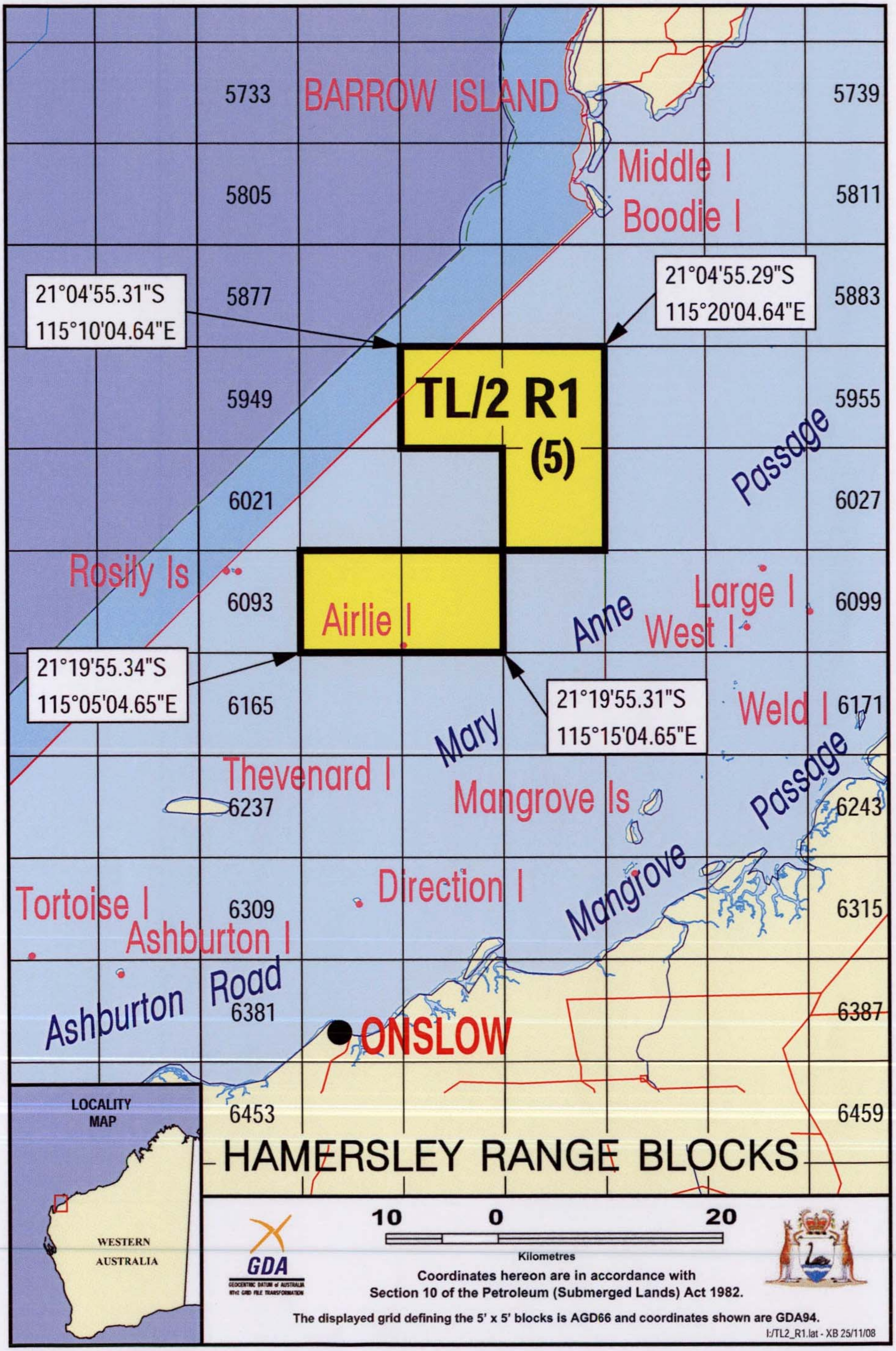
DESCRIPTION OF BLOCKS

The reference hereunder is to the name of the map sheet of the 1:1,000,000 series prepared and published for the purposes of the *Petroleum (Submerged Lands) Act 1982* and to the numbers of graticular sections shown thereon.

HAMERSLEY RANGE MAP SHEET

Block No.	Block No.	Block No.	Block No.
5951	5952	6024	6094
6095			

The licence area is assessed to contain five (5) blocks, to the extent only that the area is within submerged lands adjacent to the coast of Western Australia.



BARROW ISLAND
Middle I
Boodie I
5733
5739
5805
5811
5877
5883
21°04'55.31"S
115°10'04.64"E
21°04'55.29"S
115°20'04.64"E
TL/2 R1
(5)
5949
5955
6021
6027
Passage
Rosily Is
6093
6099
Airlie I
Anne
Large I
West I
21°19'55.34"S
115°05'04.65"E
21°19'55.31"S
115°15'04.65"E
6165
6171
Mary
Weld I
Thevenard I
Mangrove Is
6237
6243
Passage
Direction I
Mangrove
Tortoise I
6309
6315
Ashburton I
Ashburton
Road
6381
6387
ONSLOW
LOCALITY MAP
WESTERN AUSTRALIA
6453
6459
HAMERSLEY RANGE BLOCKS
10
0
20
Kilometres
GDA
Coordinates hereon are in accordance with
Section 10 of the Petroleum (Submerged Lands) Act 1982.
The displayed grid defining the 5' x 5' blocks is AGD66 and coordinates shown are GDA94.
I:/TL2_R1.lat - XB 25/11/08

CONDITIONS

The licensee shall, to the satisfaction of the Minister, continue to appraise and explore the licence area to determine whether additional recoverable petroleum exists in the area and shall exploit such petroleum where commercially viable.

The licensee shall develop petroleum resources in the licence area in accordance with the Field Development Plan as accepted by the Minister.

The licensee shall comply with the Environmental Management Plan (and associated Oil Spill Contingency Plan) applicable to proposed petroleum activities within the licence area, as approved by the Minister.

If no petroleum recovery operations under the licence have been carried out at any time during a continuous period of at least five years the Minister may, by written notice given to the licensee, notify the licensee that within 30 days he intends to cancel the licence.

INTERPRETATION

In this licence the "Act" means the *Petroleum (Submerged Lands) Act 1982* and includes any Act with which that Act is incorporated and words used in this licence have the same respective meanings as in the Act,

and

"Minister" means the Minister for Mines and Petroleum or the Executive Director Petroleum Division as his duly appointed delegate.

Dated this 15th day of April 2010.

Made under the *Petroleum (Submerged Lands) Act 1982* of the State of Western Australia

EXECTUTIVE DIRECTOR
PETROLEUM DIVISION
AS DELEGATE OF THE MINISTER FOR MINES AND PETROLEUM
Pursuant to the Instrument of Delegation dated 27 February 2009