Department of Defence
F-35A Aircraft Noise Effects on Fauna – Impact Assessment Results Report

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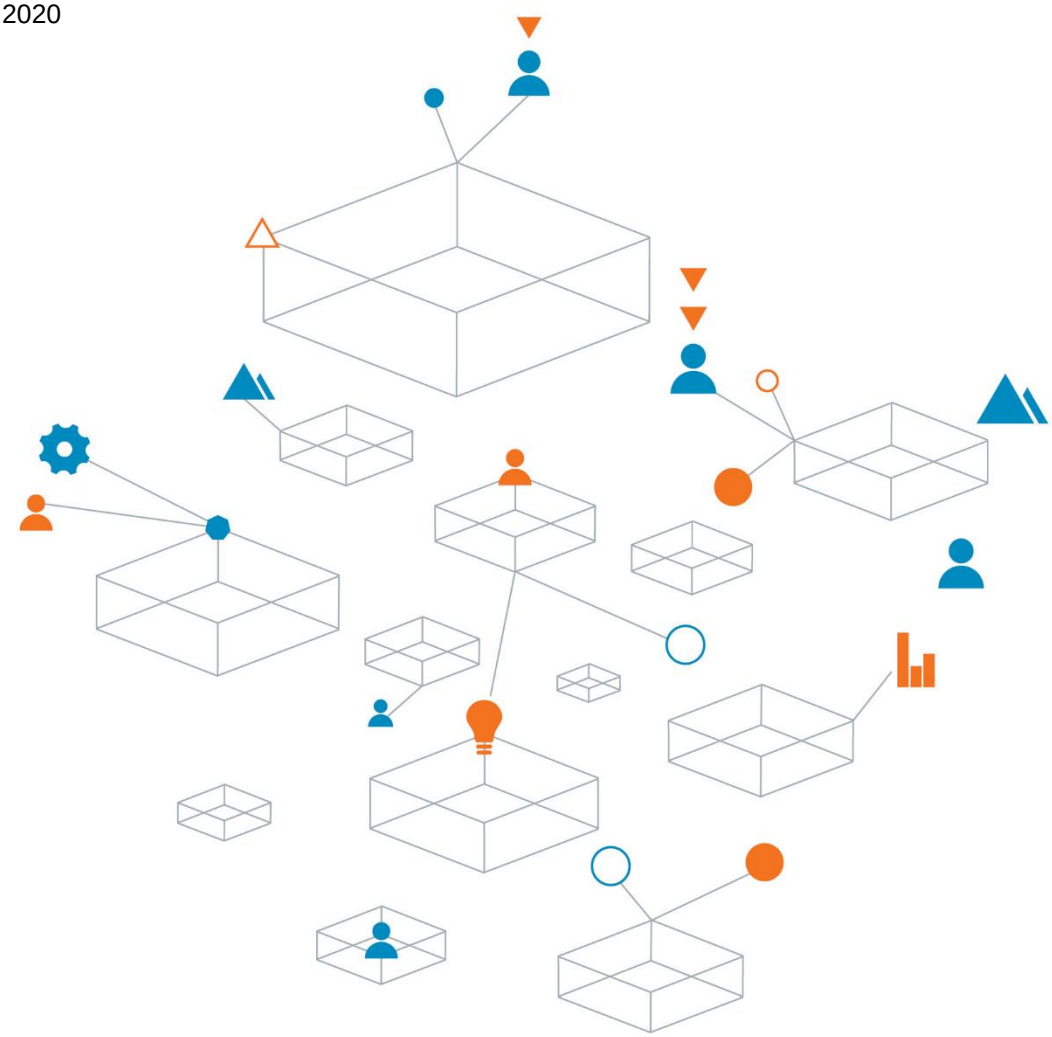

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F-35A Aircraft Noise Effects on Fauna – Impact Assessment Results Report

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Department of Defence

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Executive summary

In 1999, the Australian Department of Defence (Defence) established the New Air Combat Capability (NACC) Project to investigate aircraft options to replace the current fleet of F/A-18A/B Hornet aircraft. Following a full review of available combat aircraft, Australia joined the multi-national Joint Strike Fighter (JSF) Program in October 2002.

On 23 December 2010, the Minister for Environment determined that Phase 2A/B of NACC Project required formal assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). An environmental impact statement (EIS) for the flying operations of the F-35A Lightning II (F-35A) aircraft was prepared and aimed to compare the environmental and social impacts between the existing flying operations of the F/A-18A/B Hornet aircraft and the proposed flying operations of the F-35A aircraft, including potential impacts on the following matters of national environmental significance:

- Wetlands of international importance (i.e., Ramsar sites).
- Listed threatened species and ecological communities.
- Listed migratory species.

The Project was also deemed to be a controlled action under Section 28 of the EPBC Act in relation to Commonwealth actions that will have, or are likely to have, a significant impact on the environment.

On 10 July 2015, the Commonwealth Department of the Environment (now Department of the Environment and Energy) approved the project with four core conditions. Condition 4 of the approval decision on the EIS required the preparation and implementation of a fauna management plan (FMP) at Royal Australian Air Force (RAAF) Base Williamtown. The FMP was prepared in 2015/16 and subsequently approved by the Department of the Environment in March 2016.

To implement the FMP, Defence conducted baseline noise measurements for the F/A-18A/B Hornet aircraft at eight locations and fauna observations at five locations from November 2018 to January 2019 prior to the commencement of F-35A aircraft flying operations. Selection of monitoring locations was based on sites providing critical habitat to environmentally sensitive species in proximity to areas where increases in the 70 dB L_{Amax} extent around RAAF Base Williamtown were predicted.

A total of 2,183 aircraft noise events were recorded, of which 630 were F/A-18A/B Hornet aircraft noise events. A summary of aircraft noise events and levels for the F/A-18A/B Hornet are provided in Table ES1.

Table ES1 Summary of baseline F/A-18A/B Hornet aircraft noise levels at RAAF Base Williamtown

Location	Number of correlated events	Sound exposure level (dB)		L_{Amax} (dB)	
		Average	90th percentile	Average	90th percentile
Fullerton Cove	243	79	92	69	81
Stockton Sandspit	129	86	99	76	91
Kooragang Island	74	80	87	70	77
Hexham Swamp	39	78	87	68	78
Tilligerry Nature Reserve	61	84	91	71	80
Swan Bay	30	79	86	68	74
Myall River (Pindimar)	40	81	89	71	84
Cabbage Tree Island	14	86	88	76	79

Following the arrival of the F-35A aircraft at RAAF Base Williamtown, noise monitoring was conducted at the same eight locations between June and September 2019. The purpose of this monitoring was to determine whether baseline noise levels were exceeded following the introduction of F-35A aircraft.

A total of 108 correlated F-35A aircraft noise events were recorded during the transition period noise survey. A summary of F-35A aircraft noise events are provided in Table ES2.

Table ES2 Summary of F-35A aircraft noise events – transition period noise survey

Location	Number of correlated events	Sound exposure level (dB)		L_{Amax} (dB)	
		Average	90th percentile	Average	90th percentile
Fullerton Cove	32	80	90	70	79
Stockton Sandspit	29	83	91	73	81
Kooragang Island	9	83*	92*	71*	81*
Hexham Swamp	9	87*	95*	76*	83*
Tilligerry Nature Reserve	8	82*	87*	70*	75*
Swan Bay	15	81	87	69	77
Myall River (Pindimar)	3	82*	83*	73*	78*
Cabbage Tree Island	3	75*	77*	64*	68*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.

The FMP defines an exceedance of baseline noise levels as a difference between the average and 90th percentile of the maximum noise levels and sound exposure levels of baseline and transition noise levels, where the difference represents an increase in noise levels above 70 dB L_{Amax}.

A comparison of the measured baseline and transition noise levels are presented in Table ES3 and Table ES4. A considerably lower number of correlated aircraft noise events were recorded during the transition survey period due to the limited number of F-35A aircraft movements.

Most correlated events during the transition survey were recorded at Fullerton Cove, Stockton Sandspit and Swan Bay. Data analysis from these locations indicates no meaningful increase in F-35A aircraft noise emissions relative to the F/A-18A/B Hornet. The increases (if any) were less than 3 dB. Changes in noise level of 3 dB or less are generally not considered significant when considering the broad range of typical level variation influencing sound propagation. Factors influencing sound propagation in relation to aircraft noise emissions include aircraft operating patterns and procedures (e.g., flight profile and tracks), as well as atmospheric conditions such as variations with increasing altitude in wind speed and direction, temperature, and humidity. These factors can influence aircraft noise levels by more than 3 dB, and therefore changes in aircraft noise emissions of 3 dB or less are not considered significant.

There were less than ten correlated events at each of the remaining five monitoring locations during the transition period survey. This restricts the conclusions that can be drawn from this data. With the exception of Hexham Swamp, noise levels at the majority of these five monitoring locations did not exceed baseline noise levels by more than 3 dB. Noise level increases of more than 3 dB at these monitoring locations were not considered exceedances due to the limited number of F-35A aircraft movements to compare to baseline noise levels.

Noise levels recorded at Hexham Swamp during the transition survey period were notably higher than baseline levels. However, this exceedance was attributed to non-standard aircraft operations during the period of monitoring rather than differences in aircraft types.

Table ES3 Change in sound exposure aircraft noise levels – baseline and transition period

Location	No. correlated events		Average (dB)			90th percentile (dB)		
	Baseline	Transition	Baseline	Transition	Change	Baseline	Transition	Change
Fullerton Cove	243	32	79	80	+1	92	90	-2
Stockton Sandspit	129	29	86	83	-3	99	91	-8
Kooragang Island	74	9	80	83*	+3*	87	92*	+5*
Hexham Swamp	39	9	78	87*	+9*	87	95*	+8*
Tilligerry Nature Reserve	61	8	84	82*	-2*	91	87*	-4*
Swan Bay	30	15	79	81	+2	86	87	+1
Myall River (Pindimar)	40	3	81	82*	+1*	89	83*	-6*
Cabbage Tree Island	14	3	86	75*	-11*	88	77*	-11*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.
Of the three locations with more than 10 correlated noise events, cells have been shaded as follows:
Green, where F-35A aircraft noise level statistics are lower than F/A-18A/B Hornet statistics.
Red, where F-35A aircraft noise level statistics are higher than F/A-18A/B Hornet statistics.

Table ES4 Change in maximum aircraft noise levels – baseline and transition period

Location	No. correlated events		Average (dB)			90th percentile (dB)		
	Baseline	Transition	Baseline	Transition	Change	Baseline	Transition	Change
Fullerton Cove	243	32	69	70	+1	81	79	-2
Stockton Sandspit	129	29	76	73	-3	91	81	-10
Kooragang Island	74	9	70	71*	+1*	77	81*	+4*
Hexham Swamp	39	9	68	76*	+8*	78	83*	+5*
Tilligerry Nature Reserve	61	8	71	70*	-1*	80	75*	-5*
Swan Bay	30	15	68	69	+1	74	77	+3
Myall River (Pindimar)	40	3	71	73*	+2*	84	78*	-6*
Cabbage Tree Island	14	3	76	64*	-12*	79	68*	-11*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.
Of the three locations with more than 10 correlated noise events, cells have been shaded as follows:

Green, where F-35A aircraft noise level statistics are lower than F/A-18A/B Hornet statistics
Red, where F-35A aircraft noise level statistics are higher than F/A-18A/B Hornet statistics

The overall number of F-35A aircraft noise events collected (108) is low compared with the baseline survey (630). While five of the eight monitors have less than 10 noise readings (which can be attributed to Air Combat Group (ACG) standard departure and recovery flight paths that normally avoid overflight of these areas), the F-35A aircraft noise data collected during the mandated period of monitoring under the EIS conditions of consent appears consistent with the noise data collected from F/A-18A/B Hornet (baseline survey).

Key conclusions from noise monitoring for the Fauna Management Plan include:

- There have been 108 correlated F-35A aircraft noise events.
- The majority of F-35A aircraft average and 90th percentile LAmax readings are consistent with or less than the F/A-18A/B Hornet baseline noise survey
- There have been five sites (Kooragang Island, Hexham, Tilligerry, Myall River (Pindimar), Cabbage Tree Island) with less than 10 correlated noise events. As ACG's standard operating procedures don't include frequent overflight of these locations, there is always going to be a low flight frequency over these areas.
- The remaining three sites (Fullerton Cove, Stockton Sandspit, Swan Bay) have had more than 10 events. Most results from these sites indicate noise emissions from F-35A aircraft are below or within 2 dB of the noise emissions from the F/A-18A/B Hornet baseline noise survey results.

Table ES5 details the F-35A aircraft noise events and F/A-18A/B Hornet baseline noise survey data for comparison.

Table ES5 Transition survey versus baseline survey noise emission data

	Correlated F-35A aircraft noise events (Operational survey only – 9 weeks data)				Correlated F/A-18A/B Hornet noise events (Baseline survey only)		
Location	**Count**	**Highest measured L_{Amax}**	**Average measured L_{Amax}**	**90th percentile L_{Amax}**	**Count**	**Average measured L_{Amax}**	**90th percentile L_{Amax}**
Fullerton Cove	32	103	70	79	243	69	81
Stockton Sandspit	29	99	73	81	129	76	91
Kooragang Island	**9**	82	71	81	74	70	77
Hexham	**9**	85	**76**	**83**	39	68	78
Tilligerry	8	76	70	75	61	71	80
Swan Bay	15	78	69	77	30	68	74
Myall River (Pindimar)	**3**	79	**73**	78	40	71	84
Cabbage Tree Island	**3**	69	64	68	14	76	79

Of the three locations with more than 10 correlated noise events, cells have been shaded as follows:
Green, where F-35A aircraft noise level statistics are lower than F/A-18A/B Hornet statistics
Red, where F-35A aircraft noise level statistics are higher than F/A-18A/B Hornet statistics

The number of correlated F-35A aircraft noise events is low in comparison to the correlated F/A-18A/B Hornet noise events (baseline survey only). However, due to the number of F-35A aircraft available for flying and the current number of flights being undertaken, it is very unlikely there will be a significant increase in the number of correlated noise events in the near future to match the number of F/A-18A/B Hornet baseline survey noise events.

While the FMP does require noise level monitoring, it is critical to note that it is the fauna response to aircraft operations and associated noise at specific locations that is the focus of the FMP. The separate Noise Flight Path Monitoring System, in operation over the next three years will provide updated data on noise levels correlated to the levels provided in the EIS by noise modelling. Defence reports on this condition annually to comply with Parts 1 and 3 of the 'Conditions of Approval' for the 'Flying Operations of the F-35A Lightning II'.

Based on the noise emission data collected to date, Stage 4.2 'Post FAA noise measurement and fauna observation' (i.e. further noise monitoring and bird observations at the environmentally sensitive locations) is not deemed necessary at this stage.

If material noise emission exceedances are identified between the F-35A aircraft and those predicted by the EIS during the first two years of F-35A flying operations, additional noise monitoring and bird observations at sensitive environmental locations may be warranted.

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Appendix

Appendix A – Transition Period Noise Survey

1. Introduction

1.1. Purpose

This report characterises the noise levels of F-35A Lightning II (F-35A) aircraft at selected environmentally sensitive locations near the Royal Australian Air Force (RAAF) Base Williamtown. The intent of this report is to compare baseline F/A-18A/B Hornet aircraft noise levels with F-35A aircraft noise levels to determine whether baseline noise levels were exceeded. This report was prepared in accordance with approval conditions of the environmental impact statement (EIS) issued under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the subsequent approved fauna management plan (FMP).

1.2. Background

RAAF Base Williamtown (the Base) is located approximately 15 km northeast of Newcastle, New South Wales, within the Port Stephens Local Government Area. Salt Ash Air Weapons Range (SAAWR) is located approximately 8 km east of the Base and is used to conduct air-to-ground strafing and weapons training for aircraft at the Base. Land use surrounding these areas include urban zones, agriculture and Crown land used for environmental management (Coffey, 2014). Land surrounding the Base and SAAWR is predominantly zoned for environmental conservation, including areas of native vegetation and wetlands (Figure 1.1).

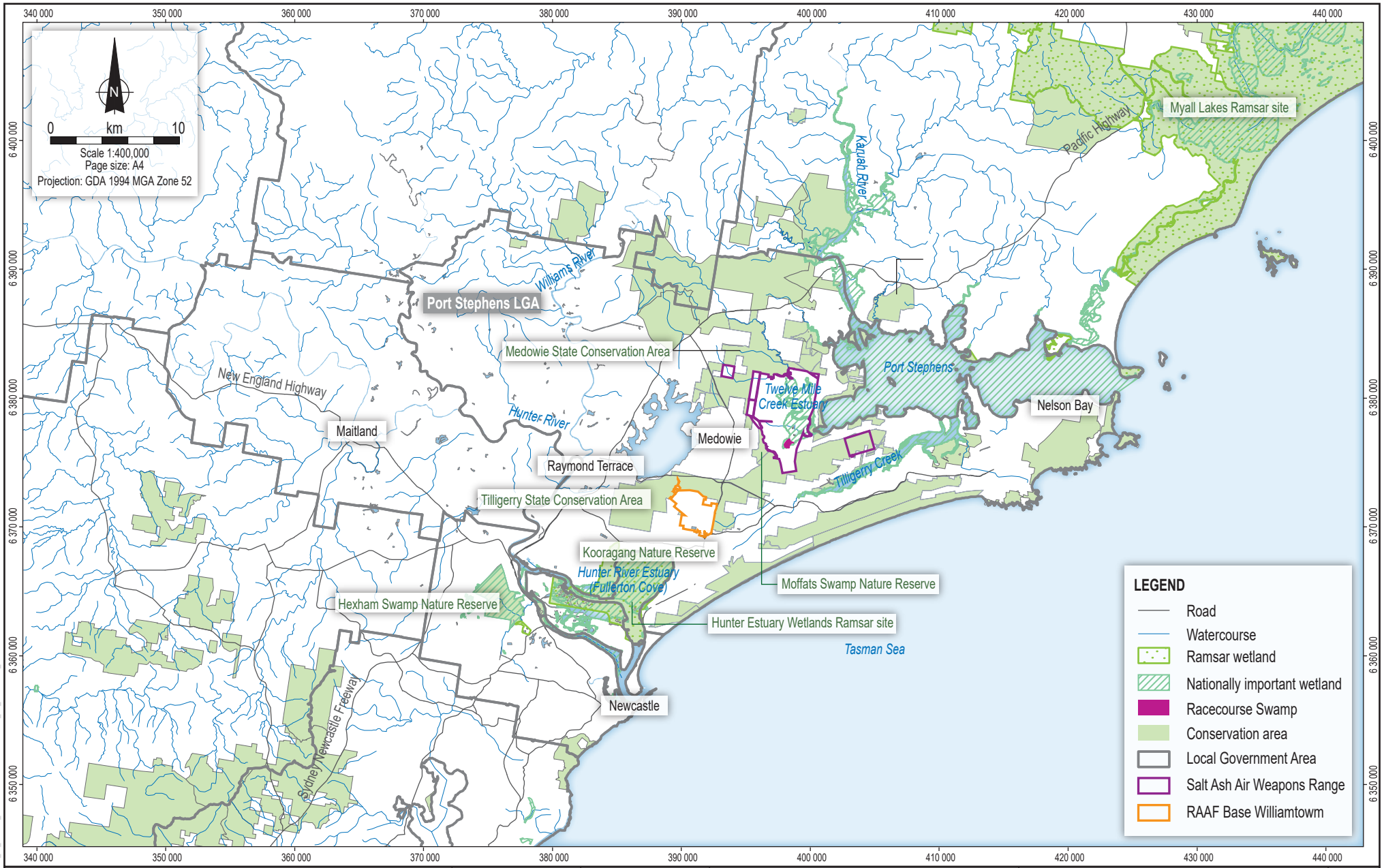
Within the Base, native vegetation has been largely cleared to support the current land use. Vegetation within the buffer zone at SAAWR is relatively undisturbed, with remnant vegetation that supports a diversity of species. RAAF Base Williamtown has been a permanent aircraft base since it was constructed in 1941 during World War II and accommodates numerous military aircraft squadrons currently operational in Australia, including:

- F/A-18A/B Hornet aircraft.
- Hawk 127 aircraft.
- E 7A Wedgetail Airborne Early Warning and Control.
- PC-9/As (light propeller aircraft).
- F-35A aircraft (commenced 2018).

The area surrounding the Base and SAAWR includes:

- Agricultural land located along both Cabbage Tree Road and Nelson Bay Road, which is used for livestock grazing and hobby farming.
- Residential areas at Raymond Terrace and Medowie, located to the northwest and north.
- Key environmental features including:
    - A contiguous block of native vegetation from Watagans to Port Stephens, which comprises Tilligerry State Conservation Area to the north and east, and Hunter Water Corporation land to the west of the Base and SAAWR.
    - Moffats Swamp Nature Reserve located approximately 5 km northeast of the Base.
    - Hunter Estuary Wetlands Ramsar site located approximately 10 km southwest of the Base. This site includes the Kooragang Nature Reserve, the Hunter Wetlands Centre Australia and Fullerton Cove.
    - Hexham Swamp Nature Reserve located approximately 15 km southwest of the Base.
    - Myall Lakes Ramsar site located approximately 30 km northeast of the Base.
    - Medowie State Conservation Area to the north and west of SAAWR.
    - Nationally important wetlands, including Twelve Mile Creek Estuary in the northeast section of SAAWR.
    - Racecourse Swamp to the east of SAAWR.

Figure 1.1 presents the locations of these environmental features.



Source:
Base boundaries,, roads, watercourses and Racecourse Swamp from Department of Defence, 2013.
Place names and coastline from GEODATA250K (Optimum scale 1:250,000).
Conservation areas and Marine Park Zones from OEH (Office of Environment & Heritage), Feb 2019.
Directory of Important Wetlands Australia (DIWA, 2006) from DEE, 2016.
Ramsar sites from Commonwealth of Australia, Department of Environment and Energy, Feb 2019.

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Key environmental features surrounding RAAF Base Williamtown and SAAWR

Figure No: **1.1** DRAFT

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1.2.1. Joint Strike Fighter Program

In 1999, the Australian Department of Defence (Defence) established the New Air Combat Capability (NACC) Project to investigate aircraft options to replace the current fleet of F/A-18A/B Hornet aircraft. The current F/A-18A/B Hornet aircraft were introduced into the Defence fleet in the 1980s for multi-role combat. Following a full review of available combat aircraft, Australia joined the multi-national Joint Strike Fighter (JSF) Program in October 2002. Current planning predicts the transition from F/A-18A/B Hornet to F-35A aircraft to be complete by 2023. Under the NACC Project, Defence will acquire up to 100 F-35A aircraft through a three-phase acquisition process. The Australian government approved the acquisition of 14 F-35A aircraft in 2009 (Phase 2A) and a further 58 aircraft in 2014 (Phase 2B). A decision on the acquisition of the remaining 28 F-35A aircraft has been delayed to 2022 (Phase 2C). In December 2018, the first two F-35A aircraft arrived at the Base, with an additional four aircraft delivered in April and September 2019.

1.2.2. Environmental impact statement

On 23 December 2010, the Minister for Environment determined that Phase 2A/B of the NACC Project required formal assessment under the EPBC Act.

The EIS aimed to compare the environmental and social impacts between the existing flying operations of the F/A-18A/B Hornet aircraft and the proposed flying operations of the F-35A aircraft, including potential impacts on the following matters of national environmental significance:

- Wetlands of international importance (i.e., Ramsar sites).
- Listed threatened species and ecological communities.
- Listed migratory species.

The Project was also deemed to be a controlled action under Section 28 of the EPBC Act in relation to Commonwealth actions that will have, or are likely to have, a significant impact on the environment.

On 10 July 2015, the Commonwealth Department of the Environment (now Department of the Environment and Energy) approved the project with four core conditions. Section 2 of this report provides further detail on the legislative requirements of this project.

1.3. Implementation of the fauna management plan

The FMP was prepared in accordance with Condition 4 of the EIS approval decision (see Section 2.4) (Coffey, 2016). This plan was submitted to Department of the Environment (now Department of the Environment and Energy) in February 2016 and after consultation was subsequently approved in March 2016.

To implement the FMP, Defence conducted baseline noise measurements at eight environmentally sensitive locations and fauna observations at five of these locations prior to the commencement of F-35A aircraft flying operations. Subsequent noise monitoring at these same eight locations was conducted during F-35A aircraft operations to determine if the noise levels of F-35A aircraft exceed the baseline levels of the F/A-18A/B Hornet aircraft.

An exceedance of baseline noise levels in relation to Condition 4C is defined as a statistically significant difference between the mean and 90th percentile of the L_{Amax} and sound exposure level of the measured baseline noise levels compared to the transition period noise levels, where the difference represents an increase in noise levels above 70 dB L_{Amax} due to the F-35A aircraft.

Figure 1.2 outlines the process for the implementation of the FMP.

1.4. Associated documents

This report draws on information from a range of documents previously prepared as part of the project. Key documents which have provided information for this process includes:

- Environmental Impact Statement for the Flying Operations of the F-35A Lightning II (Coffey, 2014). The findings of this report will be used to describe the existing conditions in relation to the noise environment and fauna observations.
- Fauna Management Plan RAAF Base Williamtown Flying Operations of the F-35A Lightning II (Coffey, 2016). The methodology described as part of the FMP will be used to inform the monitoring program undertaken as part of this report. This plan was approved in March 2016.
- Operation of the JSF Aircraft as New Air Combat Capability (NACC) at RAAF Base Williamtown. Draft Public Environment Report (SKM, 2009). This report draws on the ambient noise conditions and fauna observation data presented in the public environment report (PER).
- F-35A Aircraft Noise Effects on Fauna Baseline Report (Coffey, 2019). The findings of this report will be used to describe the existing noise environment baseline noise levels of F/A-18A/B Hornet aircraft.
- Monitoring and Documenting F-35A Noise Effects on Fauna, Transition Period Noise Survey (MDA, 2019). This report includes the noise monitoring results recorded during the transition period noise survey and analyses noise data to meet the requirements of the FMP.

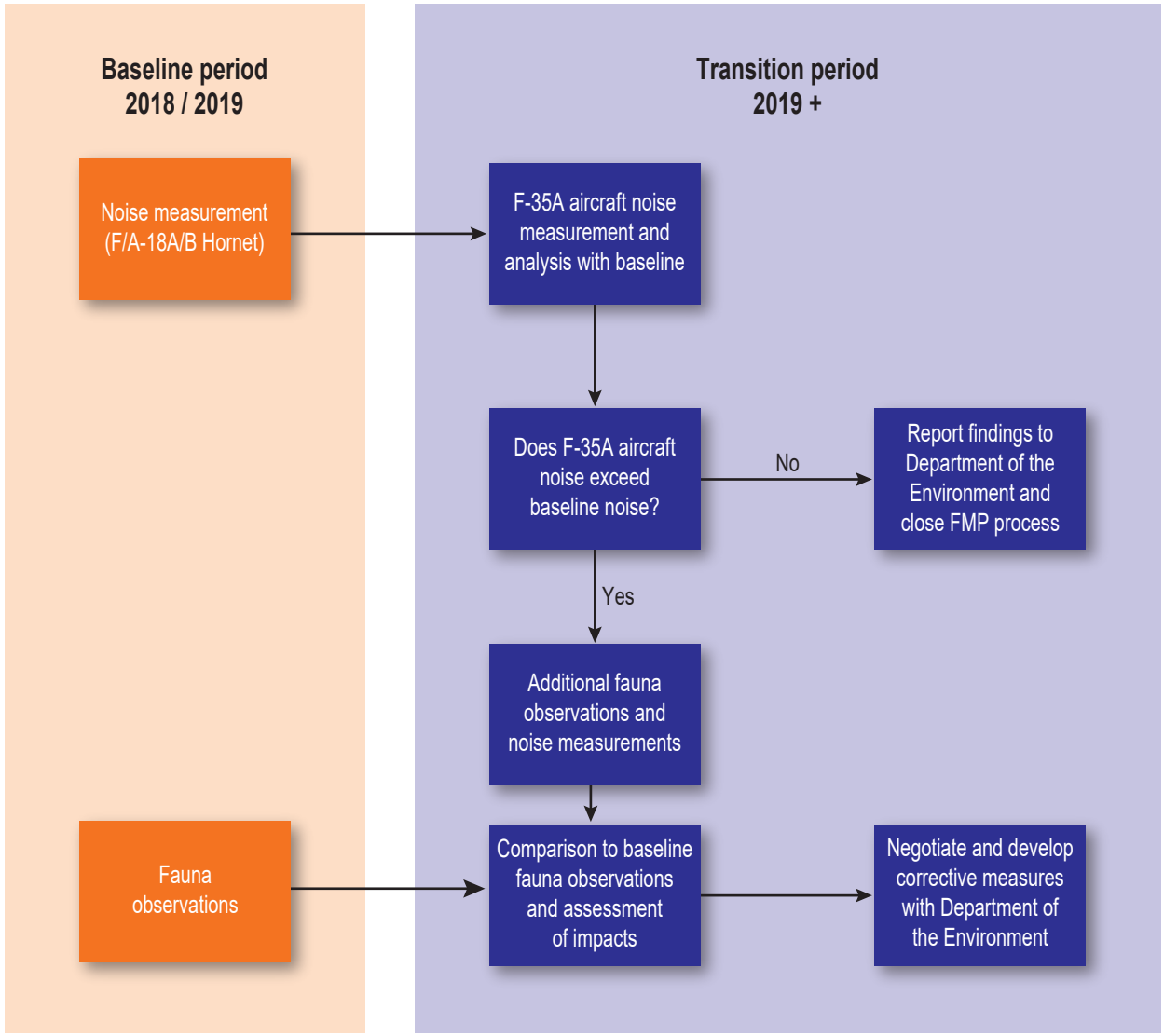

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Figure No: 1.2 DRAFT

AI Reference: 223496_04_GRA002.ai_1

2. Relevant legislation, guidelines and commitments

2.1. Relevant legislation

The main environmental legislation applicable to the FMP is the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The proposed flying operations of the F-35A aircraft were assessed under the requirements of the EPBC Act.

The final environmental impact statement (EIS) (comprised of the draft EIS and a supplementary EIS) for the flying operations of the F-35A Lightning II (F-35A) aircraft was submitted to the Minister for the Environment in April 2015. In July 2015, the Commonwealth Department of the Environment published its approval decision for the flying operations of the F-35A aircraft. The project was approved with four core conditions. The FMP was prepared to meet the requirements of Condition 4.

Flying operations at the Base are conducted by a Commonwealth agency, the Department of Defence (Defence), on Commonwealth land and in national airspace and are therefore not subject to state or local environmental or developmental controls. However, Defence aims to be a good environmental steward and through its Fly Neighbourly Policy, aims to comply with New South Wales and local government legislation and policies to the extent that these do not conflict with Commonwealth legislative obligations or compromise operational objectives or capability.

2.2. Defence policies

A range of flying policies and environmental management plans have been developed by Defence and are in place to reduce the impact of its flying operations. Those relevant to the FMP include:

- Royal Australian Air Force Aircraft Operations Environmental Management Plan – Environmental Planning Handbook.
- Defence Instructions (Air Force) 03-07 – Aircraft Noise Nuisance.
- Air Combat Standing Instruction (Operations) 03-02 – Low Flying.
- Air Combat Group Standing Instruction (Operations) 03-03 – Fly Neighbourly Policy (hereafter referred to as the Fly Neighbourly Policy). This policy provides instructions to RAAF aircrew for minimising aircraft noise and, while subject to change, currently includes guidance on hours of operations, flight-path, minimum altitudes and power usage for routine training operations.

2.3. Relevant guidelines

The following guidelines were considered in the procurement, siting and installation of noise measurement equipment:

- AS IEC 61672-1 Electroacoustics – Sound Level Meters – Part 1: Specifications.
- AS/NZA 4476:1997, Acoustics – Octave band and fractional octave band filters.
- IEC 61260 – 1 Electroacoustics – Octave-band and fractional-octave-band-filters – Part 1: Specifications.
- AS IEC 60942 Electroacoustics – Sound calibrators.

2.4. Pre-existing commitments

Pre-existing commitments with respect to the monitoring and documenting of noise and fauna observations are listed in Table 2.1. These commitments have been made by Defence in the following documents:

- Environmental Impact Statement, 2015.
- Compliance with approval Condition 4 requirements.

- Fauna Management Plan, 2016.

Only commitments relevant to the implementation of the FMP have been included.

Table 2.1 Pre-existing commitments

Source	Commitment
Condition 4 of the approval decision on the EIS	Prepare and implement a Fauna Management Plan. This plan must include, but not be limited to:
	a. establishing a baseline measurement of noise levels at environmentally sensitive locations prior to the flying operations of the F-35A Lightning II aircraft.
	b. measurement of noise levels at environmentally sensitive locations during the flying operations of the F-35A Lightning II aircraft.
	c. if measured F-35A Lightning II aircraft noise levels exceed the baseline measurement of noise levels at environmentally sensitive locations prior to the flying operations of the F-35A Lightning II aircraft, then corrective measures must be developed and implemented until an appropriate assessment of noise impacts is reached, as agreed with the Minister.
	d. reporting the results of noise level measurements to ensure data is publically [sic] available.
Fauna management plan – site selection	A minimum of six measurement locations will be selected.
Fauna management plan – noise measurement and survey duration	The duration of noise measurements at each location shall extend over a period of two months for both baseline measurements and during the transition period.
Fauna management plan – noise measurement and survey duration	Baseline noise measurements will be conducted in 2017 prior to the arrival of the F-35A aircraft.
Fauna management plan – noise measurement and survey duration	Noise measurements will be conducted within the months when migratory shorebirds are present in the area (September to February).
Fauna management plan – noise measurement and survey duration	If noise levels during the transition period are found to exceed baseline levels further noise measurements shall be conducted during the period of subsequent fauna measurement in order to correlate noise levels with disturbance factors and bird reactions.
Fauna management plan – noise measurement and survey duration	Sound level meters will be sited within 500 m of the selected locations.
Fauna management plan – observation method	Baseline observation of fauna behaviour will be conducted in conjunction with noise measurements in 2017, to ensure observations are made prior to the introduction of the F-35A aircraft.
Fauna management plan – observation method	Observe migratory shorebirds during foraging and roosting activities. Observations shall be conducted at both high and low tide.
Fauna management plan – observation method	Observe grey-headed flying-fox camps for two hours before dusk.
Fauna management plan – observation method	Conduct observation for two hours before peak tide time and one hour after. Monitoring shall be conducted at each shorebird location for two tide cycles.

Source	Commitment
Fauna management plan – observation method	Conduct observation over two intervals, one in November at the beginning of the migration season and one in February/March at the end of the migration season*.
Fauna management plan – observation method	Population data collected by NSW Parks and Wildlife (Gould's Petrel) and Hunter Bird Observers Club (Australasian Bittern) will be reviewed to identify any population changes after the introduction of the F-35A aircraft. In order to do this, Defence will: • Obtain population data for 2016 to 2019 from NSW Parks and Wildlife and Hunter Bird Observers Club. • Use population data from 2016 to 2017 as baseline set. • Compare population data from 2016 to 2017 with 2018 to 2019 to determine if there is any statistically significant change in population since the introduction of the F-35A aircraft.
Fauna management plan – observation method	Published records of the Australian painted snipe will be used to note any trends in observations during the monitoring periods. In order to do this, Defence will: • Obtain published records from 2016 to 2019 from a range of databases including Hunter Bird Observers Club, BirdLife Australia and eBird. • Analyse data to identify any trends/changes in records over the monitoring periods.
Fauna management plan – performance standards	To quantify the change in noise levels between the baseline period and transition period, a statistical analysis shall be undertaken, with reference to the mean and 90th percentile of the noise levels and number of aircraft events.
Fauna management plan – performance standards	Any noise exceedances recorded during the transition period will be assessed against the EIS noise modelling results to determine if they are consistent with the EIS predictions.
Fauna management plan – performance standards	Observations of environmentally sensitive species will only be conducted during the transition period if and where an exceedance of baseline noise levels is recorded.
Fauna management plan – corrective measures	If the results of further fauna observations record an increase in the level of reaction observed due to increased noise levels associated with the F-35A aircraft, then Defence will develop corrective measures in consultation with the Department of the Environment.
Fauna management plan – reporting	Results of the data analysis will be reported to the Department of the Environment within three months of completion of each stage.
EIS – noise monitoring	Noise and flight path monitoring will continue throughout the operations of the F-35A aircraft. Monitoring will provide information to satisfy stakeholder concerns regarding noise.
EIS – noise monitoring	Comply with flight path requirements as specified in the Defence policies.
EIS – noise monitoring	Follow the Air Combat Group Fly Neighbourly Policy guidelines where training and operational requirements, and flight safety circumstances allow.
EIS – biodiversity	Abide by the no-fly zone over Cabbage Tree Island and Boondelbah Island during Gould's petrel breeding season. Under the no-fly zone, it is proposed that the F-35A aircraft will have altered flight paths to avoid flying close to, or above the islands.

* Fauna observations were conducted during the migratory period but on an opportunistic basis rather than two separate intervals in order to fulfil all other FMP commitments and meet operational requirements. For example, when tide times and flying operations aligned, observations were conducted at that location. Fauna observations had to be completed by January as the F-35A aircraft commenced flying operations at the end of January.

3. Existing environment

This section describes the current flying operations of F/A-18A/B Hornet and F-35A aircraft, the existing ambient noise levels surrounding the Base and the F/A-18A/B Hornet aircraft baseline noise levels. The information presented in this section has been drawn from previous studies conducted within the study area, including the fauna baseline report (Coffey, 2019), FMP (Coffey, 2016) and EIS (Coffey, 2014).

3.1. Current flying operations

3.1.1. Hours of operation

In accordance with the Fly Neighbourly Policy, where practicable, during normal training operations the RAAF limits flying activity at the Base to the following hours of operations:

- 7.00 a.m. to 10.00 p.m. (11.00 p.m. during daylight saving).
- Night continuous circuit training will cease by 9.00 p.m. (10.00 p.m. during daylight saving).

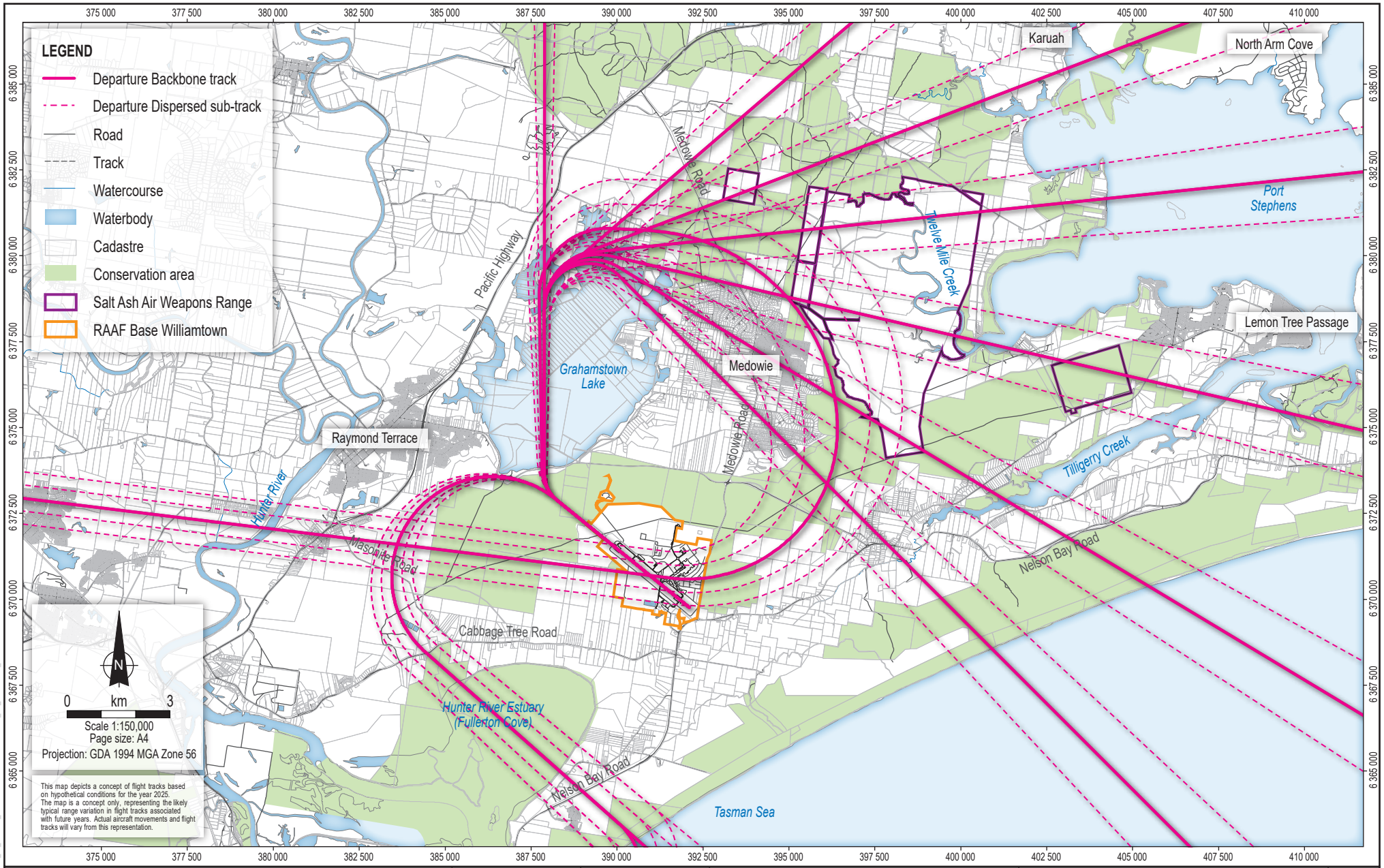
3.1.2. Flight paths

Flight paths at the Base have been developed to be consistent with the Hawk Consent (GHD, 2007) and the Fly Neighbourly Policy, and will avoid population areas, where practicable. The most recent guidance that has been provided by the Fly Neighbourly Policy is as follows:

- Departures from Runway 30 are to turn east or west to minimise direct flight over Raymond Terrace. Aircraft will conduct the majority of departures over Grahamstown Dam and then turn to the departure gates either north of Medowie or overfly Medowie not below 3,500 feet (or 1,067 m) above mean sea level (amsl) (Figure 3.1).
- Departures from Runway 12 are to climb straight ahead for three nautical miles before turning to their destination, or until an altitude of 2,500 feet amsl is reached, whichever comes first (Figure 3.2).
- Visual arrivals are to minimise direct over-flight of Medowie, Tanilba Bay, Lemon Tree Passage and Raymond Terrace.

The Fly Neighbourly Policy defines a number of height recommendations in regard to aircraft performing low altitude procedures over land, including:

- Flights over urban areas (defined as recognisable townships with recognisable cross streets or where the population is expected to exceed 150 people) should not occur at less than approximately 1,500 feet (or 460 m).
- Attack procedures involving flight below approximately 1,000 feet (or 305 m) should avoid urban areas by more than 5 km.
- Low level coastal transits are to occur offshore, and afterburner usage is to be avoided.



Source: Flight path data provided by Marshall Day Acoustics, 2013.
Base boundaries, cadastre, roads and watercourses from Department of Defence, 2013.
Place names, reserves and coastline from GEODATA250K (Optimum scale 1:250,000).
Conservation areas from OEH (Office of Environment & Heritage), Feb 2019.
Ramsar sites from Commonwealth of Australia, Department of Environment and Energy, Feb 2019.

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F-35A aircraft departure pathway from Runway 30 at RAAF Base Williamtown

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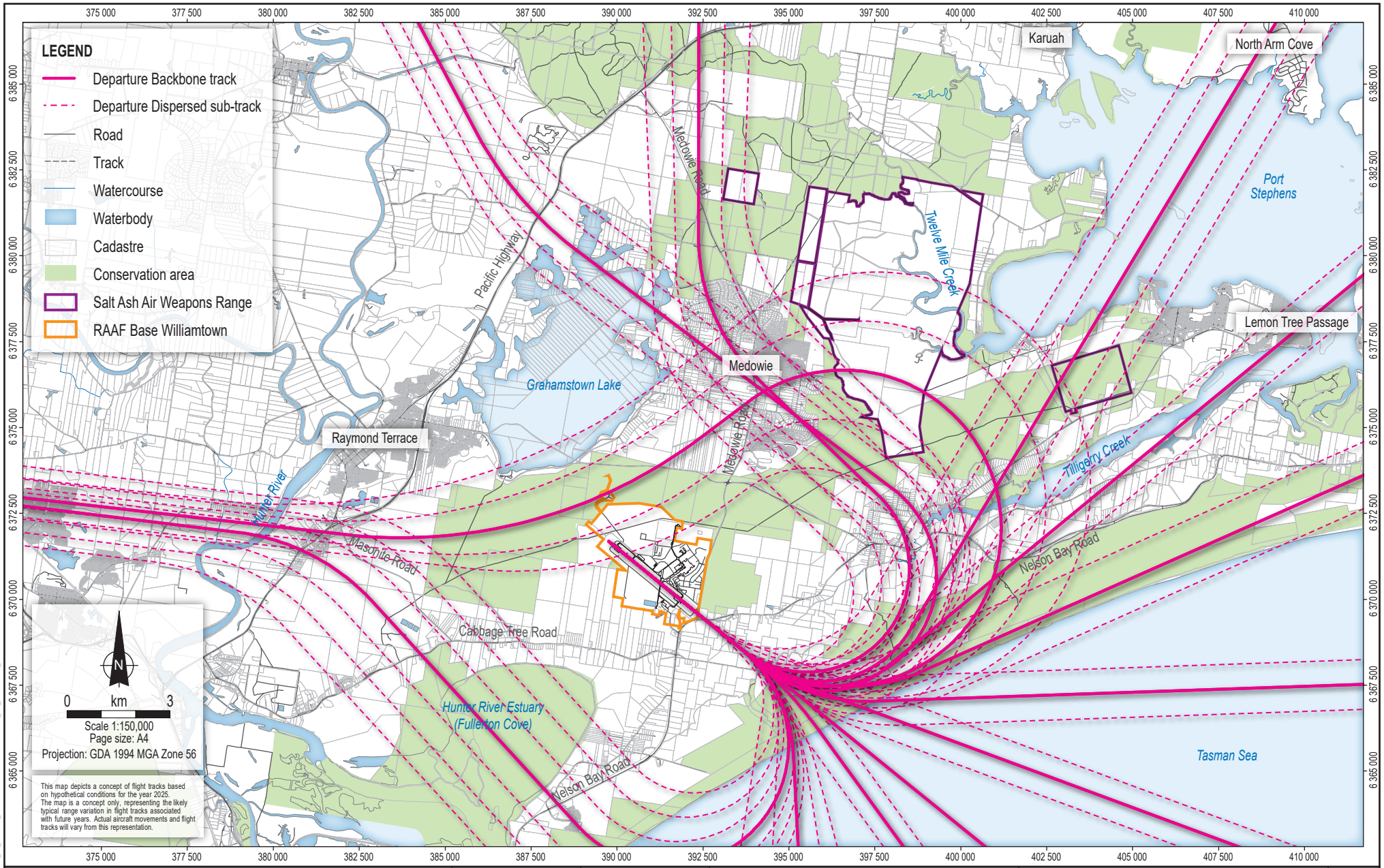

Source: Flight path data provided by Marshall Day Acoustics, 2013.
Base boundaries, cadastre, roads and watercourses from Department of Defence, 2013.
Place names, reserves and coastline from GEODATA250K (Optimum scale 1:250,000).
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F-35A aircraft departure pathway from Runway 12 at RAAF Base Williamtown

Figure No: 3.2 DRAFT

MXD Reference: 223496_01_GIS004_v0.mxd AI Reference: 223496_04_GRA004.ai_1

3.1.3. Movements

The typical movements of F/A-18A/B Hornet and F-35A aircraft are presented in Table 3.1. The information presented in Table 3.1 is an average representation of the current movements for the F/A-18A/B Hornet and F-35A aircraft. Variations to the numbers presented in the table may occur due to seasonal variations and operational and safety requirements. Daily variations in runway use will occur depending on seasonal and weather conditions.

Table 3.1 Typical and expected aircraft movements

Activity	F/A-18A/B Hornet	F-35A aircraft
Annual departures	7,745[a]	6,964[b]
Annual arrivals	7,745[a]	6,964[b]
Annual touch and go circuits	2,017[a]	3,118
Flight distribution (day)	90%[a]	80%
Flight distribution (night[c])	10%[a]	20%
Runway use (Runway 12)	59%[a]	45%
Runway use (Runway 30)	41%[a]	55%

Source: Coffey, 2014
a. Based on the 2011 Australian Noise Exposure Index (ANEI) movement summary, which provides current movement distributions prior to the introduction of the F-35A aircraft at RAAF Base Williamtown.
b. Includes based and visiting squadron movements for Phase 2A/B and Phase 2C.
c. Night is defined (in the Australian Noise Exposure Forecast system) as being the hours between 7.00 p.m. and 7.00 a.m.

3.2. Noise environment

This section describes the existing ambient noise environment within the Base noise study area and the F/A-18A/B Hornet aircraft noise level data obtained during the baseline noise survey. This information provides baseline conditions prior to the commencement of F-35A aircraft operations. The information presented is based on the findings of the Noise Impact Assessment prepared by Marshall Day Acoustics as part of the EIS (Coffey, 2014) and the F-35A Aircraft Noise Effects on Fauna Baseline Report (Coffey, 2019).

3.2.1. Setting

RAAF Base Williamtown and SAAWR are surrounded by rural and semi-rural land uses. Raymond Terrace and Medowie are the closest residential areas located approximately 9 km and 6 km north of the Base, respectively (see Figure 1.1). RAAF Base Williamtown is bounded by Nelson Bay Road to the southeast, Medowie Road to the east and Hunter Water Corporation land to the north and west.

Newcastle Airport currently operates within the Base under a lease with Defence. Commercial airlines that operate daily flights from the airport include Qantas Airways, Jetstar and Virgin Australia.

3.2.2. Meteorological conditions

The distribution of sound through the atmosphere is directly influenced by humidity, pressure, temperature and wind. Changes to these atmospheric parameters can affect how sound is absorbed and the path that a sound wave follows. It is predicted that wind intensity and direction will be the most significant influences on aircraft noise from F-35A aircraft flying operations. For example, strong winds could lead to increases in perceived noise levels at locations downwind from the Base.

General meteorological conditions at the Base have been characterised (Coffey, 2014):

- Mild thermal inversions typically occur between 6.00 p.m. to 12.00 a.m.
- Stronger thermal inversions typically occur between 1.00 a.m. to 5.00 a.m.
- Thermal inversions were estimated to occur on approximately 65% of days of the year.

The meteorological conditions recorded during the noise assessment survey period are discussed further in Section 4.2.4 of this report.

3.2.3. Ambient noise conditions

The ambient noise conditions indicate that the existing noise environment surrounding the Base can be characterised by frequent and periodic noise created from military aircraft, daily commercial airline flights and other transport noises from vehicle traffic. Table 3.2 presents a summary of typical ambient noise levels at each noise monitor location. Noise monitoring locations were selected where there would be a low influence of ambient noise on the measured aircraft noise levels.

Table 3.2 Description of ambient noise levels surrounding the RAAF Base Williamtown

Location	Typical ambient noise levels		Comments
	Day	Night	
Fullerton Cove	45 to 55 dB L_{Aeq}	35 to 40 dB L_{Aeq}	Bird calls were common, resulting in noise levels of approximately 50 dB L_{Aeq}. During monitor deployment, military fast jets could be heard and seen departing from the Base.
Stockton Sandspit	50 to 55 dB L_{Aeq}	40 to 50 dB L_{Aeq}	Stockton Centre maintenance workshop activity and distant noise from beach present at time of monitor deployment.
Kooragang Island	50 to 60 dB L_{Aeq}	40 to 50 dB L_{Aeq}	Noise levels from nearby industry occasionally ranged between 60 and 70 dB L_{Aeq}.
Hexham Swamp	50 to 55 dB L_{Aeq}	40 to 50 dB L_{Aeq}	Occasional noise from distant trains increased short term noise levels up to 60 dB L_{Aeq}.
Tilligerry Nature Reserve	50 to 55 dB L_{Aeq}	45 to 50 dB L_{Aeq}	Some anthropogenic noise from nearby activities were detected during monitor deployment.
Swan Bay	40 to 50 dB L_{Aeq}	25 to 40 dB L_{Aeq}	Occasional noises from birds, bats and frogs resulted in noise levels of 45 to 50 dB L_{Aeq} at times.
Myall River (Pindimar)	45 to 50 dB L_{Aeq}	30 to 40 dB L_{Aeq}	Noise from flocking birds increased noise levels up to 60 dB L_{Aeq} for periods of one to two hours.
Cabbage Tree Island	45 to 50 dB L_{Aeq}	45 to 50 dB L_{Aeq}	Ambient noise levels were dominated by waves breaking on the island shoreline. Surf noise from the coastline was also prominent depending on weather conditions.

3.2.4. Baseline noise levels

Noise levels from baseline aircraft operations, i.e., F/A-18A/B Hornet aircraft movements only, were recorded at eight locations between November 2018 and January 2019, further details are provided in the F-35A Aircraft Noise Effects on Fauna Baseline Report (Coffey, 2019). Table 3.3 presents a summary of F/A-18A/B Hornet aircraft noise levels obtained from the baseline noise survey.

Table 3.3 Summary of F/A-18A/B Hornet aircraft noise levels

Location	Number of correlated events	Sound exposure level (dB)		L_{Amax} (dB)	
		Average	**90th percentile**	**Average**	**90th percentile**
Fullerton Cove	243	79	92	69	81
Stockton Sandspit	129	86	99	76	91
Kooragang Island	74	80	87	70	77
Hexham Swamp	39	78	87	68	78
Tilligerry Nature Reserve	61	84	91	71	80
Swan Bay	30	79	86	68	74
Myall River (Pindimar)	40	81	89	71	84
Cabbage Tree Island	14	86	88	76	79

4. Method

4.1. Monitoring locations

A total of eight potential monitoring locations were identified in the FMP. Selection of monitoring locations was based on sites providing critical habitat to environmentally sensitive species (as defined in Section 2 of the FMP) in proximity to areas where increases in the 70 dB L_{Amax} extent around the Base are predicted. The noise monitoring locations for the transition period noise survey were the same as those used during the baseline survey, with the exception of the following:

- Cabbage Tree Island: located 80 m north of previous survey location due to re-evaluation of access to a safer monitoring location and a site less affected by extraneous noise.
- Tilligerry Nature Reserve: located 250 m south of previous survey location due to sun shading issues affecting the solar panel. There was also a request from the site owner to relocate to a more remote location.

Given the large variation in aircraft flight paths in the vicinity of the monitoring locations and the small magnitude of change, these monitoring locations are considered to be consistent with the baseline monitoring locations.

Details of the selected measurement locations and the selection rationale are listed in Table 4.1 and shown in Figure 4.1.

Table 4.1 Selected monitoring locations

Monitoring location	Description	Direction and distance from RAAF Base Williamtown	Selection rationale
Fullerton Cove	Private land, Fullerton Cove Road, Fullerton Cove	6.5 km south-southwest	This is an intertidal site for migratory shorebirds. This area is a sensitive location in the Hunter Estuary complex and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on departure from Runway 30 to the Hunter Region overflight.
Stockton Sandspit	Stockton Centre east site boundary	10 km south-southwest	This is the largest wader roost in the area and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on departure from Runway 30 to the Hunter Region overflight.
Kooragang Island	499 Tomago Road	11 km west-southwest	This site provides critical habitat (reed bed areas as well as areas of shallow waterbodies) for migratory shorebirds. This area is a sensitive location in the Hunter Estuary complex and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on the departure on Runway 30 to the Hunter Region overflight.
Hexham Swamp	Private land, Woodsland Close Hexham	15 km west-southwest	This is one of the main breeding areas for Australasian bittern in the area and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on departure from Runway 30 to the Hunter Region overflight.

Monitoring location	Description	Direction and distance from RAAF Base Williamtown	Selection rationale
Tilligerry Nature Reserve	Research Drive, Taylor Beach	21 km east-northeast	This has previously been recorded as a flying-fox camp with grey-headed flying-fox recorded in November 2014 and February 2015, (Department of the Environment, 2015). This area is also subject to potential increases in the 70 dB L_{Amax} on the easterly departures on runways 12 and 30.
Swan Bay	Private land, Swan Bay Road, Swan Bay	16.5 km northeast	This area provides potential foraging and roosting habitat for migratory shorebirds and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on the SAAWR overflight.
Myall River (Pindimar)	Private land, Cunningham Street, Pindabah	27 km northeast	This area provides foraging and roosting habitat for migratory shorebirds and is potentially subject to an increase in noise levels above 70 dB L_{Amax} on easterly departure from Runway 30.
Cabbage Tree Island	Restricted island only accessible by NSW National Parks and Wildlife service	38 km east-northeast	This is a known breeding island for Gould's petrel and is subject to potential increases in 70 dB L_{Amax} on the easterly departures on runways 12 and 30.

Myall Lakes Ramsar site was not selected as a measurement location given its distance from the Base and SAAWR and it was outside the 70 dB L_{Amax} noise contour where impacts were considered possible.

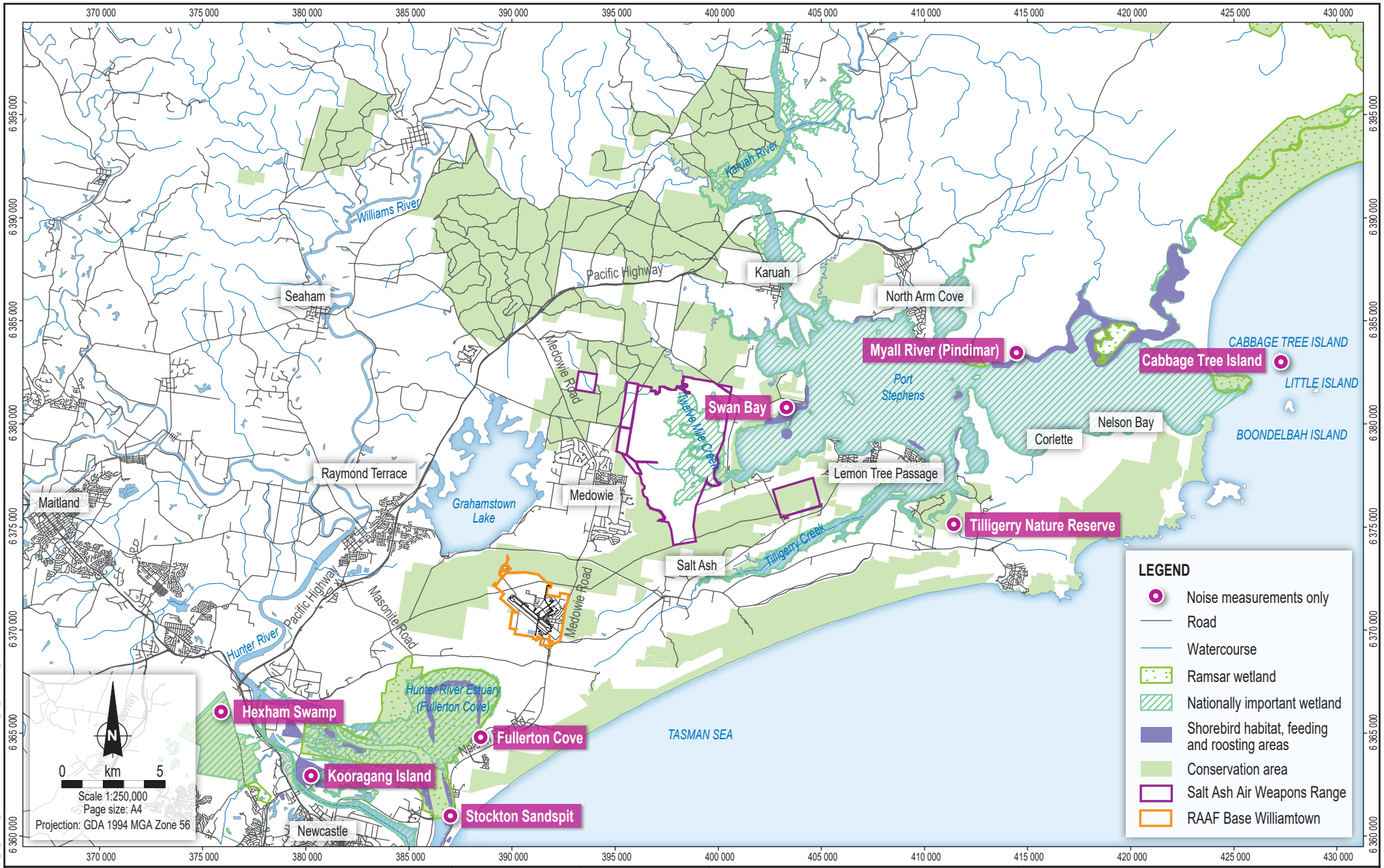
The majority of the selected locations were accessed by public roads and tracks except for Fullerton Cove and Cabbage Tree Island. Access to Fullerton Cove required liaison with private landholders. Landholders were contacted and agreed to provide access to establish noise monitoring equipment on the property. Access to Cabbage Tree Island required transport and escort by a New South Wales National Parks and Wildlife (NPWS) ranger. New South Wales NPWS was contacted, and access arranged prior to the start of deployment.

Flying operations of the F-35A aircraft during the monitoring period were conducted in accordance with the proposed long-term flying program of future squadrons. Flight paths and flying operations were not altered for the purposes of monitoring to ensure datasets are representative of flight procedures following the transition from F/A-18A/B Hornet aircraft to F-35A aircraft operations.

4.2. Noise measurements

The transition period noise survey was conducted in accordance with the conditions outlined in the FMP (Coffey, 2016). The survey was undertaken between 19 June 2019 and 24 September 2019 (14 weeks total) at eight monitoring locations, shown in Figure 4.1. The survey period was extended from the minimum nominated period of two months to account for the limited number of F-35A aircraft movements at the Base.

Noise measurements were conducted using a solar powered unattended sound level meters including microphone, wind shield and recorder, in accordance with *Electroacoustics - Sound Level Meters - Part 1: Specifications* (AS IEC 61672-1:2004).



Source:
Monitoring locations from Coffey, 2015. Shorebird roosting data from Birds Australia, 2008.
Base boundaries, roads and watercourses from Department of Defence, 2013.
Place names and coastline from GEODATA250K (Optimum scale 1:250,000).
Conservation areas from OEH (Office of Environment & Heritage), Feb 2019.
Ramsar sites from Commonwealth of Australia, Department of Environment and Energy, Feb 2019.

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Selected monitoring locations

Figure No: 4.1
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MXD Reference: 223496_01_GIS006_v0.mxd AI Reference: 223496_04_GRA005.ai_1

Disclaimer: This figure has been produced for internal review only and may contain inconsistencies or omissions. It is not intended for publication.

The noise monitors were configured to continuously measure noise levels at 0.5 second intervals for the duration of the survey. When establishing the monitoring sites, the following factors were implemented:

- The noise monitors were located at least 3 m away from any dwelling or significant vertical reflecting structures.
- The microphone height was at least 4 m above ground level where local equipment siting arrangements permit, to minimise interference effects with ground reflections.
- The noise monitors were located as far as practical from taller vegetation and any obvious sources of extraneous noise.

4.2.1. Identification of aircraft operations

A list of identified potential aircraft noise events was generated for each noise monitoring location where the measured noise levels increased above ambient noise levels and reduced again (i.e., an aircraft flying past the noise monitor). Each event was coded using an automatic coding process based on the measured changes in noise levels.

An aircraft noise event was coded if there was an increase in noise level over a given maximum noise threshold[1] and maintained above that threshold for a minimum of 10 seconds, but no longer than 160 seconds, then fell below that threshold. The coding thresholds and durations for each monitoring location were consistent with the baseline survey and were selected based on a review of sample aircraft events, ambient noise conditions and audio recordings.

The list of identified potential aircraft noise events was subsequently cross referenced with aircraft flight path data from the permanent Noise and Flight Path Monitoring System (NFPMS) used at the Base. This database provided information on: the aircraft type; runway and operation type (i.e., arrival, departure, touch and go), altitude, airspeed, time of closest approach and minimum distance to noise monitors for each individual flight.

4.2.2. Noise event and data correlation

To correlate flight segments with aircraft noise events, the time stamps from noise monitor data and the NFPMS dataset were compared and where a potential aircraft noise event occurred within a 60 second period of a flight segment, the two data entries were paired. Once a potential aircraft noise event had been paired with a flight segment, the noise event could not be paired again.

Noise events that did not correlate to a radar aircraft event segment within a certain time period or monitoring distance were considered irrelevant events and were excluded from further analysis. Additionally, aircraft segments that were not paired with a noise event were assumed to have not generated a distinct rise and fall in noise level above other ambient noise present at the time and were therefore excluded from further analysis.

Consistent with the FMP, noise levels were analysed in terms of the average and the upper 90th percentile sound exposure level (SEL) and maximum noise level (L_{Amax}) for each aircraft category at each monitoring location.

4.2.3. Data analysis

To determine whether F-35A aircraft noise levels exceed baseline noise levels, a statistical analysis of SEL and L_{Amax} values for the two datasets was conducted. The data was analysed to understand the variation in the spread of measured noise levels. This was achieved by calculating the first quartile,

[1] The maximum noise level threshold varied depending on the ambient noise level conditions at each monitoring location.

median, third quartile, mean and maximum measured noise levels of the baseline and transition period datasets.

Due to the difference of the flying operations between the two datasets and the low number of correlated events at most of the monitoring locations during the transition period, further detailed statistical analysis for each location was not conducted as this would not produce a reliable comparison.

Where differences between baseline and transition period noise levels were identified, the following items were considered prior to determining whether the differences were statistically significant:

- Number of correlated noise events for each monitoring location. Datasets with fewer correlated noise events generally have a greater variation of noise levels which can reduce the reliability of measured noise levels. In accordance with *Acoustics – Description, measurement and assessment of environmental noise* (ISO 1996-2:2017), 16 noise measurements are required to limit uncertainties for SEL and L_{Amax} values.
- Potential for variability in noise levels due to differences in aircraft operating patterns and procedures rather than differences in aircraft type.
- Differences in average SEL and L_{Amax} measurements of 3 dB or less were considered marginal on the basis that it was much smaller than the overall range of measured aircraft noise levels.

The 90th percentile noise levels for datasets with less than 10 correlated noise events were not compared as they are prone to be distorted by a single outlier datapoint. As such the 90th percentile value was based on a single event with the highest noise levels.

4.2.4. Exclusions

Weather conditions

Data collected during days of high winds and significant rain were excluded from analysis. A threshold of 5 m/s average windspeed and presence of rainfall greater than 1 mm/hour was considered when excluding noise monitoring data. Weather data used for the analysis was collected from weather stations installed with the noise monitors at Fullerton Cove and Swan Bay.

Due to the relatively few correlated F-35A aircraft noise events, each event was individually reviewed for evidence of extraneous noise that may have affected the measured noise level. Where there was evidence that a measured noise level was affected by extraneous noise, the event was excluded from further analysis.

A considerably higher number of measured noise events were recorded at Fullerton Cove than could be accounted for when paired with the flight data, which is an indication that extraneous noise influences exist at this location. A review of the additional identified events indicated that most were likely attributed to the presence of persistent and high-speed winds. Dates of noise monitoring data that were excluded from analysis as a result of periods of extraneous noise are shown in Table 4.2.

Table 4.2 Dates of excluded data due to periods of extraneous noise

Monitoring location	July 2019	August 2019	September 2019
Fullerton Cove	11,12,13	8, 9, 10, 11, 12, 16, 17, 19, 20, 21, 24, 25, 26, 27, 29, 30, 31	1, 2, 7, 8, 9, 10, 12, 14, 16, 17, 18

Flight track and radar data

Inherent technical issues within the flight track and radar data from the NFPMS may reduce the accuracy when identifying correlated noise events. Known limitations with radar data for military fast jets are:

- **Flights of low altitudes.** Sections of flight paths can be missed by the radar if aircraft fly at particularly low altitudes.
- **Formation flying.** For some types of formation flying only the lead aircraft of the formation may be recorded by the NFPMS.
- **Classification of aircraft events.** There are instances where departure, training operations away from the Base and the subsequent arrival are captured as one flight path and classified as one operation type (usually a touch and go operation). The NFPMS classifies this flight path as only one movement (touch and go). This could be considered as three distinct movements: departure, overflight and arrival.

The implication of the missing data on the survey is there may be aircraft noise events that were captured by noise monitors for which there is no corresponding NFPMS data. These are therefore not classified as an aircraft noise event and were excluded from further analysis.

Technical faults

Technical faults were experienced with three noise monitors: Kooragang Island, Stockton Sandspit and Tilligerry Nature Reserve. A summary of the technical faults experienced included:

- **Kooragang Island**. The original noise monitor was collected following evidence of internal battery deterioration. The subsequent noise monitor was discovered leaning against an adjacent fence, however no damage was detected, and the noise data was considered valid.
- **Stockton Sandspit**. Upon retrieval, the noise monitor could not be calibrated due to the presence of moisture within the device. A review of internal systems indicated that the failure had occurred after 17 September 2019 and was likely attributed to unprecedented weather. Of the total monitoring period, only the final week was affected and therefore the data recorded prior to this was considered valid.
- **Tilligerry Nature Reserve**. Due to poor remote connectivity, the original noise monitor was replaced by another device, with minimal data lost.

5. Results

This section presents the results of the noise measurements obtained during the transition period noise survey and are based on the specialist report prepared by Marshall Day Acoustics (Appendix A).

5.1. Noise measurements

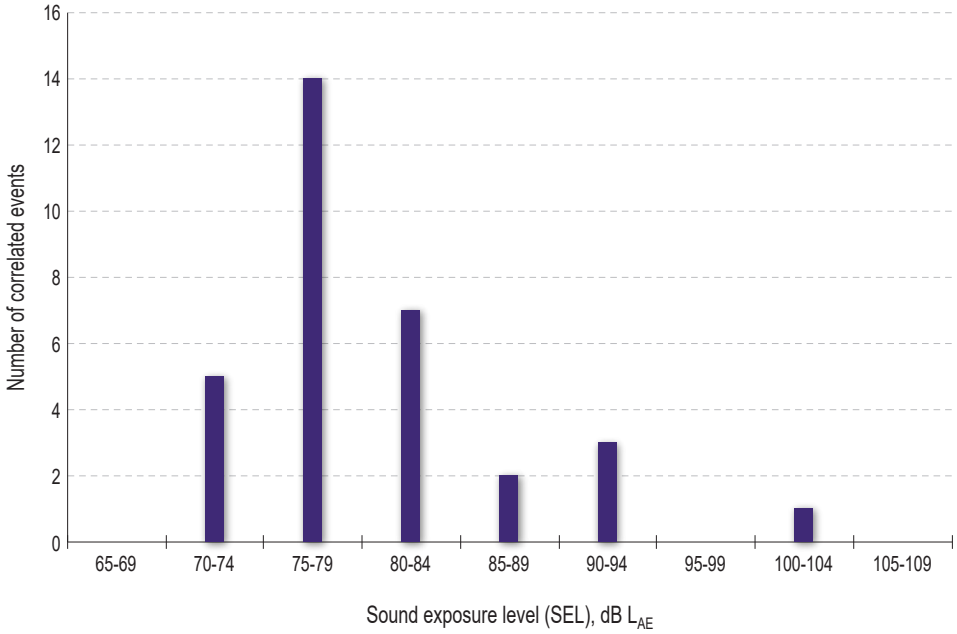
A total of 108 F-35A aircraft noise events were recorded. The majority of aircraft noise events were recorded at Fullerton Cove, Stockton Sandspit and Swan Bay monitoring locations. A summary of aircraft noise events and levels are presented in Table 5.1. Consistent with the FMP requirements and baseline data, noise levels are presented in terms of the average and the 90th percentile sound exposure level (SEL) and maximum noise level (L_{Amax}).

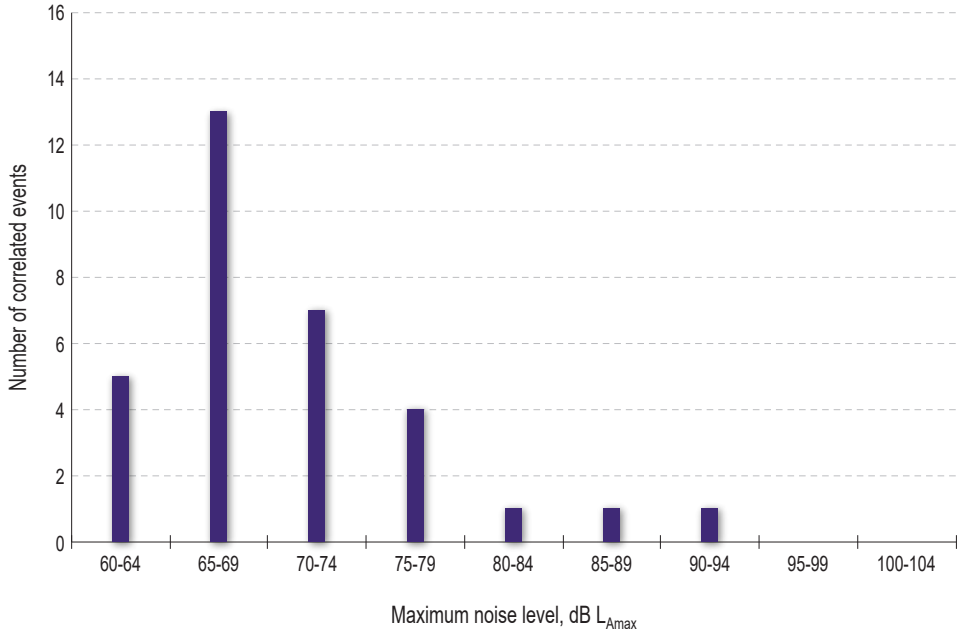
Table 5.1 Summary of F-35A aircraft noise levels

Location	Number of correlated events	Sound exposure level (dB)		L_{Amax} (dB)	
		Average	90th percentile	Average	90th percentile
Fullerton Cove	32	80	90	70	79
Stockton Sandspit	29	83	91	73	81
Kooragang Island	9	83*	92*	71*	81*
Hexham Swamp	9	87*	95*	76*	83*
Tilligerry Nature Reserve	8	82*	87*	70*	75*
Swan Bay	15	81	87	69	77
Myall River (Pindimar)	3	82*	83*	73*	78*
Cabbage Tree Island	3	75*	77*	64*	68*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.

Histographs showing SEL and L_{Amax} levels and the frequency of these aircraft events for each monitoring location are presented in Figures 5.1 to 5.8. The presence of high ambient noise levels at six of the eight monitoring locations limited the number of low noise events that could be identified. As the focus of the noise monitoring was noise events greater than 70 dB L_{Amax}, aircraft events with maximum noise levels less than 60 dB L_{Amax} were excluded from the dataset as these events were considered irrelevant to the findings of this survey.

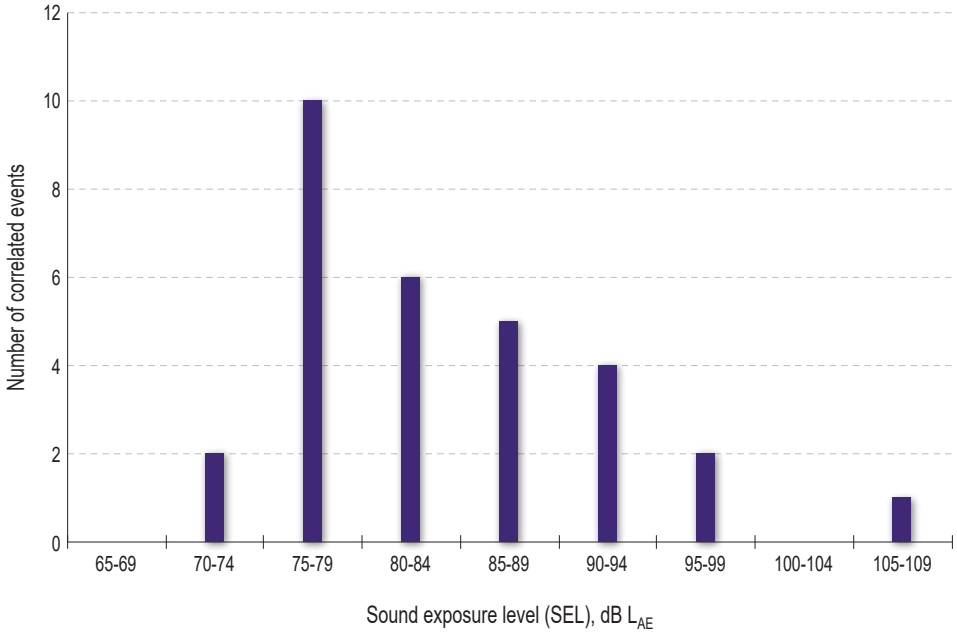




coffey A TETRA TECH COMPANY	Date: 18.11.2019 Project: 754-MELEN223496 File Name: 223496_04_F05.01_GRA	Department of Defence F-35A Aircraft Noise Effects on Fauna - Impact Report	Sound exposure levels and maximum noise levels of F-35A aircraft events at Fullerton Cove

Figure No: 5.1 DRAFT

AI Reference: 223496_04_GRA006.ai_2



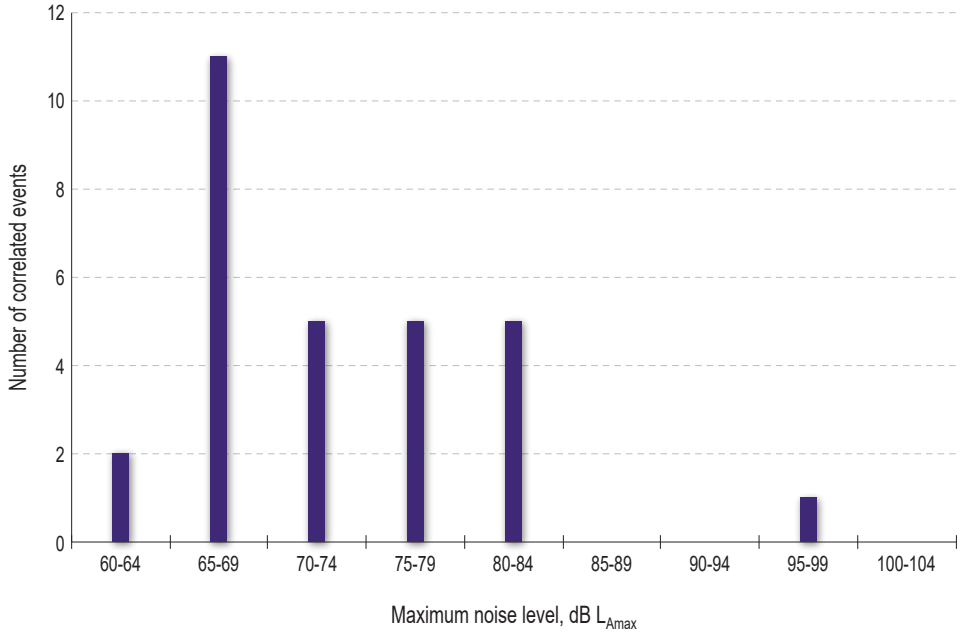


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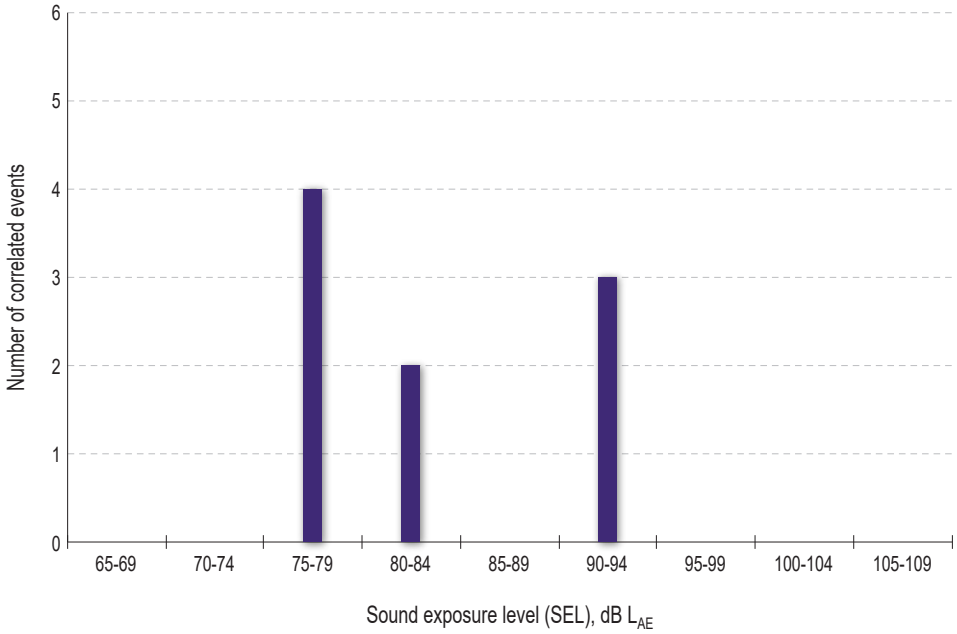
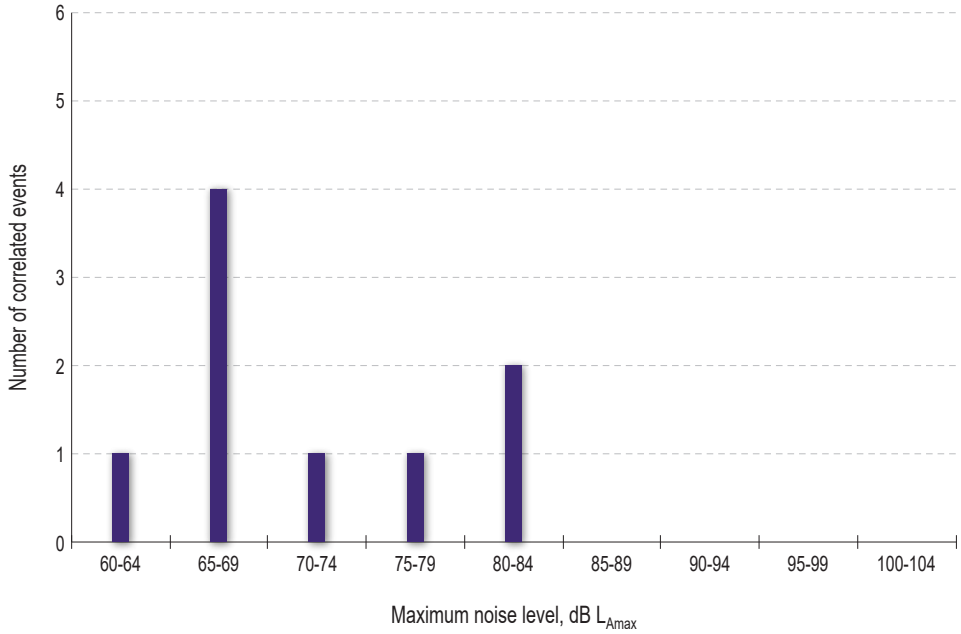
Figure No: 5.2 DRAFT

AI Reference: 223496_04_GRA006.ai_2





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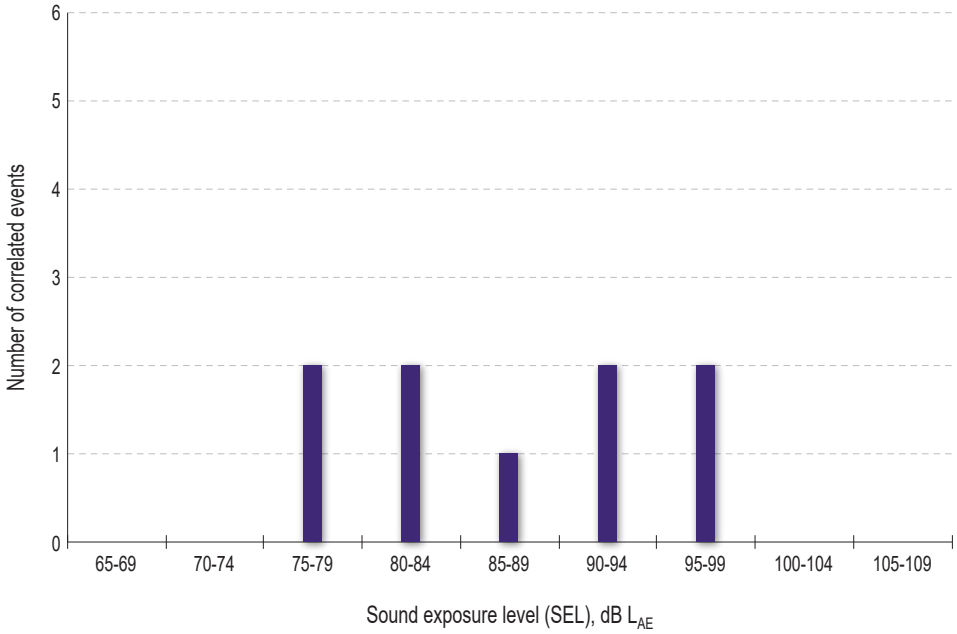
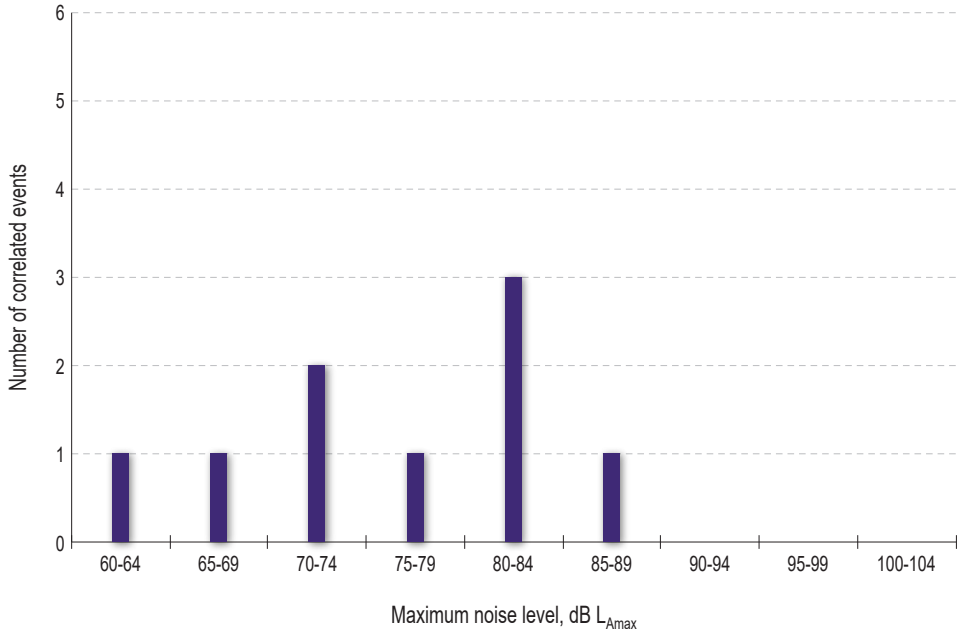
AI Reference: 223496_04_GRA006.ai_2





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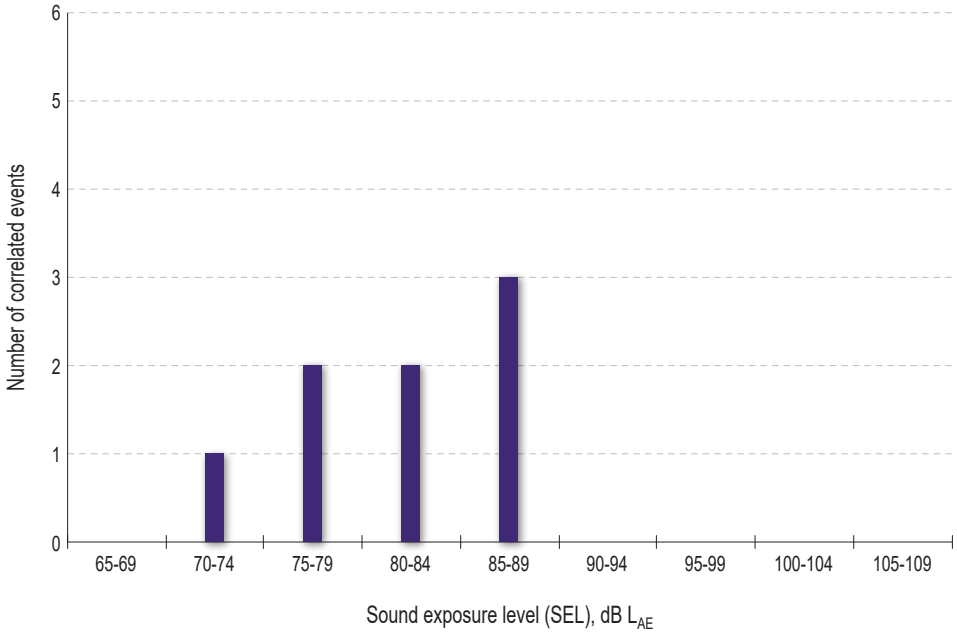
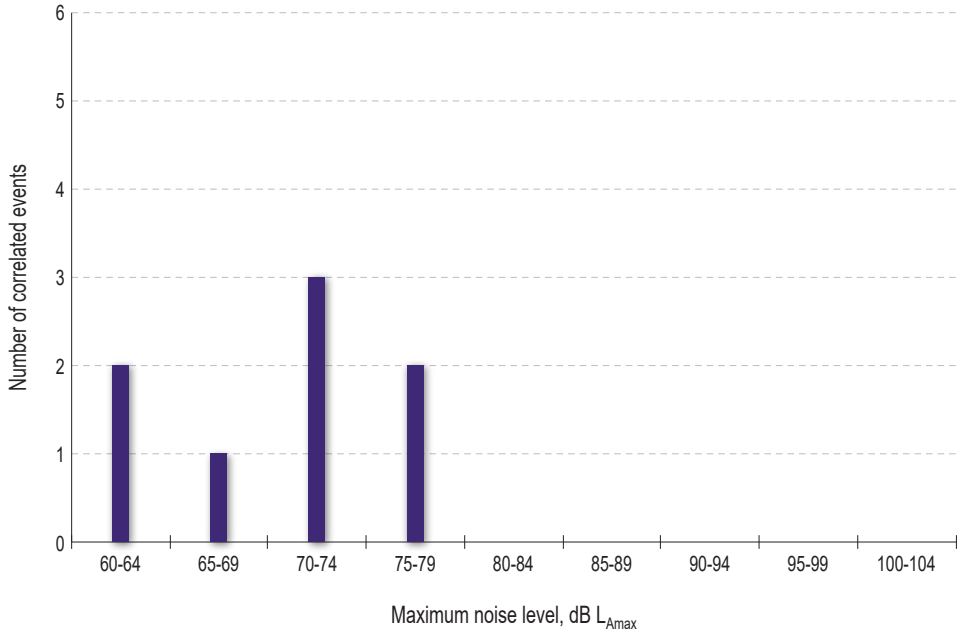
A1 Reference: 223496_04_GRA006.ai_1

Disclaimer: This figure has been produced for internal review only and may contain inconsistencies or omissions. It is not intended for publication.





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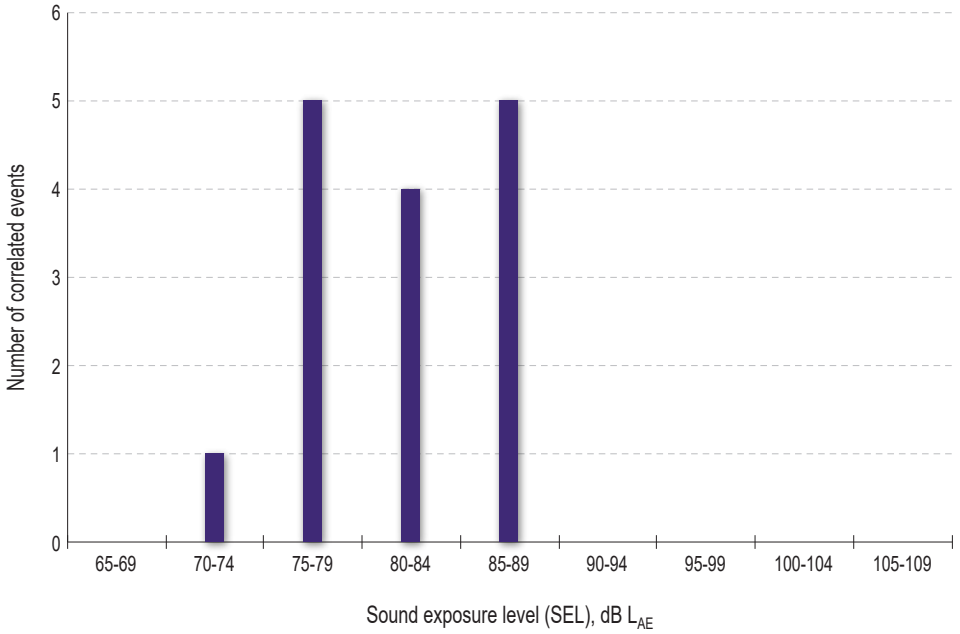
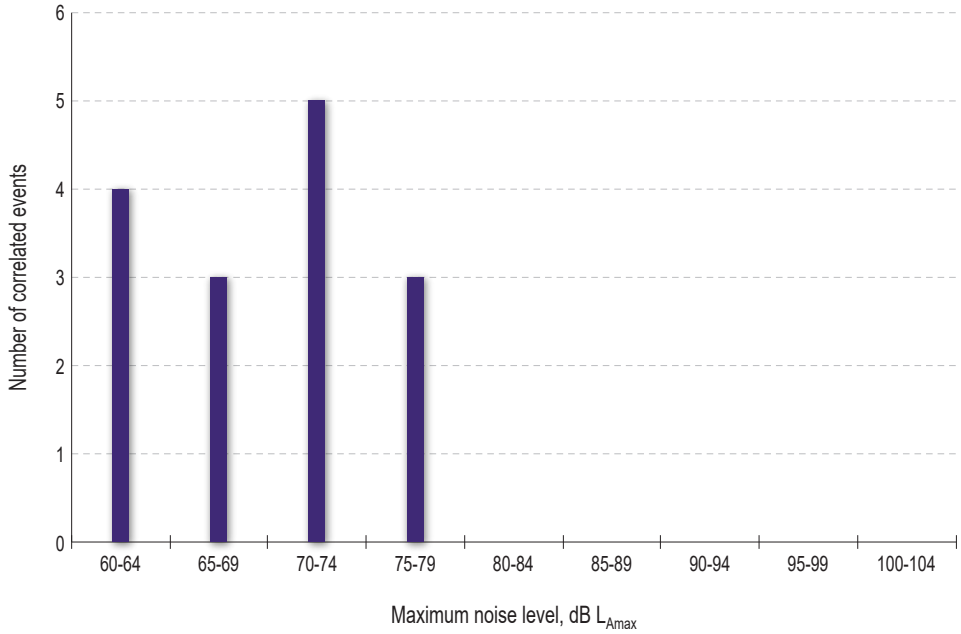
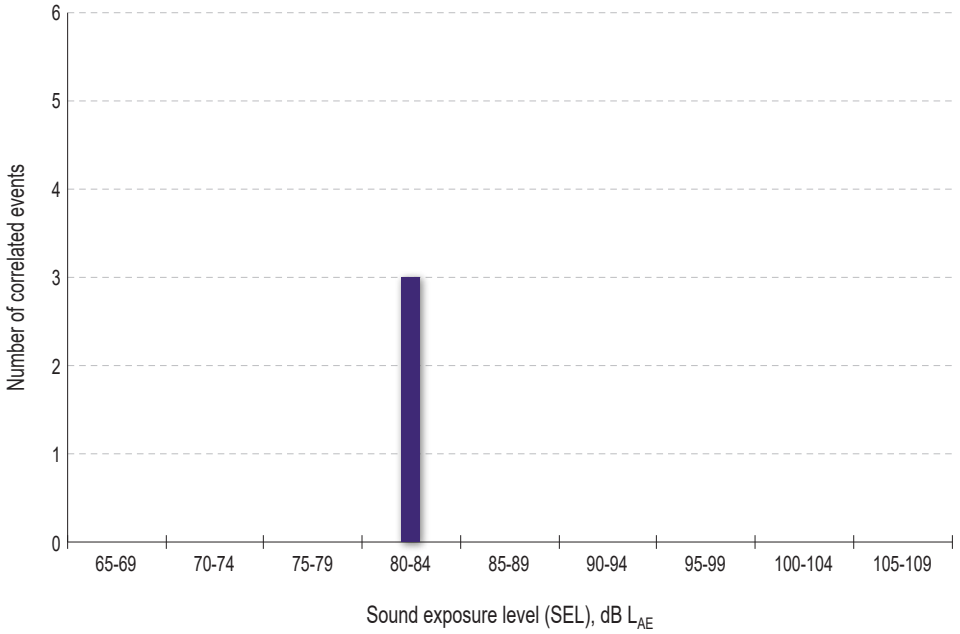
A1 Reference: 223486_04_GRA006.ai_1

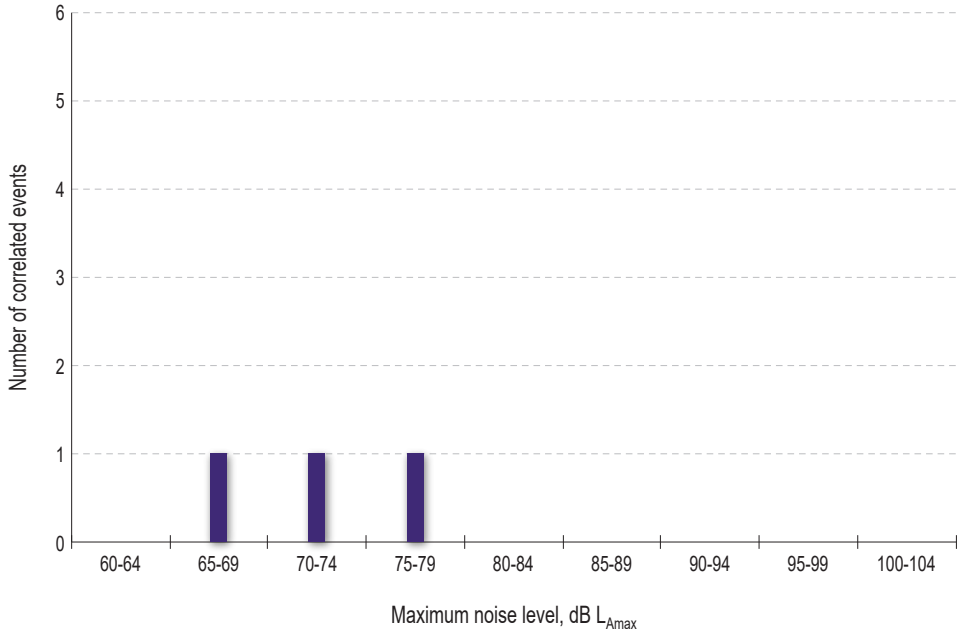




coffey A TETRA TECH COMPANY	Date: 11.11.2019 Project: 754-MELEN223496 File Name: 223496_04_F05.06_GRA	Department of Defence F-35A Aircraft Noise Effects on Fauna - Impact Report	Sound exposure levels and maximum noise levels of F-35A aircraft events at Swan Bay	Figure No: 5.6 DRAFT

AI Reference: 223496_04_GRA006.ai_1





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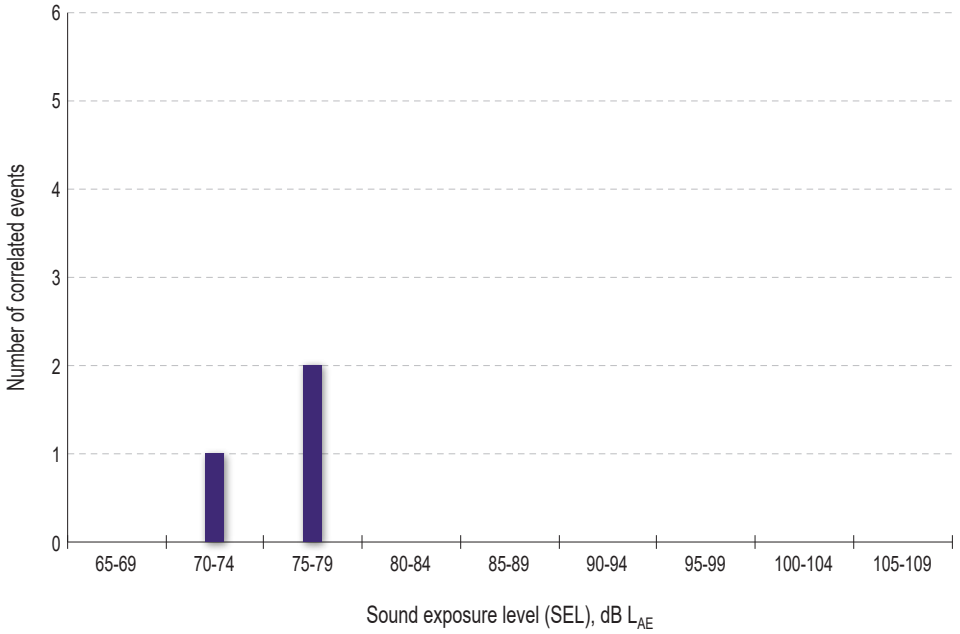
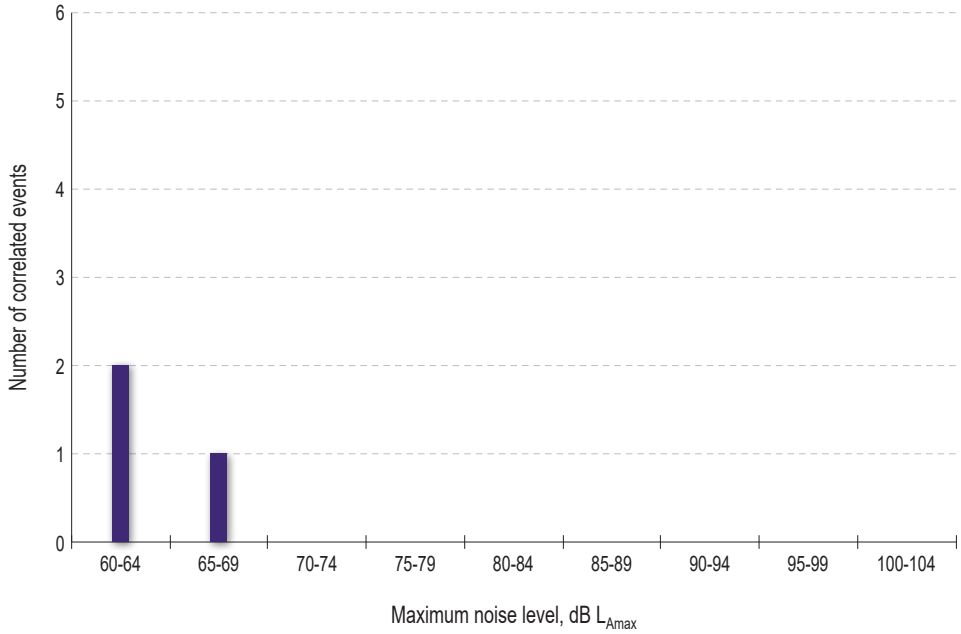
AI Reference: 223486_04_GRA006.ai_1





coffey A TETRA TECH COMPANY	Date: 11.11.2019 Project: 754-MELEN223496 File Name: 223496_04_F05.08_GRA	Department of Defence F-35A Aircraft Noise Effects on Fauna - Impact Report	Sound exposure levels and maximum noise levels of F-35A aircraft events at Cabbage Tree Island	Figure No: 5.8 DRAFT

AI Reference: 223486_04_GRA006.ai_1

5.2. Analysis

The FMP requires an analysis of baseline noise levels and F-35A aircraft noise levels obtained during the transition period noise survey to determine whether baseline noise levels were exceeded. An exceedance of baseline noise levels is defined as a significant difference between the average and 90th percentile of the L_{Amax} and SEL values of baseline and transition noise levels, where the difference represents an increase in noise levels above 70 dB L_{Amax} (Coffey, 2016).

A comparison of the measured baseline and transition period aircraft noise levels are presented in Table 5.2 and Table 5.3. A considerably lower number of correlated aircraft noise events were recorded during the transition survey period due to the limited number of F-35A aircraft movements and suitable pilots. The limited number of correlated F-35A aircraft noise events reduced the ability to conduct a meaningful comparison with F/A-18A/B Hornet aircraft noise events.

With the exception of Hexham Swamp, noise levels at the majority of monitoring locations did not exceed baseline noise levels by more than 3 dB. These increases are considered marginal given the range of measured aircraft noise levels. Noise level increases of more than 3 dB at monitoring locations with less than 10 correlated F-35A aircraft events were not considered exceedances due to the limited number of F-35A aircraft movements to compare to baseline noise levels.

Noise levels recorded at Hexham Swamp during the transition survey period were notably higher than baseline levels (see tables 5.2 and 5.3). However, this exceedance was attributed to differences in aircraft operations, such as arrival or departure, rather than differences between F/A-18A/B and F-35A aircraft.

During the baseline noise monitoring survey, F/A-18A/B Hornet aircraft were primarily conducting arrival operations near the Hexham Swamp monitoring location, which generally use a low power setting, therefore creating less noise when compared to departure operations. During the transition noise monitoring survey, F-35A aircraft were primarily conducting departure operations which may have been operating at a higher power setting and therefore releasing greater noise emissions.

Table 5.2 Change in sound exposure aircraft noise levels – baseline and transition period (SEL)

Location	No. correlated events		Average (dB)			90th percentile (dB)		
	Baseline	Transition	Baseline	Transition	Change	Baseline	Transition	Change
Fullerton Cove	243	33	79	80	+1	92	90	-2
Stockton Sandspit	129	29	86	83	-3	99	91	-8
Kooragang Island	74	9	80	83*	+3*	87	92*	+5*
Hexham Swamp	39	9	78	87*	+9*	87	95*	+8*
Tilligerry Nature Reserve	61	8	84	82*	-2*	91	87*	-4*
Swan Bay	30	15	79	81	+2	86	87	+1
Myall River (Pindimar)	40	3	81	82*	+1*	89	83*	-6*
Cabbage Tree Island	14	3	86	75*	-11*	88	77*	-11*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.

Table 5.3 Change in maximum aircraft noise levels – baseline and transition period (LAmax)

Location	No. correlated events		Average (dB)			90th percentile (dB)		
	Baseline	**Transition**	**Baseline**	**Transition**	**Change**	**Baseline**	**Transition**	**Change**
Fullerton Cove	243	33	69	70	+1	81	79	-2
Stockton Sandspit	129	29	76	73	-3	91	81	-10
Kooragang Island	74	9	70	71*	+1*	77	81*	+4*
Hexham Swamp	39	9	68	76*	+8*	78	83*	+5*
Tilligerry Nature Reserve	61	8	71	70*	-1*	80	75*	-5*
Swan Bay	30	15	68	69	+1	74	77	+3
Myall River (Pindimar)	40	3	71	73*	+2*	84	78*	-6*
Cabbage Tree Island	14	3	76	64*	-12*	79	68*	-11*

Note: * These values are based on a dataset with fewer than 10 noise events. These values are prone to be distorted by a single outlier datapoint, as the 90th percentile value was based on a single event with the highest noise levels.

In the absence of definitive noise level exceedances, a comparison of transition period noise levels and EIS noise modelling results (as referenced in Section 4.4.3 of the FMP) was not considered necessary. Additionally, at the two monitoring locations where noise levels were elevated, the F-35A aircraft flight paths were not consistent with those used in the EIS noise model. Therefore, there was no merit in comparing the predicted EIS noise modelling results with the operational noise at these locations during the transition period survey.

6. Conclusions

To implement the FMP, Defence conducted a baseline noise monitoring survey at eight locations and fauna observations at five locations prior to the commencement of F-35A aircraft flying operations. Subsequent noise monitoring was conducted at the same eight monitoring locations during F-35A aircraft operations to determine whether the operational aircraft noise levels exceeded baseline levels.

A considerably lower number of correlated aircraft noise events were recorded during the transition survey period due to the limited number of F-35A aircraft movements. The available data for the transition period does not demonstrate an exceedance of baseline noise levels.

Data analysis from Fullerton Cove, Stockton Sandspit and Swan Bay indicates no meaningful increase in F-35A aircraft noise emissions relative to the F/A-18A/B Hornet.

The low number of correlated F-35A aircraft noise events at Kooragang Island, Hexham Swamp, Tilligerry Nature Reserve, Myall River (Pindimar) and Cabbage Tree Island does not allow Coffey to definitively conclude that measured noise emissions are representative of future noise emissions.

Additional noise emission data at the five locations with less than 10 correlated events would allow for a more definitive analysis of the dataset. However, additional monitoring may not increase the amount of data enough for such an analysis, due to the ACG standard departure and recovery flight paths that normally avoid overflight of these areas.

While the FMP requires noise level monitoring, it is important to note that it is fauna response to aircraft operations/noise at specific locations that is the focus of the FMP. The separate Noise Flight Path Monitoring System, occurring over the next three years will provide updated data on noise levels correlated to the levels provided in the EIS by noise modelling. Defence reports on this condition annually to comply with Parts 1 and 3 of the ‘Conditions of Approval’ for the ‘Flying Operations of the F-35A Lightning II’.

Based on the data available and in accordance with the EIS approval conditions, specifically Condition 4C, further fauna behaviour monitoring and corrective strategies, i.e., Stage 4.2 ‘Post FAA noise measurement and fauna observation’ is not deemed necessary at this stage.

If material noise emission exceedances are identified between the F-35A aircraft and those predicted by the EIS during the first two years of F-35A flying operations, additional noise monitoring and bird observations at sensitive environmental locations may be warranted.

7. References

Coffey. 2014. Draft environmental impact statement for flying operations of the F-35A Lightning II. Prepared for Department of Defence, Canberra, Australia.

Coffey. 2016. Fauna management plan: RAAF Base Williamtown flying operations of the F-35A Lightning II. Prepared for Department of Defence, Canberra, Australia.

Coffey. 2019. F-35A Aircraft Noise Effects on Fauna Baseline Report. Prepared for Department of Defence, Canberra, Australia.

Department of the Environment. 2015. National Flying-fox monitoring viewer. An interactive database accessed on 9 November 2015 and 12 March 2019 at http://www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf. Database maintained by Commonwealth of Australia, Canberra, Australia.

GHD. 2007. Introduction of the Hawk Lead-In-Fighter at RAAF Base Williamtown and Salt Ash Air Weapons Range, Environmental Status Report, Revision 2. Prepared for Department of Defence, Newcastle, Australia.

International Organisation for Standardisation. 2017. Acoustics – Description, measurement and assessment of Environmental Noise – Part 2: Determination of Sound Pressure Levels, ISO 1996-2:2017.

MDA. 2019. Monitoring and Documenting F-35A Noise Effects on Fauna Transition Period Noise Survey. Marshall Day Acoustics. Prepared for Coffey Services, Adelaide, Australia.

SKM. 2009. Operation of the JSF Aircraft as New Air Combat Capability (NACC) at RAAF Base Williamtown. Draft Public Environment Report prepared for Department of Defence. Melbourne, Victoria.

Standards Australia/International Electrotechnical Commission. 2004. Electroacoustics - Sound Level Meters - Part 1: Specifications, AS IEC 61672-1.

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Appendix A

Transition Period Noise Survey

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MARSHALL DAY Acoustics

MONITORING AND DOCUMENTING F-35A NOISE EFFECTS ON FAUNA TRANSITION PERIOD NOISE SURVEY

Rp 002 20181180 | 2 March 2020

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Project: **MONITORING AND DOCUMENTING F-35A NOISE EFFECTS ON FAUNA**
Transition Period Noise Survey

Prepared for: **Coffey Environments Australia Pty Ltd**
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Attention: **Mr Mark Pendlebury**

Report No.: **Rp 002 20181180**

Document Control

Status:	Ver:	Comments	Date:	Author:	Reviewer:
Final	01	Issued	2 March 2020	A. Morabito/L. Deen	J. Adcock

EXECUTIVE SUMMARY

The Department of the Environment's approval decision on the flying operations of the F-35A aircraft, dated 10 July 2015, includes conditions concerning noise levels and fauna impacts around RAAF Base Williamtown and Salt Ash Air Weapons Range.

Condition 4 of the approval decision requires the Department of Defence to prepare and implement a Fauna Management Plan (FMP).

A FMP prepared on behalf of the Department of Defence and was subsequently approved by the Commonwealth Department of the Environment.

The FMP requires an assessment of the change in measured aircraft noise levels at selected environmentally sensitive locations around RAAF Base Williamtown and Salt Ash Air Weapons Range as a result of the transition from current aircraft (F/A-18A/B Hornet) to future aircraft (F-35A) operations.

Noise levels from baseline aircraft operations (F/A-18A/B Hornet) were measured at eight (8) locations which were selected to represent environmentally sensitive locations around RAAF Base Williamtown and Salt Ash Air Weapons Range, between November 2018 and January 2019 (baseline noise survey). The noise of F-35A aircraft operations during the F-35A aircraft transition phase have since been measured as part of a transition period survey at the same locations, between June 2019 and September 2019 (transition period noise survey).

Radar data from RAAF Base Williamtown's permanent Noise and Flight Path Monitoring System was used to correlate measured aircraft noise levels with the corresponding aircraft type and operation at each monitoring location.

A summary of the F/A-18A/B Hornet noise level data obtained during the baseline noise survey is detailed in Table 1.

Table 1: Summary of F/A-18A/B aircraft noise levels – baseline survey, dB

Location	Number of correlated events	SEL	L_{ASmax}
		Mean / 90th percentile	Mean / 90th percentile
Fullerton Cove	243	79 / 92	69 / 81
Stockton Sandspit	129	86 / 99	76 / 91
Kooragang Island	74	80 / 87	70 / 77
Hexham Swamp	39	78 / 87	68 / 78
Tilligerry	61	84 / 91	71 / 80
Swan Bay	30	79 / 86	68 / 74
Myall River (Pindimar)	40	81 / 89	71 / 84
Cabbage Tree Island	14	86 / 88	76 / 79

A summary of the F-35A aircraft noise level data obtained during the transition period noise survey is detailed in Table 2. The data in Table 2 indicates a considerably lower number of correlated events during the transition period survey compared with the baseline survey, despite the increased survey duration. This is due to the low number of F-35A aircraft based at RAAF Base Williamtown and the low rate of movements that currently occur.

Table 2: Summary of F-35A aircraft noise levels – transition period survey, dB

Location	Number of correlated events	SEL	L_{ASmax}
		Mean / 90th percentile	Mean / 90th percentile
Fullerton Cove	32	80 / 90	70 / 79
Stockton Sandspit	29	83 / 91	73 / 81
Kooragang Island	9	(83 / 92)	(71 / 81)
Hexham Swamp	9	(87 / 95)	(76 / 83)
Tilligerry	8	(82 / 87)	(70 / 75)
Swan Bay	15	81 / 87	69 / 77
Myall River (Pindimar)	3	(82 / 83)	(73 / 78)
Cabbage Tree Island	3	(75 / 77)	(64 / 68)

Note: The values in brackets indicate values based on a dataset with fewer than 10 events. Accordingly, these values are more prone to be distorted by a single outlier datapoint, e.g. the 90th percentile of fewer than 10 events will depend on a single value.

The two datasets were then compared to determine if an increase in aircraft noise levels had occurred at the environmentally sensitive locations following the commencement of F-35A aircraft flying operations.

An analysis of the two datasets was undertaken for each monitoring location. The analysis was primarily used as a tool for illustrating variation in levels and to determine whether any observed change in the mean or 90th percentile measured noise values indicated a likeliness of a difference in noise levels between the two (2) aircraft types and for comparable operations.

In general, differences in the measured mean and 90th percentile aircraft noise levels were observed. However, the following is noted and has been considered when comparing the datasets:

- There is a considerable difference in the number of correlated events measured during the baseline and transition period surveys
  - At locations where the most data were obtained (Fullerton Cove, Stockton Sandspit and Swan Bay), the increase (where applicable) in noise levels are less than 3 dB;
  - There is larger variation in the difference in noise levels at locations with fewer data points;
- Environmental aircraft noise levels are inherently variable due to changes in aircraft operating patterns (flight profiles and paths), aircraft procedures, and atmospheric conditions that influence sound propagation
  - Differences in the flight track, movement patterns and operation type at locations with fewer correlated events or where the datasets primarily compare different operations between the two datasets are the primary reason for differences in aircraft noise levels;
  - Changes in noise level of the order of 3 dB or less is generally not considered significant when considered in the broader range of typical level variation influencing sound propagation.

The difference in flight tracks, operation type, likely power settings and hence aircraft noise levels between the two datasets means that it is not possible to conclude whether there is a system difference in noise levels associated with like-for like operations of the two aircraft. The differences are primarily indicative of variation in noise levels associated with different operations flown during the respective surveys rather than aircraft type.

The available data for the transition period does not demonstrate an exceedance of the baseline data and hence the need for further noise measurements and concurrent fauna observations as detailed in Stage 4.2 of the FMP.

However, as a result of the difference in the operations occurring during the baseline and transition period surveys, combined within the limited number of events identified at the majority of locations during the transition period survey, it is not possible to conclude that this outcome is representative of other operating conditions. The FMP does not provide any guidance on the actions to be undertaken for such circumstances. Further noise monitoring, preferably at a time of when a greater number of F-35A aircraft numbers and movements are expected, would be required to definitively compare F-35A noise levels to the results of the baseline period survey.

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1.0 INTRODUCTION

The Department of the Environment's approval decision on the Environmental Impact Statement for the flying operations of the F-35A Lightning II aircraft, dated 10 July 2015, includes conditions concerning the potential effect of noise levels on environmentally sensitive species. Specifically, Condition 4 of the approval includes a requirement that Defence prepare and implement a Fauna Management Plan (FMP).

A FMP was prepared on behalf of the Department of Defence and was subsequently approved by the Commonwealth Department of the Environment.

The FMP requires an assessment of the change in measured noise levels at selected environmentally sensitive locations around RAAF Base Williamtown (the Base) and Salt Ash Air Weapons Range (SAAWR) as a result of the transition from current aircraft (F/A-18A/B Hornet) to future aircraft (F-35A) operations.

Baseline noise levels from current aircraft operations (F/A-18A/B Hornet) were measured at the selected environmentally sensitive locations around the Base and SAAWR prior to the commencement of F-35A aircraft flying operations. The baseline noise level survey was undertaken between November 2018 and January 2019, with details provided in the 2019 report (Marshall Day Acoustics). The baseline noise level survey findings are referred to herein.

Noise levels from F-35A aircraft operations during the transition phase have since been measured as part of a transition period survey. This report details the transition period noise levels from F-35A aircraft operations at the eight (8) identified environmentally sensitive locations around the Base between June 2019 and September 2019. The noise level data was cross referenced with flight track and radar data from The Base's permanent Noise and Flight Path Monitoring System to correlate measured aircraft noise levels with the corresponding aircraft type and operation at each location.

The transition period noise levels have then been compared with the baseline noise survey to determine if differences in F-35A aircraft noise levels relative to F/A-18A/B Hornet aircraft noise levels are statistically significant (as per the FMP). In accordance with the FMP, where there are instances in which an increase in noise levels are able to be determined from the measurements, the data is compared with the predicted noise levels presented in the EIS.

This report presents a summary of the transition period noise level measurement method and measured noise levels, and a comparison of the measured noise levels made during the transition period survey against those measured during the baseline survey.

A glossary of acoustic terminology used throughout this report is provided in Appendix A.

A list of referenced documents throughout this report is provided in Appendix B.

2.0 TRANSITION PERIOD NOISE SURVEY

The transition period noise monitoring survey has been conducted in accordance with the *Fauna Management Plan* (FMP) (Coffey Environments Australia Pty Ltd, 2016) and the baseline noise survey (Marshall Day Acoustics, 2019).

This section of the report presents:

- An overview of the survey method; and
- Details of the selected noise monitoring locations.

2.1 Method

The survey method comprised monitoring noise levels for a minimum period of two (2) months and correlating the measured noise levels with aircraft flight track and radar data.

The survey was conducted between 19 June 2019 and 24 September 2019 (approximately 14 weeks). This period was nominated by the Department of Defence to achieve the minimum required survey period of two (2) months, but was extended in duration to account for the limited number of F-35A aircraft and hence limited number of current operations at the Base. It is understood that there were four (4) F-35A aircraft operational at the Base during the survey period.

Noise monitors were deployed to continuously measure noise levels at the eight (8) identified environmentally sensitive locations around the Base and SAAWR specified in the FMP. Two weather stations were also deployed to identify periods when wind and rainfall may have significantly influenced the measured noise levels. Full details of the noise monitoring and weather instrumentation is provided in Appendix C.

The aircraft flight track and radar data was supplied by EMS Brüel & Kjær (responsible for the management of the Base's permanent Noise and Flight Path Monitoring System on behalf of the Department of Defence) following the noise monitoring survey.

This radar data included references to aircraft type, runway, nominal operation type (arrival, departure, touch and go), altitude and airspeed. This information was used to establish the time and the distance of closest approach of the aircraft to the noise monitors for each correlated aircraft event.

2.2 Monitoring locations

The transition period noise monitoring survey was carried out at the eight (8) environmentally sensitive locations identified in the FMP. These locations were identified in the FMP as being areas known to provide critical habitat to key species of interest and where the predicted noise levels of from F-35A aircraft operations indicated increases in the 70 dB L_{ASmax} contour extent, relative to F/A-18A/B Hornet operations around the Base and SAAWR.

The FMP identified representative noise monitoring sites for each environmentally sensitive location with consideration of the following:

- The general noise environment, specifically avoiding areas affected by anthropogenic noise (e.g. existing traffic, industry) or natural noise (including wind in trees, ocean, frogs, insects etc) sources where possible;
- The ambient noise and whether it is likely to vary significantly across the area, given the single but large monitoring area of interest;
- Avoiding any transient swamp or estuary conditions, noting changes from dry ground to swamped conditions affects ground reflected aircraft noise;

- Located within 500 m of the site co-ordinates nominated within the FMP. It is however noted, only five of the eight nominated monitoring sites in the FMP provided reference co-ordinates. Based on practical limitations, there were instances where the noise monitoring location was not within 500 m of the co-ordinates nominated within the FMP. The noise monitoring locations were selected on the basis that it was representative of noise levels at the relevant fauna observation location. Furthermore, the noise monitoring site would be representative of a location where the change in noise levels between the fauna observation and noise monitoring locations would be consistent;
- Located at least 3 m away from any dwellings or significant vertical reflecting structures; and
- The microphone height was at least 4 m above ground level where local equipment siting arrangements permitted, to minimise interference effects with ground reflections.

The noise monitors for the transition period noise survey were located at the same locations as those during the baseline survey, with the exception of the following and as described in Appendix C:

- Cabbage Tree Island: located 80 m north of baseline survey location due to re-evaluation of access to a safer monitoring location and a site less affected by extraneous noise; and
- Tilligerry: located 250 m south of baseline survey location due to sun shading issues affecting the solar panel. There was also a request from the site owner to relocate the unit to a less trafficable location.

The revised noise monitoring locations were selected on the basis that it was representative of noise levels at the location used for the baseline survey. The sites are therefore representative of a location where the change in noise levels between the baseline and transition period noise monitoring locations would be consistent.

Details of the noise monitoring locations are provided in Table 3 and are shown relative to the Base and SAAWR in Figure 1.

Table 3: Transition period noise monitoring locations

Location name	Description	Direction and distance from the Base
Fullerton Cove [1]	Private land located on Fullerton Cove Road Fullerton Cove	6.5 km south-south-west
Stockton Sandspit	Stockton Centre, east site boundary	10 km south-south-west
Kooragang Island	Private land, located on Tomago Road, Tomago	11 km west-south-west
Hexham Swamp	Private land, Woodsland Close Hexham	15 km west-south-west
Tilligerry	Research Drive, Taylor Beach	21 km east-north-east
Swan Bay [1]	Private land, located on Swan Bay Road Swan Bay	16.5 km north-east
Myall River (Pindimar)	Private land, located on Cunningham Street Pindabah	27 km north-east
Cabbage Tree Island	Restricted island only accessible by NSW National Parks and Wildlife Service	38 km east-north-east

Notes (1) Weather station also installed with noise monitor

Photographs of the noise monitoring location and surrounds are provided in Appendix D.

Figure 1: Noise monitoring locations (Basemap: Esri World Imagery)

3.0 EVENT CORRELATION METHOD

This section presents an overview of the correlation method, including details of the procedures used to identify aircraft noise events and correlate these events with the aircraft flight track and radar data.

3.1 Ambient noise conditions

The process of identifying aircraft noise events in the noise measurement data involves identifying characteristics of the measured aircraft noise levels that are distinct from ambient noise. Aircraft noise events are generally characterised by the progressive rise and fall in noise level associated with an aircraft overflight.

It is therefore necessary to characterise ambient noise levels in the absence of aircraft movements. This information is used to inform the selection of suitable noise level thresholds for defining periods in which an aircraft noise overflight is likely to have occurred (e.g. thresholds defined on the basis of a noise level being exceeded for a minimum period of time).

Based on observations during deployment and retrieval of the noise monitoring equipment, and sample inspections of the measured levels and audio records, Table 4 presents a summary of the typical ambient noise levels and sources at each noise monitor location.

Table 4: Description of typical ambient noise environment

Location	Typical ambient noise levels	Observations
Fullerton Cove	45 to 55 dB L_{Aeq} during day 35 to 40 dB L_{Aeq} at night	Noise from birds resulted in typical noise levels of approximately 50 dB L_{Aeq}. Typical traffic noise in the vicinity resulted in typical noise levels of 45 to 55 dB $L_{Aeq.}$ During monitor deployment, military fast jets could be heard and seen departing the Base at this location.
Stockton Sandspit	50 to 55 dB L_{Aeq} during day 40 to 50 dB L_{Aeq} at night	Stockton Centre maintenance workshop activity and distant noise from beach present at the time of deployment.
Kooragang Island	50 to 60 dB L_{Aeq} during day 40 to 50 dB L_{Aeq} at night	Noise from nearby industry occasionally ranged between 60 to 70 dB L_{Aeq}
Hexham Swamp	50 to 55 dB L_{Aeq} during day 40 to 50 dB L_{Aeq} at night	Occasional noise from distant train pass-bys increased short term noise levels up to 60 dB L_{Aeq}.
Tilligerry	50 to 55 dB L_{Aeq} during the day 45 to 50 dB L_{Aeq} at night	Some anthropogenic noise from activity elsewhere on site present at the time of deployment.
Swan Bay	40 to 50 dB L_{Aeq} during day 25 to 40 dB L_{Aeq} at night	Wildlife noise including birds, bats and frogs resulted in noise levels of 45 to 50 dB L_{Aeq} at times.
Myall River (Pindimar)	45 to 50 dB L_{Aeq} during day 30 to 40 dB L_{Aeq} at night	Noise from flocking birds would increase noise levels up to 60 dB L_{Aeq} for periods of 1 – 2 hours.
Cabbage Tree Island	45 to 50 dB L_{Aeq} during day and night	Ambient noise was most often dominated by noise from wind. Surf noise from the coast was also a prominent noise source depending on weather conditions.

3.2 Identification of aircraft operations

A list of identified potential aircraft noise events was generated for each noise monitoring location, using an automatic coding process based on the measured noise levels. This list was subsequently cross referenced with an analysis of the aircraft flight path data from the Base's permanent radar system. Broadly, the analysis of the aircraft flight path data involved dividing each recorded flight path into discrete flight segments to enable the isolation of times and sections which coincided with identified aircraft events.

Details of the identification of aircraft operations are provided in Appendix E, including further details of the analysis of the radar and flight track data to define flight segments.

The outcome of this process was a set of aircraft flight segments close to the noise monitors to be cross-referenced with the potential aircraft noise events identified from the noise monitor data.

3.3 Noise event and aircraft data correlation

To correlate flight segments with aircraft noise events, the time stamps for the two datasets were compared. Where a potential aircraft noise event occurred within a 60 second window of a flight segment, the two data entries were paired. Once a potential aircraft noise event had been paired with a flight segment, the noise event could not be paired again with another flight segment.

Noise events that did not correlate to a radar aircraft event segment within a given time window or monitor distance were considered extraneous events and therefore excluded from further analysis.

Similarly, aircraft flight segments that were not paired with a noise event were assumed to have not generated a distinct and steady rise and fall in noise level above other ambient noise present at the time and were therefore excluded from further analysis.

The outcome of this process was a set of noise events that correlated with a proximate aircraft movement.

3.4 Weather conditions

Noise monitoring data during days of high winds and significant rain requires a review and the possible exclusion from the analysis to avoid aircraft noise level measurements being contaminated by extraneous or elevated noise related to the following:

- Wind-induced microphone noise;
- Wind-disturbed vegetation; and
- Rain noise.

For the baseline noise survey, data from the Bureau of Meteorology's (BoM) permanent Williamtown weather station as well as data from weather stations installed with the noise monitors at Fullerton Cove and Swan Bay was reviewed and days of inclement weather conditions were identified. A threshold of 5 m/s average windspeed and the presence of rainfall greater than 1 mm/hour at the noise monitoring locations was generally considered when excluding noise data. Noise data captured on these days was excluded from the baseline results.

However, for the transition period noise survey, there were relatively few correlated F-35A aircraft noise events. This allowed each correlated event to be individually reviewed for evidence of ambient noise that may have affected the measured aircraft noise level. Where there was evidence that the correlated noise event was influenced by ambient or other extraneous noise, the event was excluded from the analysis.

The exception to the above were the correlated events measured at Fullerton Cove. At this particular location, there was a significantly higher number of measured noise events identified by the automated identification routine than suggested by movement data. This was an indication that extraneous noise influences were present at this location.

To evaluate and confirm if the data was affected by extraneous noise, the weather station installed at that noise monitor was reviewed in conjunction with a review of general daily ambient noise levels. The review identified that additional identified events were most likely to be attributable to the presence of persistent and high speed winds, i.e. average windspeeds above 10 m/s.

The days removed from the analysis on this basis are detailed in Table 3.

Table 3: Dates of excluded data from analysis due to periods of extraneous noise affecting measurements

Noise monitoring location	July 2019	August 2019	September 2019
Fullerton Cove	11, 12, 13	8, 9, 10, 11, 12, 16, 17, 19, 20, 21, 24, 25, 26, 27, 29, 30, 31	1, 2, 7, 8, 9, 10, 12, 14, 16, 17, 18

4.0 TRANSITION PERIOD SURVEY RESULTS

This section provides a summary of the correlated F-35A aircraft noise levels and number of events for the transition period survey at each noise monitoring location.

The attached spreadsheet in Appendix F includes tables of all the individual correlated aircraft noise level measurements for each location. It is noted that during the transition period noise survey, additional data on F/A-18A/B Hornet aircraft operations was obtained. The data analysed and documented in the noise survey report (Marshall Day Acoustics, 2019) provides the baseline data for assessing the change in noise levels during the transition period. Accordingly, the additional F/A-18A/B Hornet data has not been analysed or assessed as part of this study.

It is understood programmed F-35A aircraft flying operations during the survey were conducted as per the proposed long-term ongoing flying program of future squadrons, without modification or changes to flying operations or flight paths. That is, F-35A aircraft flying operations during the transition period survey were understood to be representative of the flight procedures to be adopted following the transition from F/A-18A/B Hornet aircraft to full F-35A aircraft operations (subject to the inherent variations of military fast jet operating patterns).

4.1 Summary information

Table 5 presents a high-level summary of the correlated F-35A aircraft noise levels and number of events for all operation types at varying distances. The data is based on the event correlation method as described in Section 3.0.

Consistent with the FMP requirements and the baseline data previously presented for the F/A-18A/B Hornet, the transition period noise level information is provided in terms of the mean and the 90th percentile for both the sound exposure level (SEL) and maximum noise level (L_{ASmax}) at each monitoring location.

Table 5: Summary of F-35A aircraft noise levels – transition period survey

Location	Number of correlated events	SEL	L_{ASmax}
		Mean / 90th percentile	Mean / 90th percentile
Fullerton Cove	32	80 / 90	70 / 79
Stockton Sandspit	29	83 / 91	73 / 81
Kooragang Island	9	(83 / 92)	(71 / 81)
Hexham Swamp	9	(87 / 95)	(76 / 83)
Tilligerry	8	(82 / 87)	(70 / 75)
Swan Bay	15	81 / 87	69 / 77
Myall River (Pindimar)	3	(82 / 83)	(73 / 78)
Cabbage Tree Island	3	(75 / 77)	(64 / 68)

Note: The values in brackets indicate values based on a dataset with fewer than 10 events. Accordingly, these values are more prone to be distorted by a single outlier datapoint, e.g. the 90th percentile of fewer than 10 events will depend on a single value.

4.2 Monitoring data

The following section details noise level event histograms at each noise monitoring location. The histograms are used to graphically present the frequency of F-35A aircraft events and respective range of noise levels.

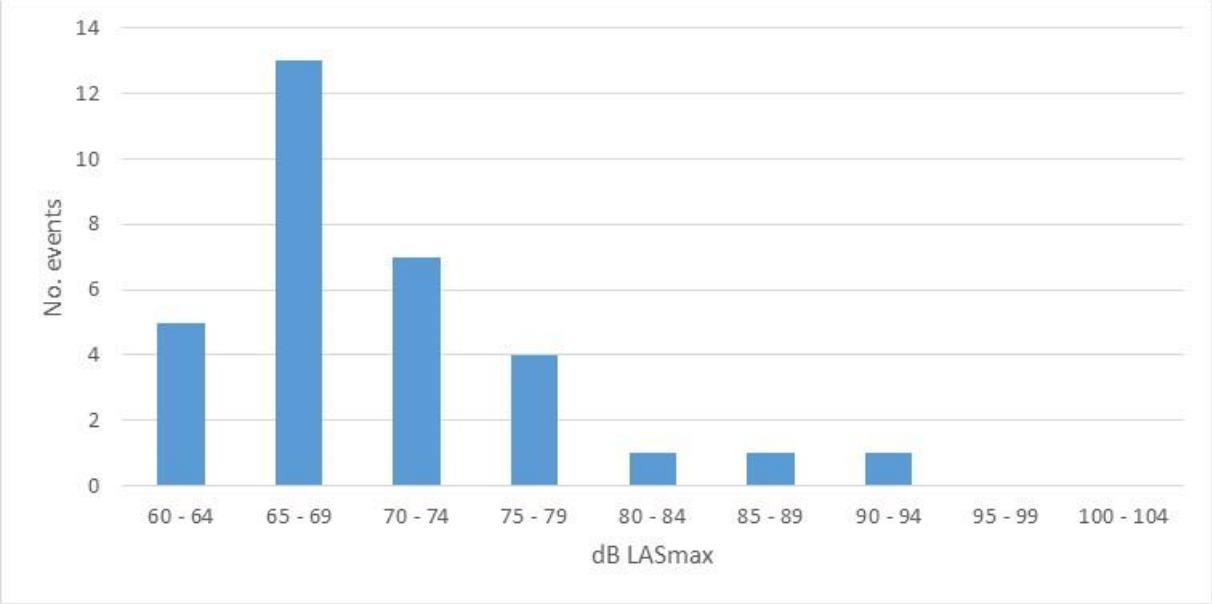
Two histograms are provided for each noise monitoring location, detailing the range of measured SEL and L_{ASmax} values.

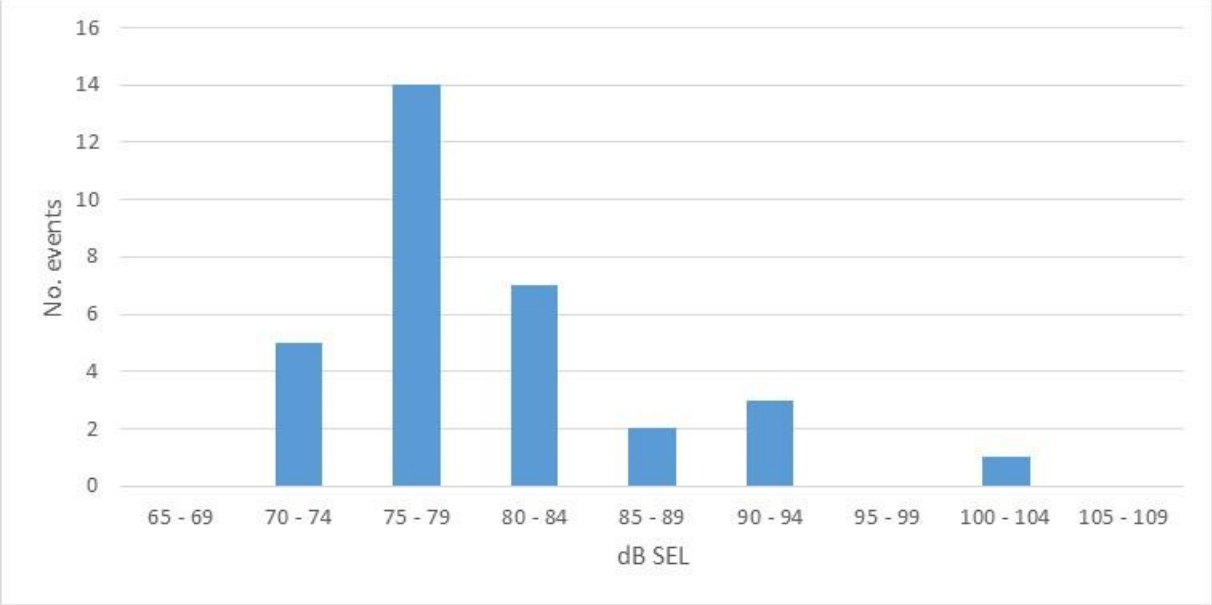
The presence of high ambient noise at six (6) of the eight (8) monitoring sites limited the number of low noise level events that could be identified. As the focus of the noise monitoring was at locations where predicted noise levels associated with future F-35A aircraft operations were greater than 70 dB L_{ASmax}, and to allow for nominal uncertainty in measurements, aircraft noise events with a maximum noise level less than 60 dB L_{ASmax} have been excluded from the dataset.

4.2.1 Fullerton Cove

Figure 2 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Fullerton Cove monitoring location.

Figure 2: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

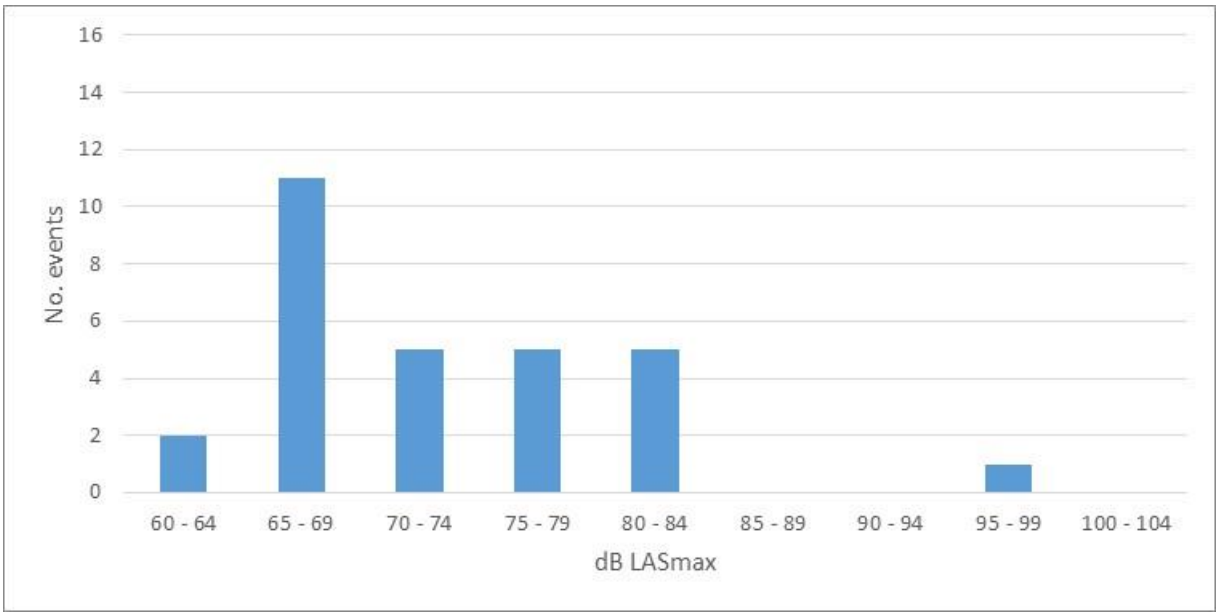


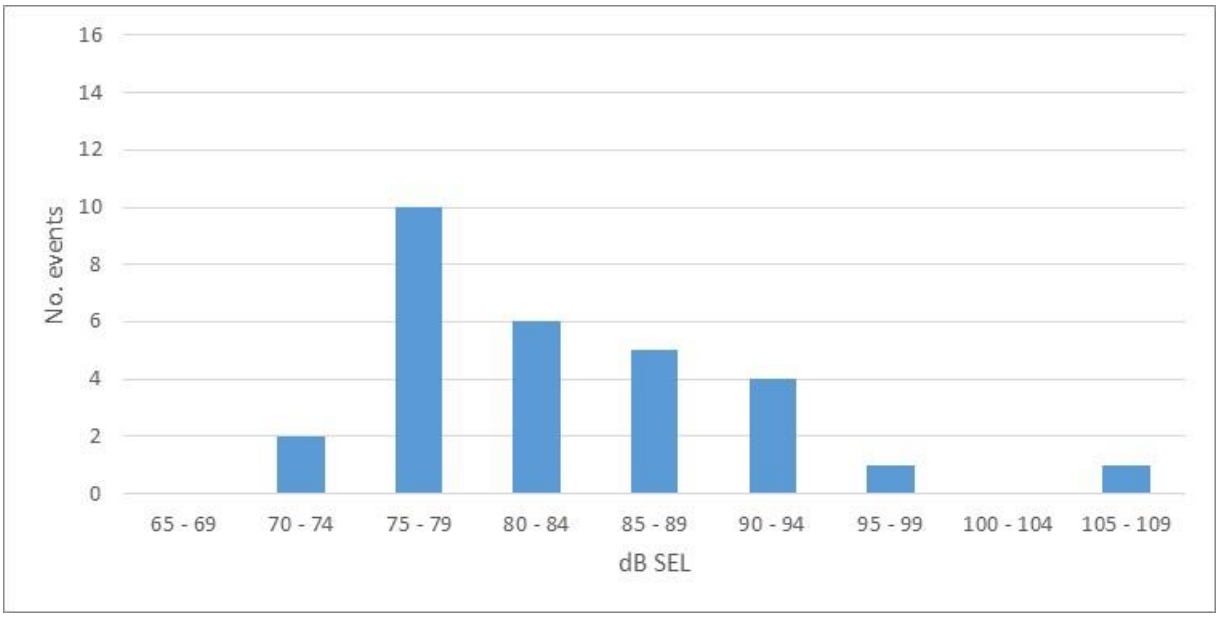


4.2.2 Stockton Sandspit

Figure 3 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Stockton Sandspit monitoring location.

Figure 3: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

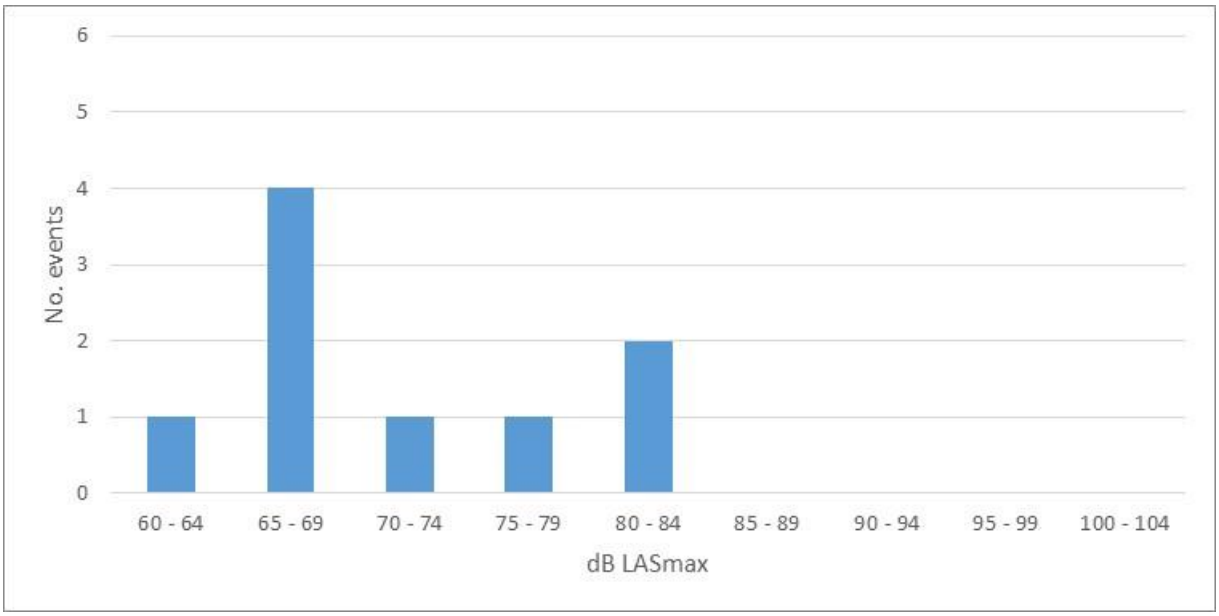


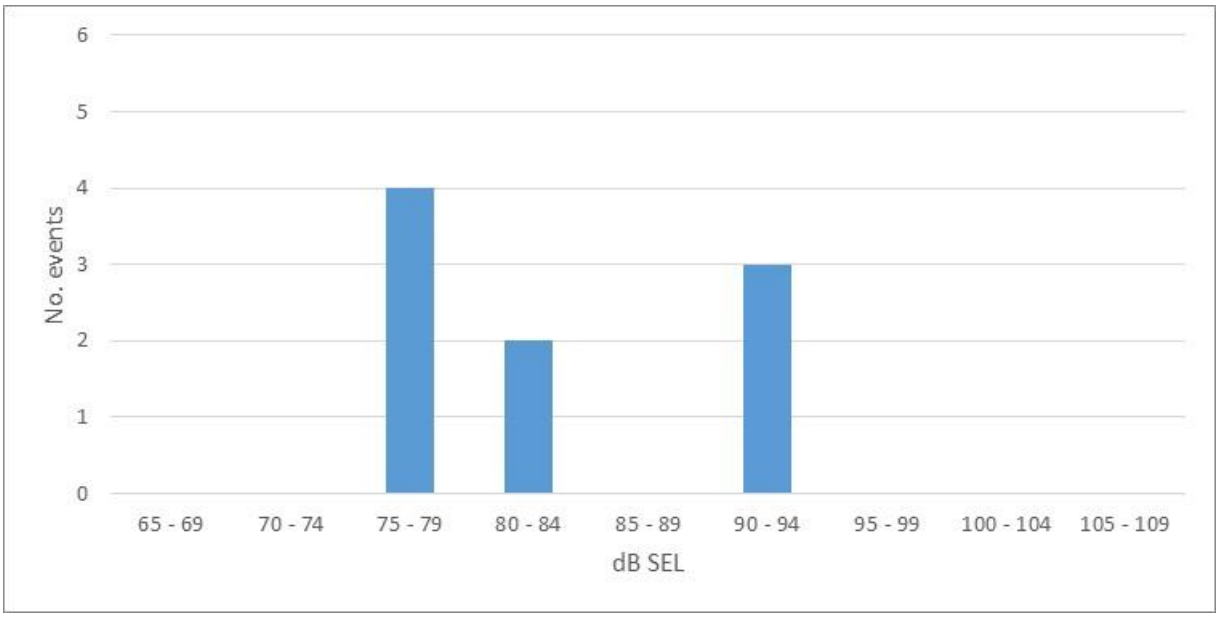


4.2.3 Kooragang Island

Figure 4 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Kooragang Island monitoring location.

Figure 4: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

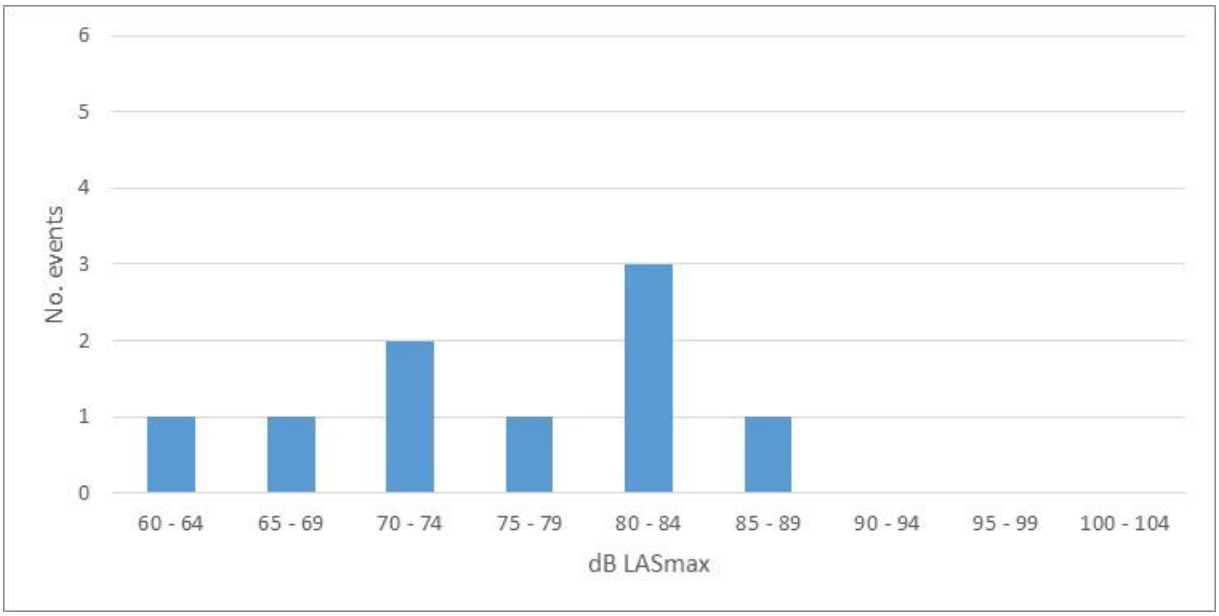


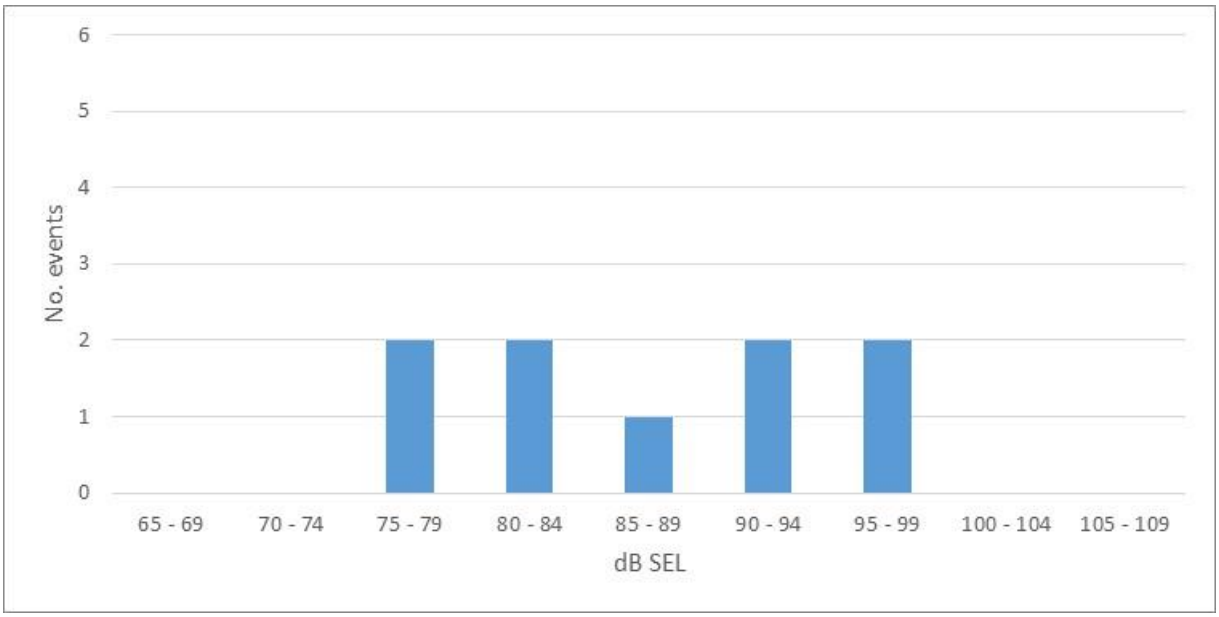


4.2.4 Hexham Swamp

Figure 5 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Hexham Swamp monitoring location.

Figure 5: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

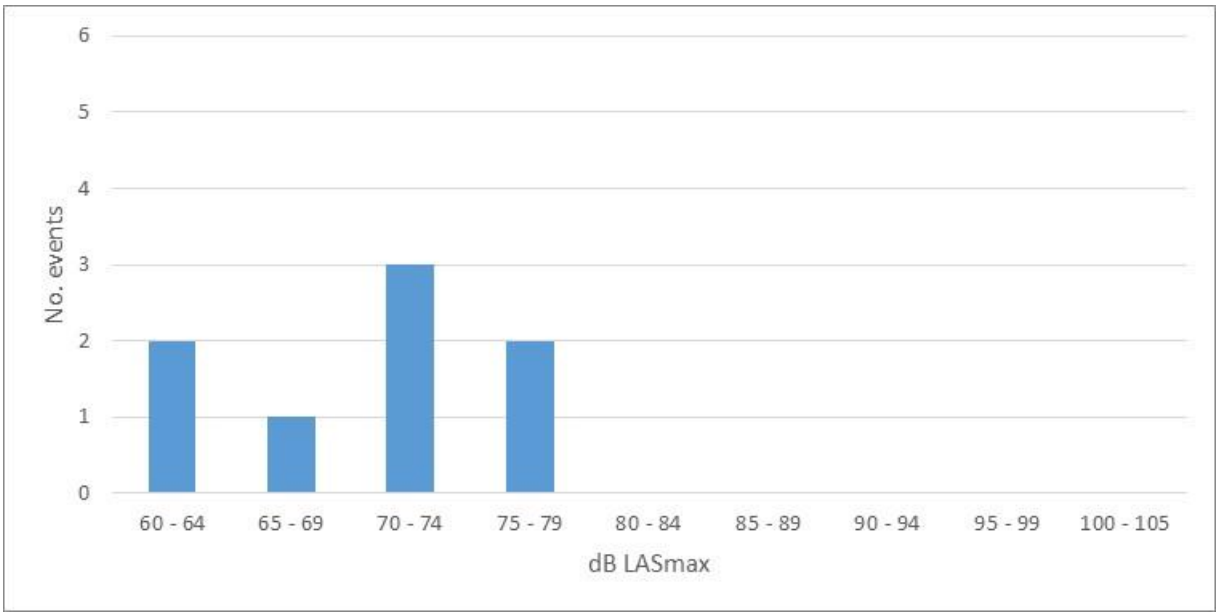


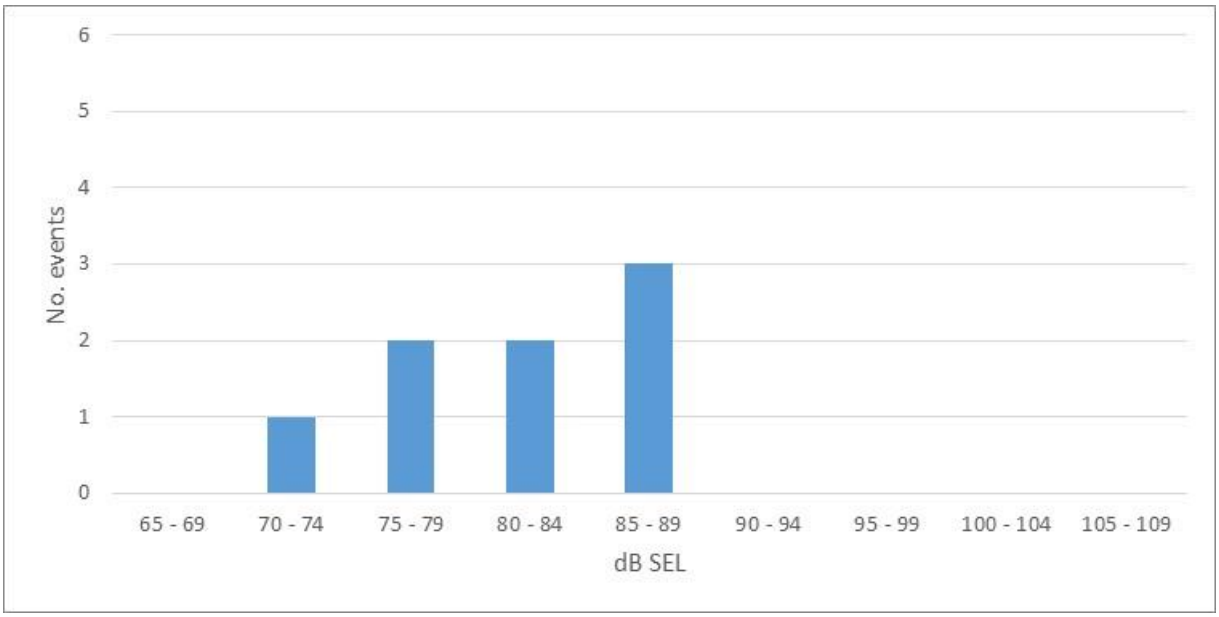


4.2.5 Tilligerry

Figure 6 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Tilligerry monitoring location.

Figure 6: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

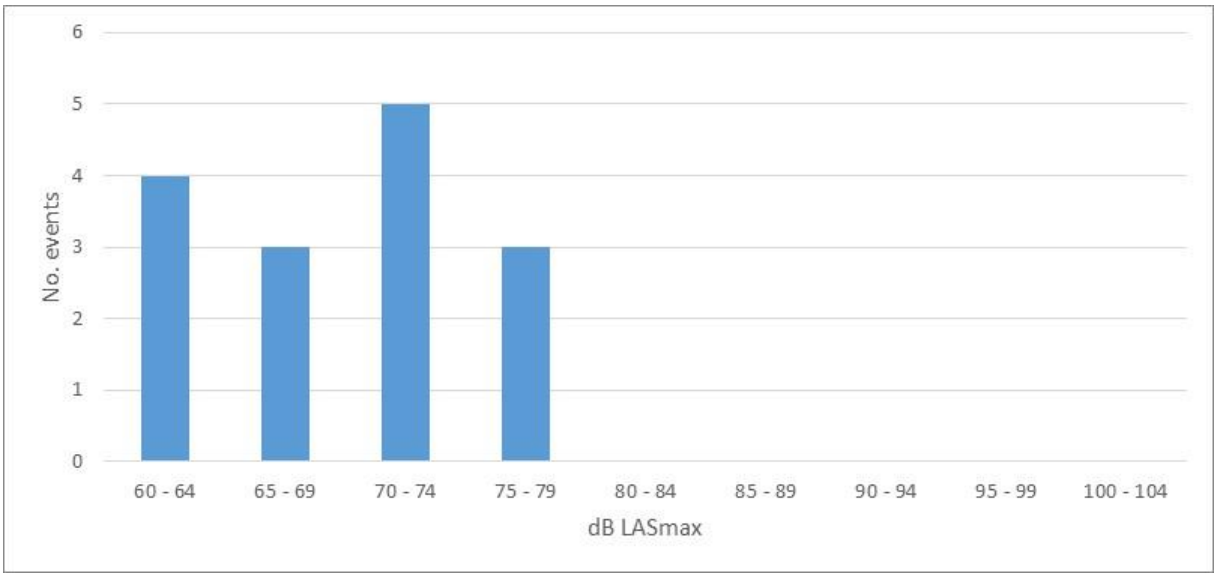


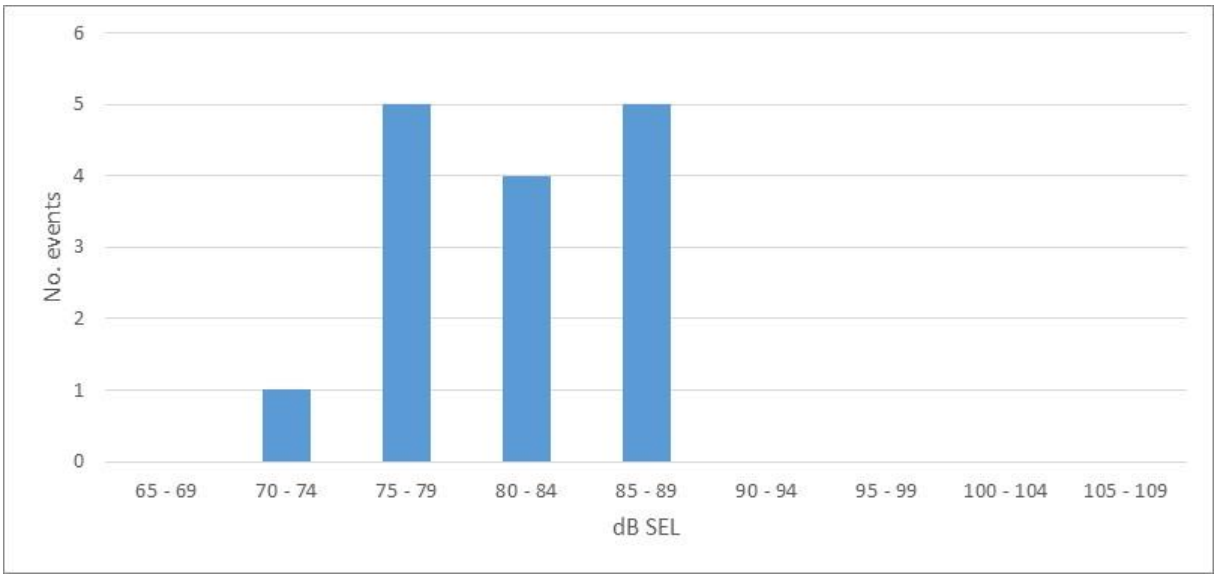


4.2.6 Swan Bay

Figure 7 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Swan Bay monitoring location.

Figure 7: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

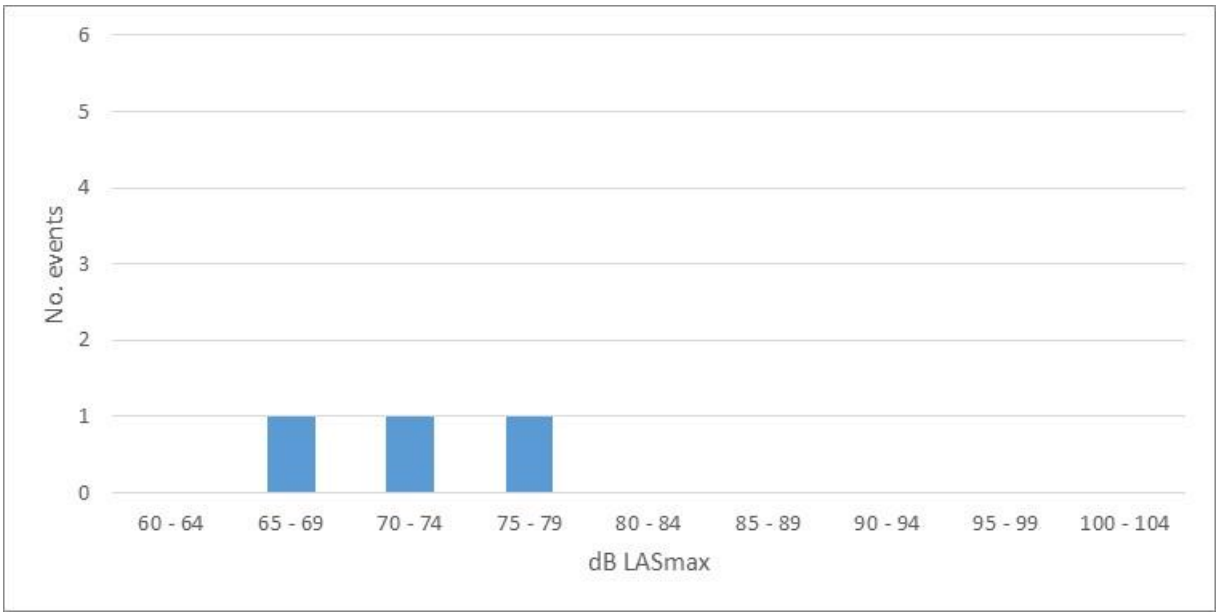


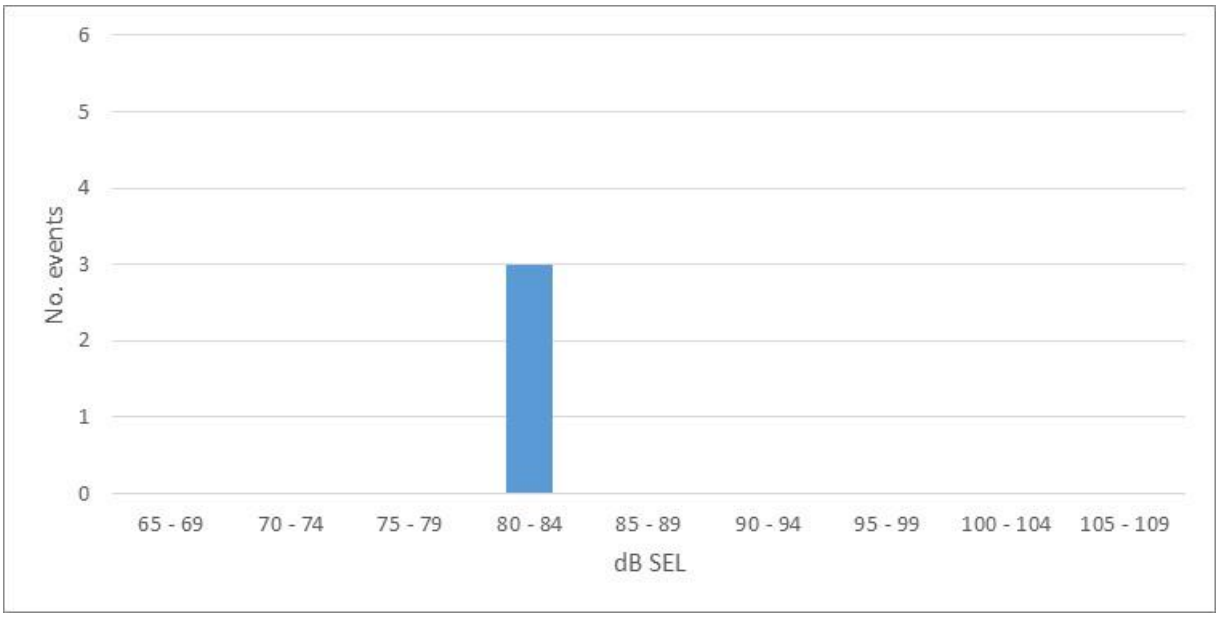


4.2.7 Myall River (Pindimar)

Figure 8 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Myall River monitoring location.

Figure 8: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events

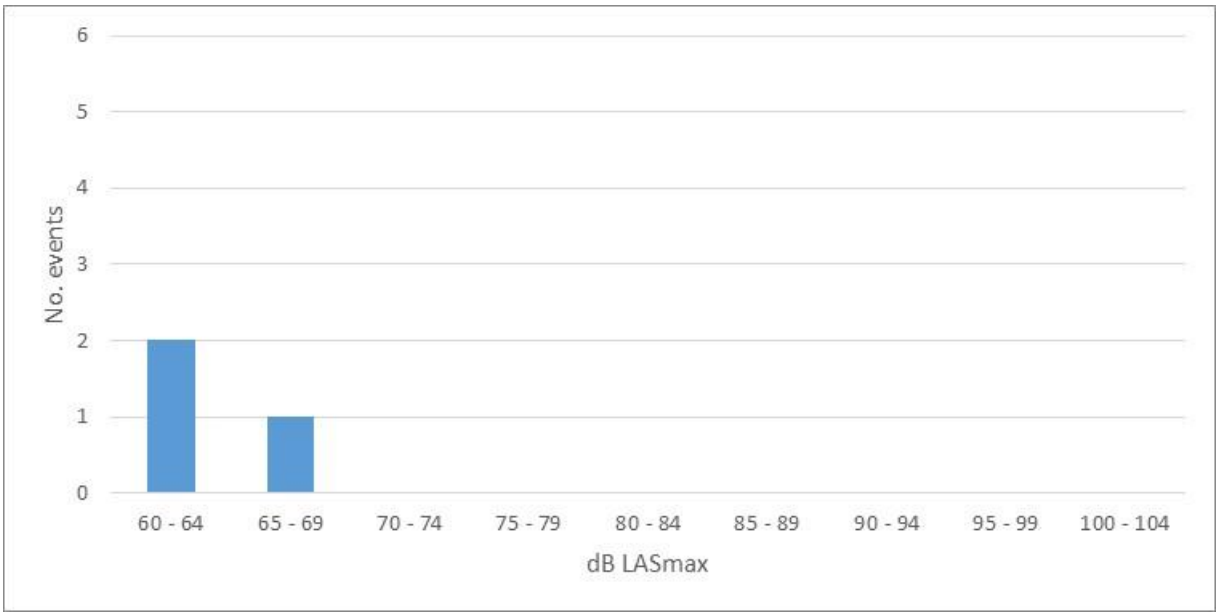


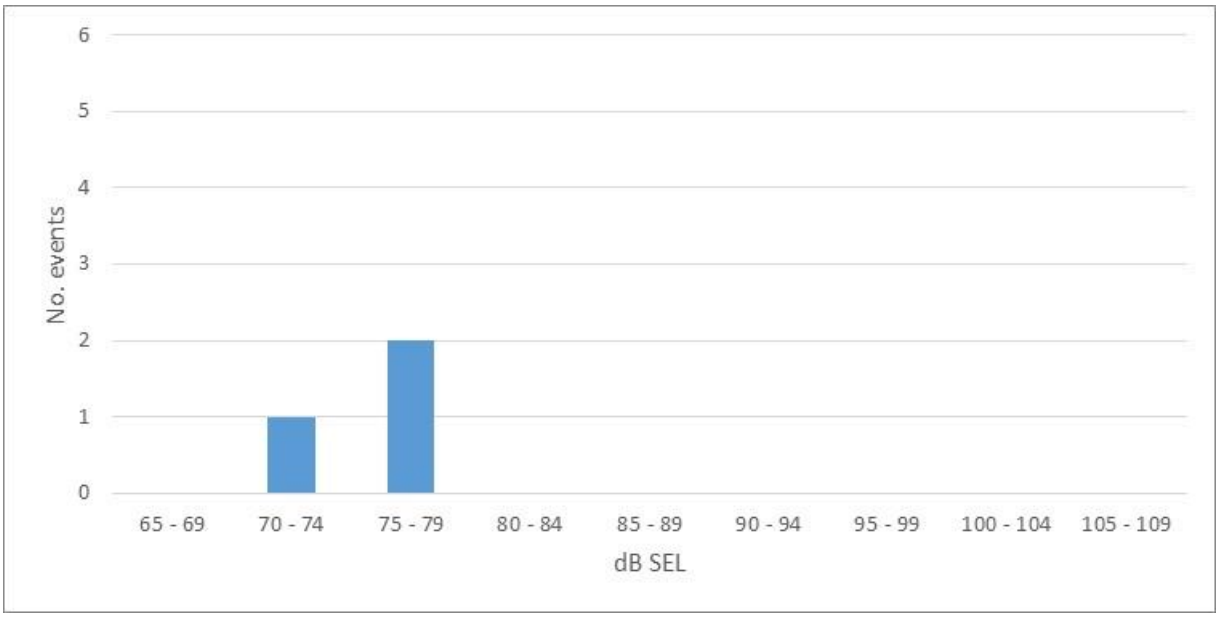


4.2.8 Cabbage Tree Island

Figure 9 presents the frequency of correlated F-35A aircraft events and range of noise levels at the Cabbage Tree Island monitoring location.

Figure 9: Histograms of sound exposure levels and maximum noise levels of F-35A aircraft noise events





5.0 ANALYSIS – BASELINE AND TRANSITION PERIOD SURVEY RESULTS

This section provides an analysis of correlated aircraft noise events at each monitoring location. Specifically, the analysis considers the following datasets:

- F/A-18A/B Hornet operational noise levels obtained during the baseline noise survey; and
- F-35A aircraft noise levels obtained as part of the transition period noise survey.

5.1 Method and considerations

The FMP requires an assessment of noise measurements based on a comparison of the mean and 90th percentile values of the baseline noise measurements to the transitional noise measurements. A statistical analysis of the L_{ASmax} and SEL values for the two datasets was conducted to determine whether any observed change in the mean or 90th percentile values were statistically significant.

The method used to assess and analyse the datasets is summarised as follows:

- The absolute difference in the measured noise levels was compared between the datasets. Where differences were identified, the following items were considered prior to determining if the differences in the measured noise levels were statistically significant:
  - Number of correlated noise events for each survey. As demonstrated in Section 5.2, there was larger variation in the range of measured noise levels at monitoring locations with fewer data points. As a guide for the analysis of the datasets, reference is made to ISO 1996-2 (International Organization for Standardization, 2017). The standard provides general guidance to address uncertainty in environmental noise measurements and indicates that 16 measurements of noise from a particular aircraft operation type (e.g. arrival, departure on a specific / well defined flight track) are required to limit uncertainties due to sampling size to 1 dB or less. The previous version of the standard provided similar guidance, by specifying a preference for a minimum of 20 measurements of a particular aircraft operation type to minimise uncertainty;
  - Environmental aircraft noise levels are inherently variable due to changes in aircraft operating patterns (flight profiles and paths), aircraft procedures, and atmospheric conditions that influence sound propagation. Examples of differences in the flight tracks and movement patterns and operation type between the two datasets are shown in Section 5.3. At locations where the datasets primarily compare different operations or where one of the datasets primarily comprises a single operation type, the difference in noise levels between the datasets is much more susceptible to the influence of these variations. Consideration was therefore given to the potential for differences in noise level arising due to the variation in operation type or flight tracks as opposed to the different aircraft type;
  - It is noted that the FMP does not define what constitutes a significant difference between the two datasets. Changes in average measured SEL and L_{ASmax} aircraft noise levels of the order of 3 dB were considered marginal on the basis that the change was much smaller than the overall range of measured aircraft noise levels throughout the surveys (i.e. a range typically of the order of 20 dB or more, and greater than 40 dB at some monitoring locations);

- The datasets were analysed regarding the variation in the spread of measured noise levels. The analysis considered statistical values, including the first quartile, median, third quartile, mean and maximum measured noise levels of the baseline and transition period datasets at each monitoring location. These statistical values were generated to inform if there was likely to be a difference in the mean of the measured noise levels for the two (2) aircraft types. However, while this analysis is informative, the extent of operational differences between the baseline period and transition periods, combined with the low number of events identified at most locations during the transition period, means that further detailed statistical analysis at each monitoring location will not enable a reliable comparison; and
- The 90th percentile values from datasets with fewer than 10 events should not be compared; the reason being that the 90th percentile value would be based solely on the highest single aircraft event encountered during the survey which may have occurred under atypical circumstances and therefore may not represent the typical highest aircraft noise events at the given location.

5.2 Summary information

The change in the absolute measured mean and 90th percentile for SEL and L_{ASmax} values for each monitoring location is summarised below in Table 6 and Table 7 respectively.

From the summary information, it can be seen that differences in the measured mean and 90th percentile aircraft noise levels were observed.

The following items are noted:

- At locations where the most data was obtained (Fullerton Cove, Stockton Sandspit, Swan Bay), the increase (if any) in noise levels are less than 3 dB;
- At the other locations, there were a limited number of correlated F-35A aircraft noise events during the transition period survey to inform a meaningful comparison with the F/A-18A/B Hornet noise events of the baseline survey; and
- At the locations with a low number of correlated F-35A noise events, differences of more than 3 dB could be attributed to differences in the majority of flying operations between the datasets.

Table 6: Change in sound exposure aircraft noise levels – baseline v transition period survey, dB SEL

Location	Number correlated events		Mean			90th percentile		
	Baseline	Transition period	Baseline	Transition period	Difference	Baseline	Transition period	Difference
Fullerton Cove	243	32	79	80	+1	92	90	-2
Stockton Sandspit	129	29	86	83	-3	99	91	-8
Kooragang Island	74	9	80	(83)	(+3)	87	(92)	(+5)
Hexham Swamp	39	9	78	(87)	(+9)	87	(95)	(+8)
Tilligerry	61	8	84	(82)	(-2)	91	(87)	(-4)
Swan Bay	30	15	79	81	+2	86	87	+1
Myall River (Pindimar)	40	3	81	(82)	(+1)	89	(83)	(-6)
Cabbage Tree Island	14	3	86	(75)	(-11)	88	(77)	(-11)

Note: The values in brackets indicate values based on a dataset with fewer than 10 events. Accordingly, these values are more prone to be distorted by a single outlier datapoint, e.g. the 90th percentile of fewer than 10 events will depend on a single value.

Table 7: Change in maximum aircraft noise levels – baseline v transition period survey, dB L_{ASmax}

Location	Number correlated events		Mean			90th percentile		
	Baseline	Transition period	Baseline	Transition period	Difference	Baseline	Transition period	Difference
Fullerton Cove	243	33	69	70	+1	81	79	-2
Stockton Sandspit	129	29	76	73	-3	91	81	-10
Kooragang Island	74	9	70	(71)	(+1)	77	(81)	(+4)
Hexham Swamp	39	9	68	(76)	(+8)	78	(83)	(+5)
Tilligerry	61	8	71	(70)	(-1)	80	(75)	(-5)
Swan Bay	30	15	68	69	+1	74	77	+3
Myall River (Pindimar)	40	3	71	(73)	(+2)	84	(78)	(-6)
Cabbage Tree Island	14	3	76	(64)	(-12)	79	(68)	(-11)

Note: The values in brackets indicate values based on a dataset with fewer than 10 events. Accordingly, these values are more prone to be distorted by a single outlier datapoint, e.g. the 90th percentile of fewer than 10 events will depend on a single value.

5.3 Location specific

An absolute change in the measured mean and 90th percentile aircraft noise levels does not necessarily indicate a statistically significant difference in the two datasets. Consideration should also be given to relative dataset sizes, comparable event types and the factors noted in Section 5.1.

Box-whisker plot

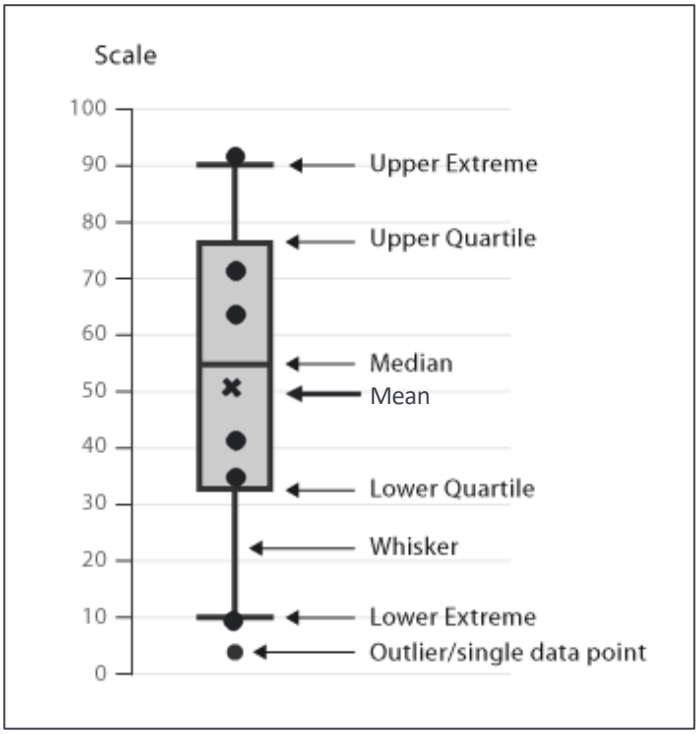
As part of a review of the measured noise levels, the datasets from the surveys are presented as a box-whisker plot for each monitoring location to inform if there is likely to be a difference in the mean of the measured noise levels between the two (2) aircraft types

The box-whisker plot is a five (5) number summary of the range of measured noise levels, including the minimum, first quartile, median, third quartile, and maximum for the correlated aircraft noise events, described in Figure 10.

Outliers[1] within each dataset are also shown. For the purpose of this analysis, a value was considered to be an outlier as per the typical definition of the box-whisker plot summary; that is, if the data point is at least 1.5 times the interquartile range[2] below the lower quartile, or at least 1.5 times the interquartile range above the upper quartile.

The purpose of the box-whisker plot is to review the distributional characteristics of each dataset of correlated noise events as well as evaluate the difference in noise levels between them. Where the measured transition period survey median noise levels lie relative to the interquartile range of the baseline survey noise levels, indicate the likeliness of an observed difference between the two datasets.

Figure 10: Elements of a box-whisker plot (source: The Data Visualisation Catalogue)



[1] Extreme values that differ greatly from other values in the dataset

[2] Difference between upper and lower quartiles

Flight track and operation

Figures are also presented to demonstrate the 2D flight tracks of correlated events for each aircraft type, operation and respective survey.

The correlated events are coloured according to the NFPMS assigned operation type:

- Red: arrival (recovery);
- Blue: departure; and
- Green: other. i.e. events classified as one operation type on a single radar track. For example, an event comprising a military fast jet departure, training operation away from the Base and the subsequent arrival are logged as one continuous flight path and classified as a single operation, "other".

The solid lines (first figure for each location) show the F/A-18A/B Hornet correlated events obtained during the baseline noise survey while the dashed line (second figure for each location) show the F-35A aircraft correlated events obtained as part of the transition period noise survey.

5.3.1 Fullerton Cove

The mean and upper 90th percentile SEL and maximum noise levels of the baseline and transition period surveys did not differ by more than 3 dB at this location. Therefore, any difference in these statistics is considered to be marginal given the range of measured aircraft noise levels throughout the surveys.

Figure 11 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Fullerton Cove monitoring location.

The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the mean of the two datasets.

The longer "whiskers" for F/A-18A/B Hornet noise events, indicates a greater variability in the range of measured noise levels while the F-35A aircraft noise events exhibited less variation. This is consistent with the range of variations in flight tracks and operations that is evident in the flight track comparison in Figure 12, that demonstrates a greater mix of operation types during the baseline survey (departures and arrivals), compared with the limited number of (primarily departure) F-35A aircraft operations during the transition period survey.

Figure 11: Box-whisker plot of sound exposure levels and maximum noise levels

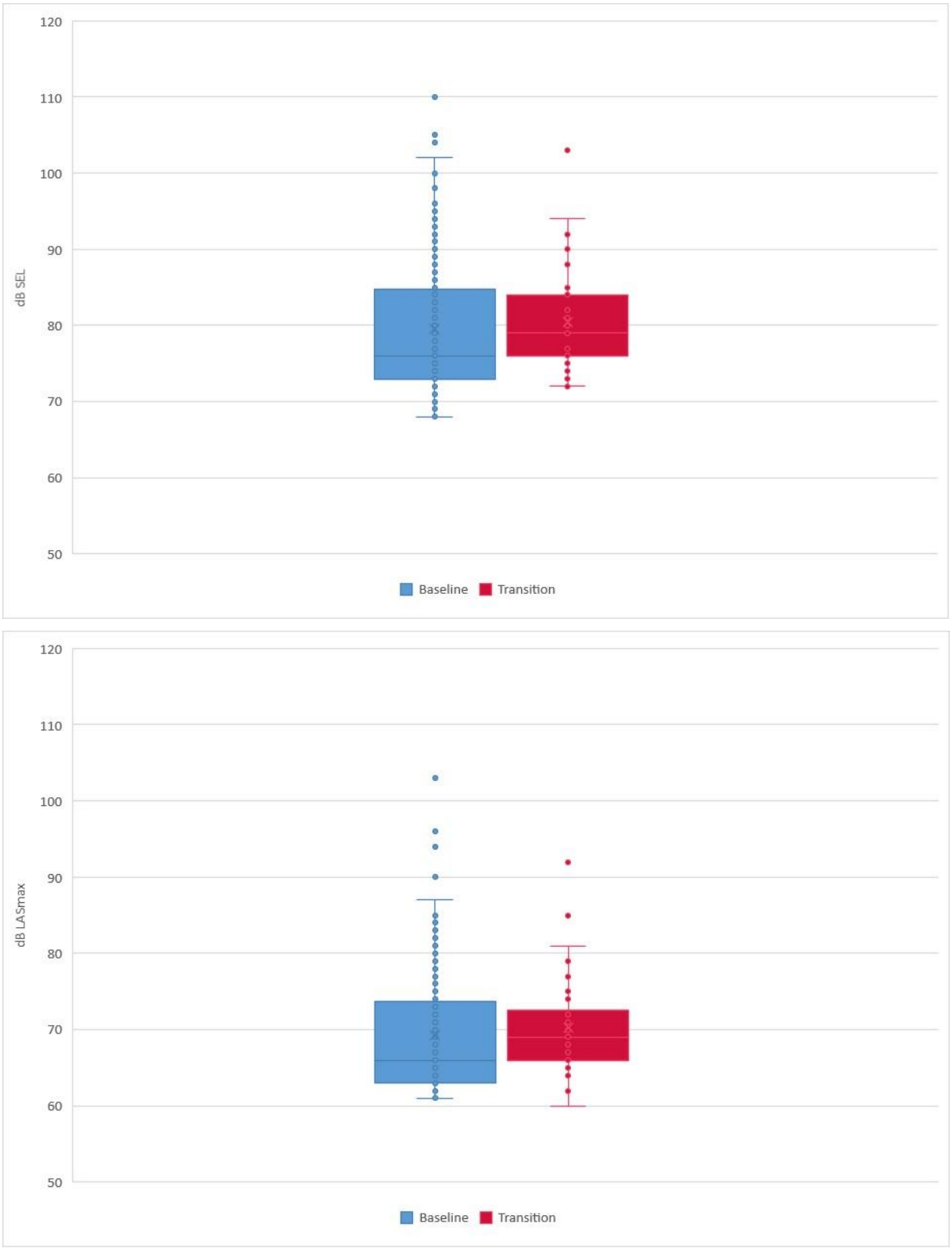
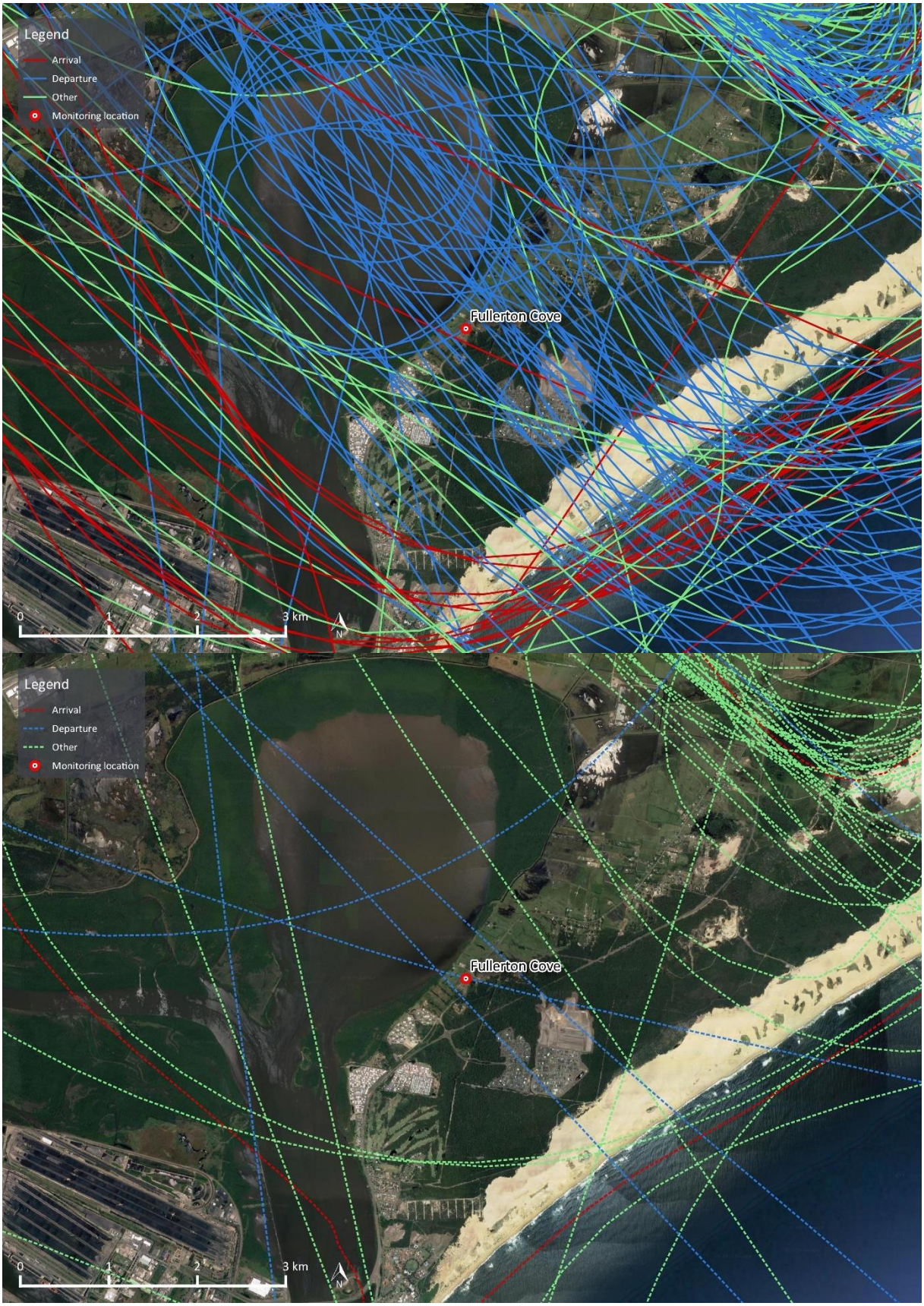


Figure 12: Fullerton Cove flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)



5.3.2 Stockton Sandspit

The mean and upper 90th percentile SEL and maximum noise levels of the transition period survey were lower than those of the baseline survey at this location.

Figure 13 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Stockton Sandspit monitoring location.

The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the two datasets, although the absolute differences in the mean and 90th percentile values indicate lower F-35A aircraft noise levels relative to F/A-18A/B Hornet aircraft noise levels.

The longer "whiskers" for F/A-18A/B Hornet noise events do however indicate a greater variability in noise levels relative to the measured the F-35A aircraft noise event levels. This is consistent with the range of variations in flight tracks and operations that is evident in the flight track comparison in Figure 14. The correlated baseline F/A-18A/B Hornet operations were generally arrival operations (solid red lines and the majority of solid green lines that follow the coastline prior to turning to the northwest on arrival) above the monitoring location. In contrast, the correlated F-35A aircraft operations were primarily other operations (dashed green lines, the majority arrivals or circuits prior to arrival) and occurred further from the monitoring location.

The difference in flight tracks, operation type, likely power settings and hence aircraft noise levels between the two datasets means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft. The differences are primarily indicative of variation in noise levels associated with different operations during the transition period survey rather than differences between the two aircraft types.

Figure 13: Box-whisker plot of sound exposure levels and maximum noise levels

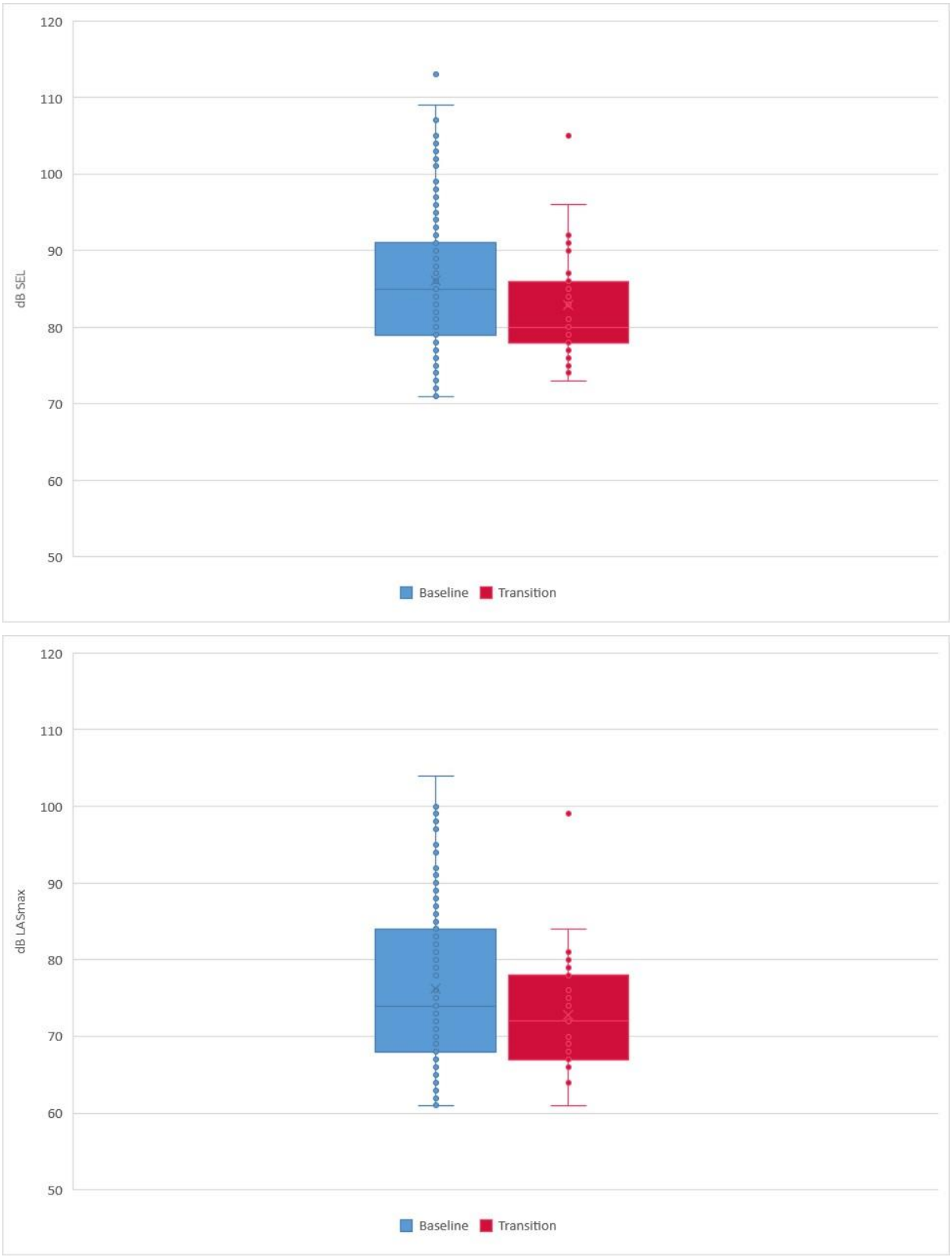
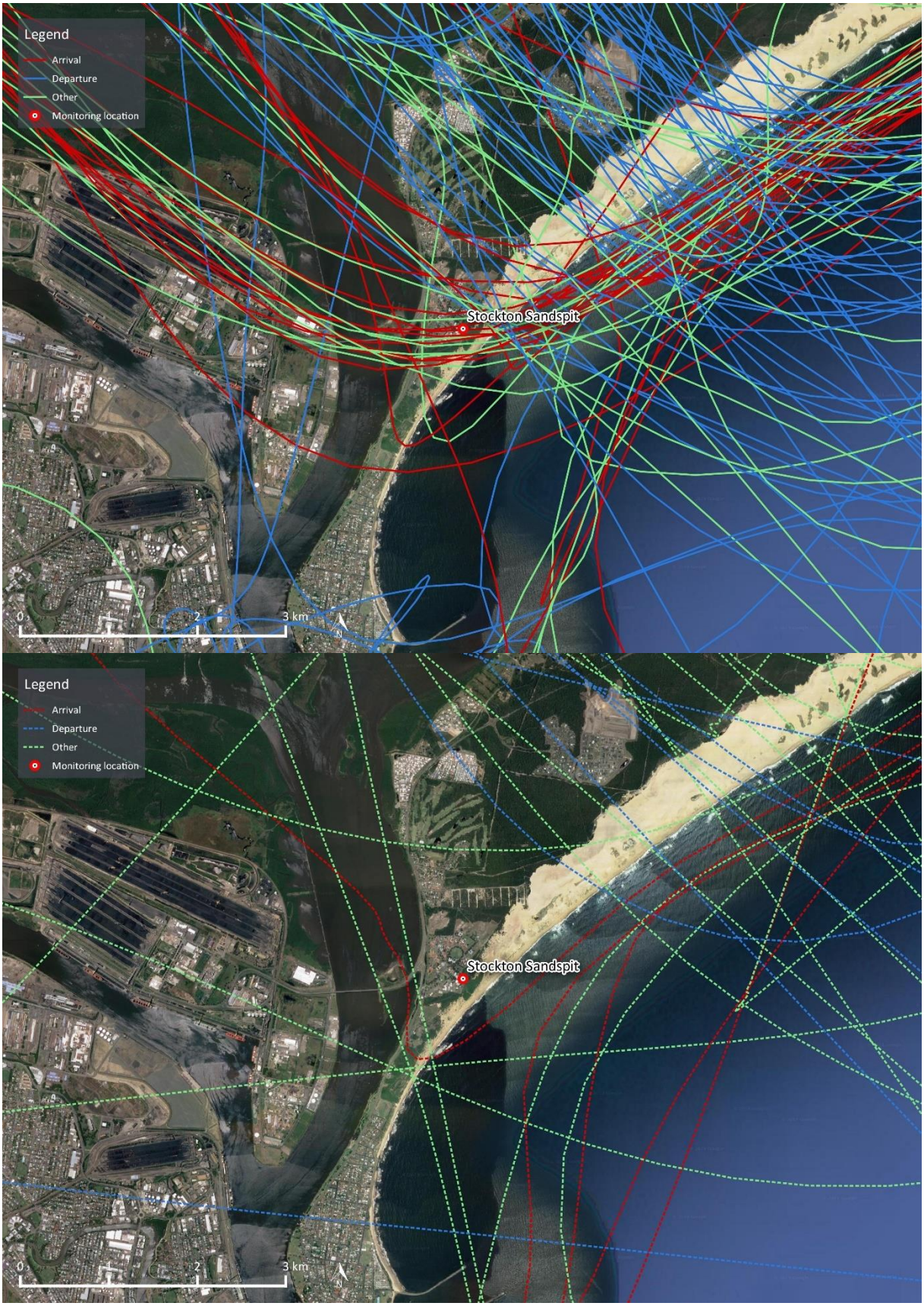


Figure 14: Stockton Sandspit flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)



5.3.3 Kooragang Island

Figure 15 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Kooragang Island monitoring location.

The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the two datasets.

Although a limited number of correlated F-35A aircraft events were identified at this location during the transition period survey, the noise levels appear higher than the baseline data. However, this does not represent an exceedance for the reasons discussed below.

As demonstrated in Figure 16, the correlated baseline F/A-18A/B Hornet operations were generally arrival operations (solid red and green lines from a review of the radar data) and spread above the monitoring location. The correlated F-35A aircraft operations were primarily departure operations (dashed blue lines) and relatively closer to the monitoring location.

During arrival operations, it is expected that the F/A-18A/B Hornet would have been using a low power setting, generating less noise when compared to the F-35A aircraft departure operations which may have been operating at a higher power setting, hence greater noise emissions.

The difference in flight tracks, operation type, likely power settings and hence aircraft noise levels between the two datasets means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft. The differences are primarily indicative of variation in noise levels associated with different operations transition period survey rather than differences between the two aircraft types.

As a result of the variations in operations, and the absence of an identified exceedance of the transition period levels relative to the baseline, a comparison of the results with the noise modelling results presented in the EIS (as referenced in the FMP) is not warranted.

In addition, the F-35A aircraft flight paths in the vicinity of the Kooragang Island monitoring do not conform to a flight corridor that was allowed for in the EIS noise model. i.e. there are no F-35A aircraft flight tracks in the model to compare against the operations captured during the survey. Comparisons of the F-35A aircraft noise measurements and the predictions in the EIS would not make for a like-for-like operation comparison and reporting of any discrepancies would be mostly trivial. Therefore, a review of the EIS modelling is not expected to assist with further analysis of the operational noise survey results at this location.

Figure 15: Box-whisker plot of sound exposure levels and maximum noise levels

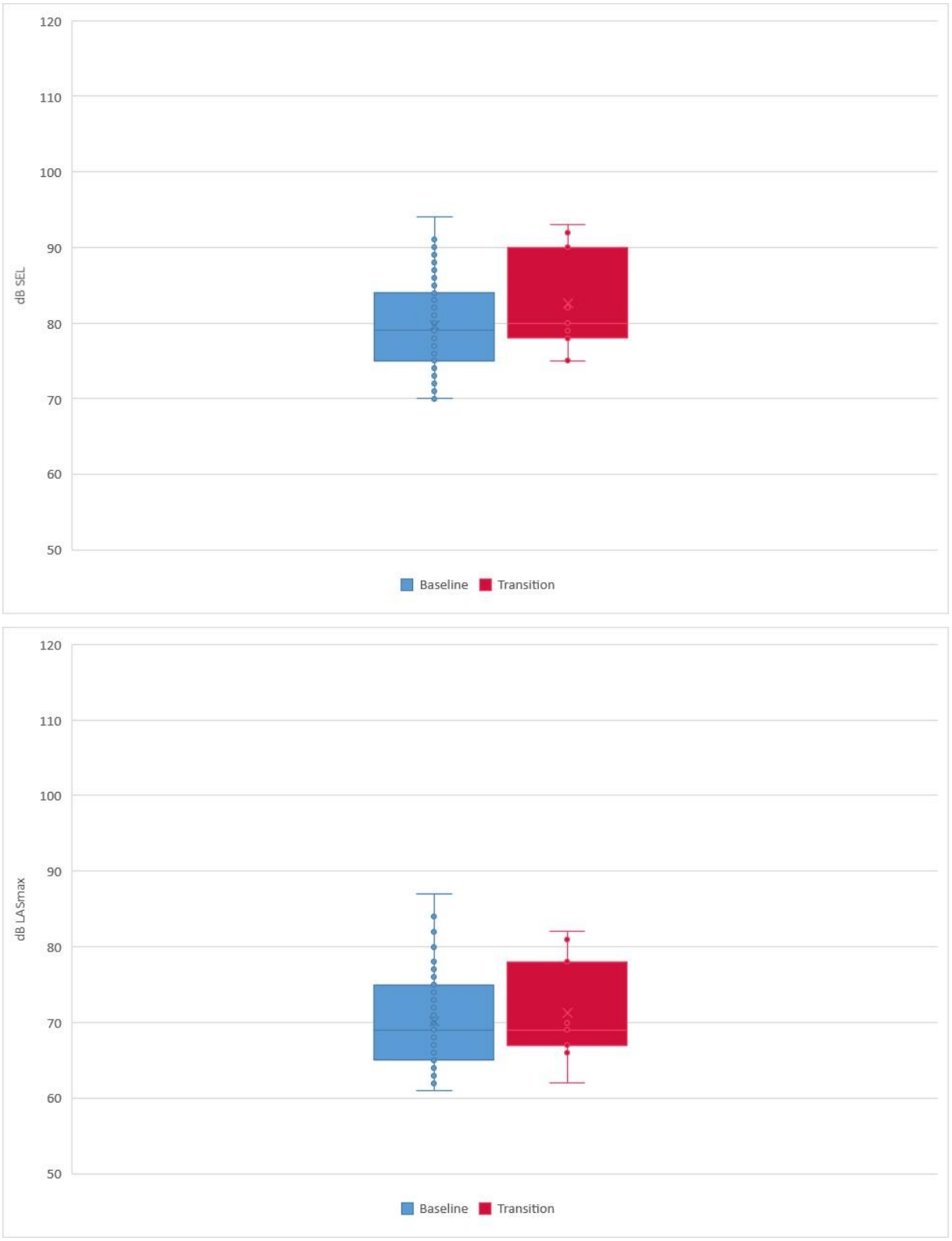
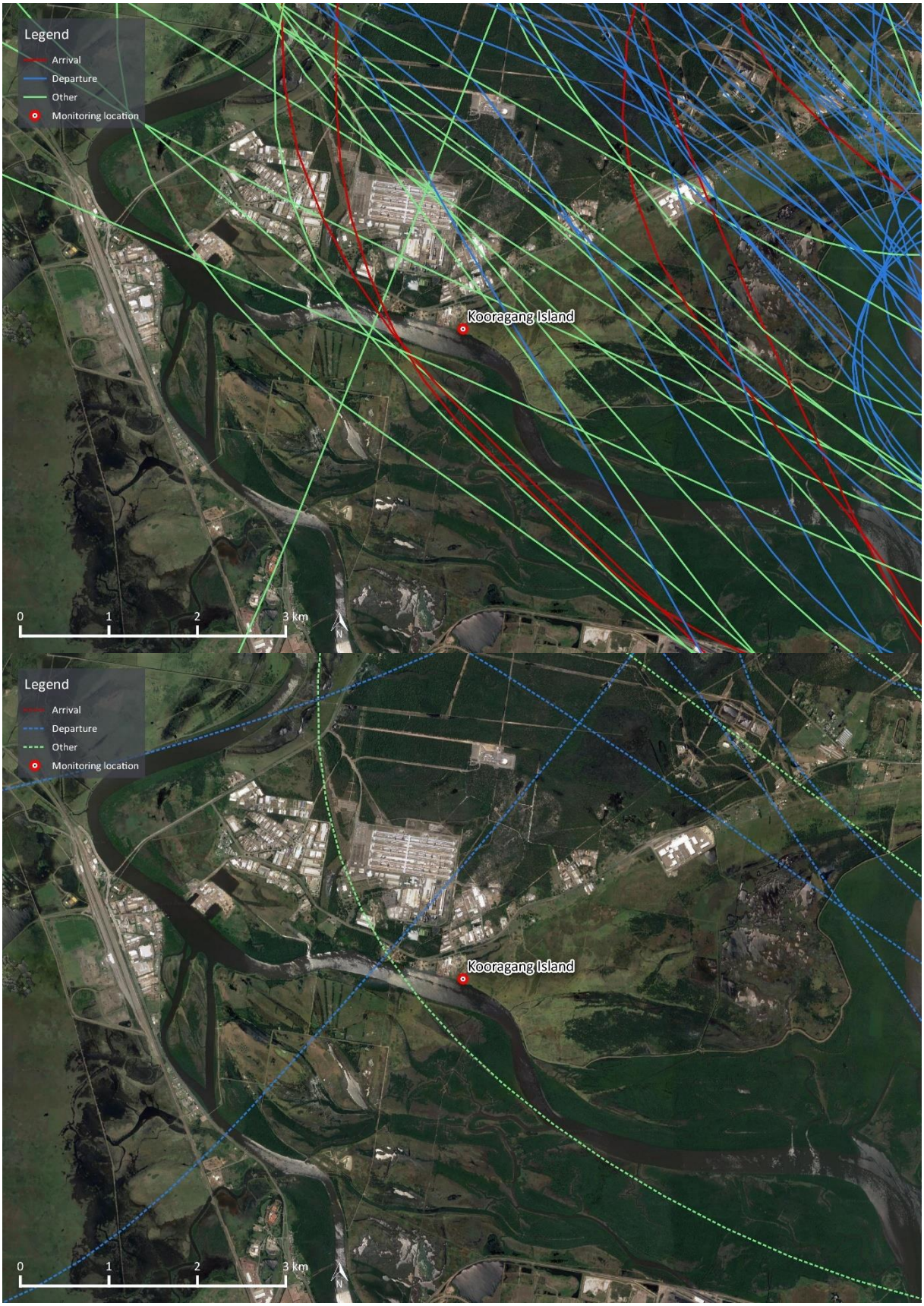


Figure 16: Kooragang Island flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)



5.3.4 Hexham Swamp

Figure 17 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Hexham Swamp monitoring location.

The F-35A aircraft median noise levels for both the SEL and L_{ASmax} are above the upper and lower quartile of F/A-18A/B Hornet noise levels. This indicates there is *likely* to be a difference between the two datasets; i.e. the measured F-35A aircraft noise levels at this location are increased relative to the baseline F/A-18A/B Hornet noise levels.

Although there were a limited number of correlated F-35A aircraft events at this location during the transition period survey, the noise levels were notably higher than baseline. However, this does not represent an exceedance for the reasons discussed below.

As demonstrated in Figure 18, the correlated baseline F/A-18A/B Hornet operations were generally arrival operations (solid red and green 'other' lines from review of the radar data), while the correlated F-35A aircraft operations were primarily departure operations (dashed blue lines) and relatively closer to the monitoring location.

During arrival operations, it is expected that the F/A-18A/B Hornet would have been using a low power setting, generating less noise when compared the F-35A aircraft departure operations which may have been operating at a higher power setting, hence greater noise emissions.

The difference in flight tracks, operation type, likely power settings and hence aircraft noise levels between the two datasets means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft. The differences are primarily indicative of variation in noise levels associated with different operations during the transition period survey rather than differences between the two aircraft types.

As a result of the variations in operations, and the absence of an identified exceedance of the transition period levels relative to the baseline, a comparison of the results with the noise modelling results presented in the EIS (as referenced in the FMP) is not warranted.

In addition, the F-35A aircraft flight paths in the vicinity of the Hexham Swamp monitoring location do not conform to a flight corridor that was allowed for in the EIS noise model. i.e. there are no F-35A aircraft flight tracks in the model to compare against the operations captured during the survey. Comparisons of the F-35A aircraft noise measurements and the predictions of the EIS would not make for a like-for-like operation comparison and reporting of any discrepancies would be mostly trivial. Therefore, a review of the EIS modelling is not expected to assist with further analysis of the operational noise survey results at this location.

Figure 17: Box-whisker plot of sound exposure levels and maximum noise levels

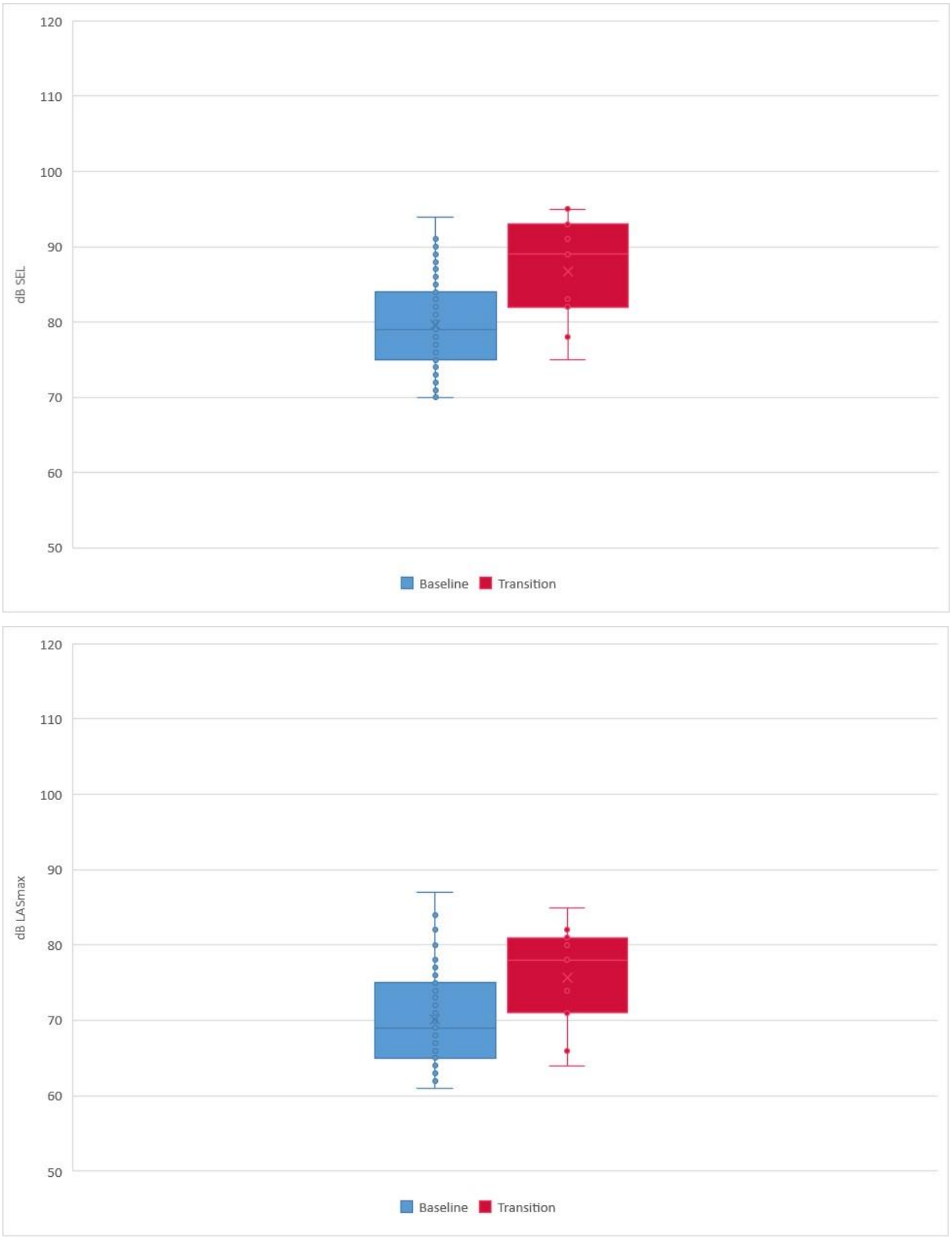
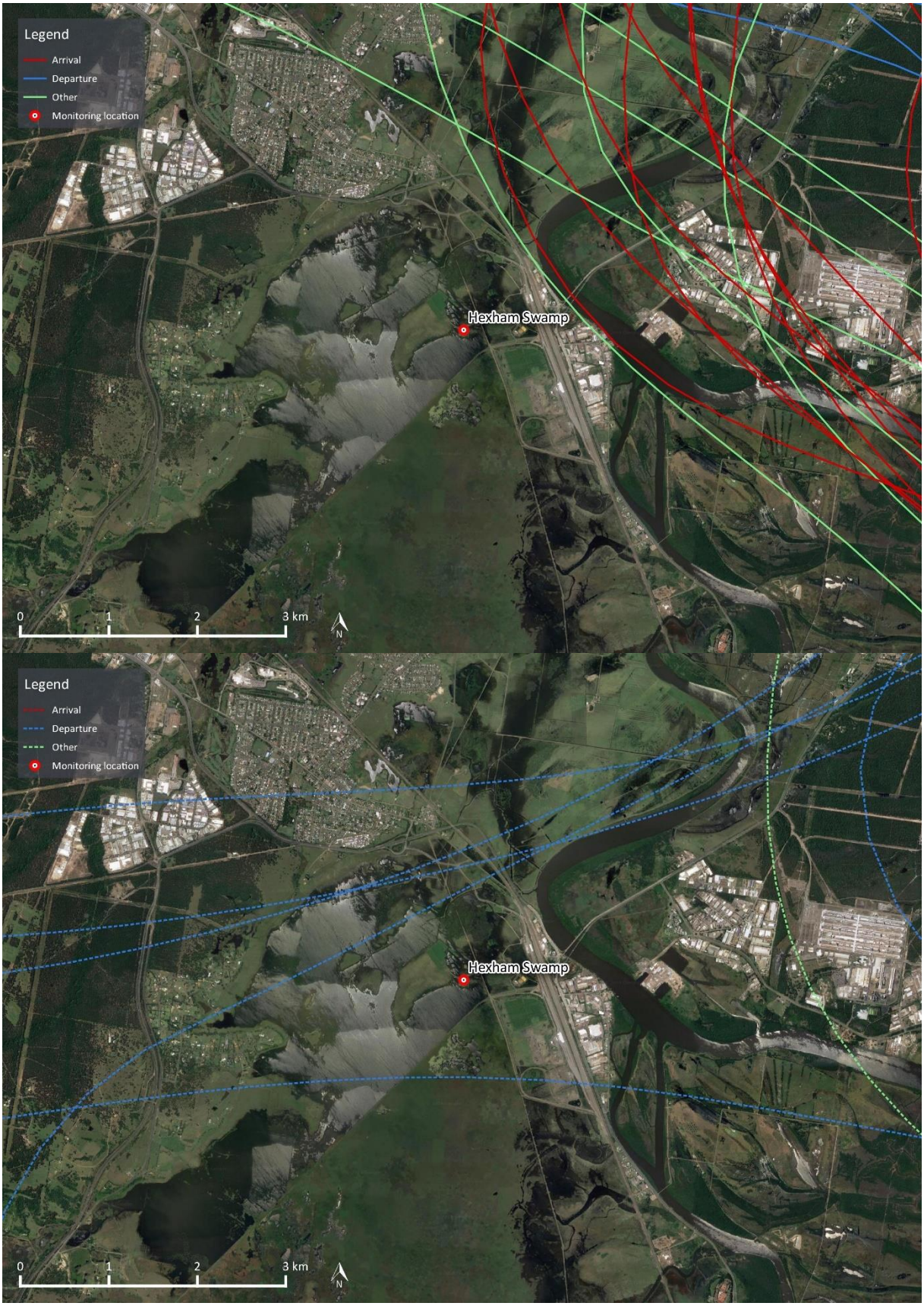


Figure 18: Hexham Swamp flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)



Note: Figures do not show all correlated aircraft noise events (some flight paths are beyond the bounds of the figures)

5.3.5 Tilligerry

The mean and upper 90th percentile SEL and maximum noise levels of the transition period survey were lower than those of the baseline survey at this location.

Figure 19 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Tilligerry monitoring location.

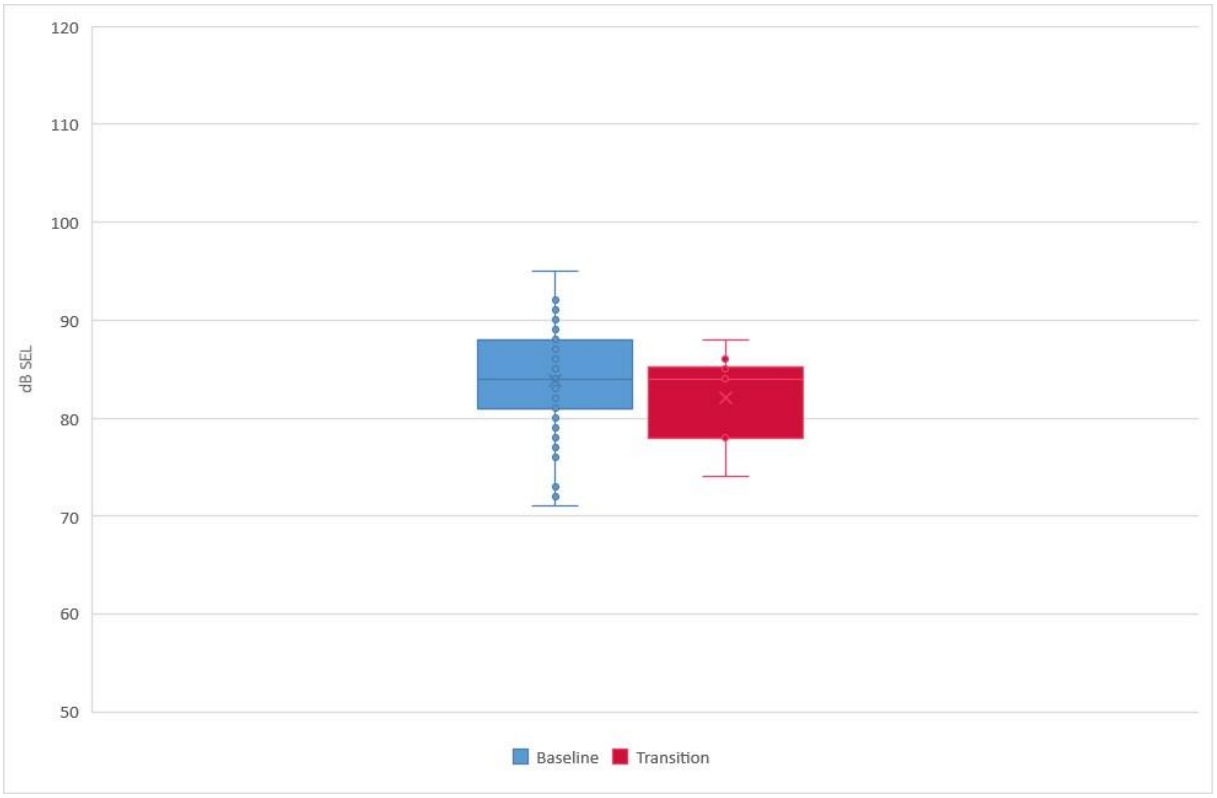
The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the two datasets.

The longer "whiskers" for F/A-18A/B Hornet noise events indicate a greater variability in noise levels while the F-35A noise events exhibited less variation, albeit due to much lower number of events.

As shown in Figure 20, the variation primarily relates to the limited number of correlated F-35A aircraft events at this location during the transition period survey.

The limited number of F-35A aircraft correlated events and range of operations means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft.

Figure 19: Box-whisker plot of sound exposure levels and maximum noise levels



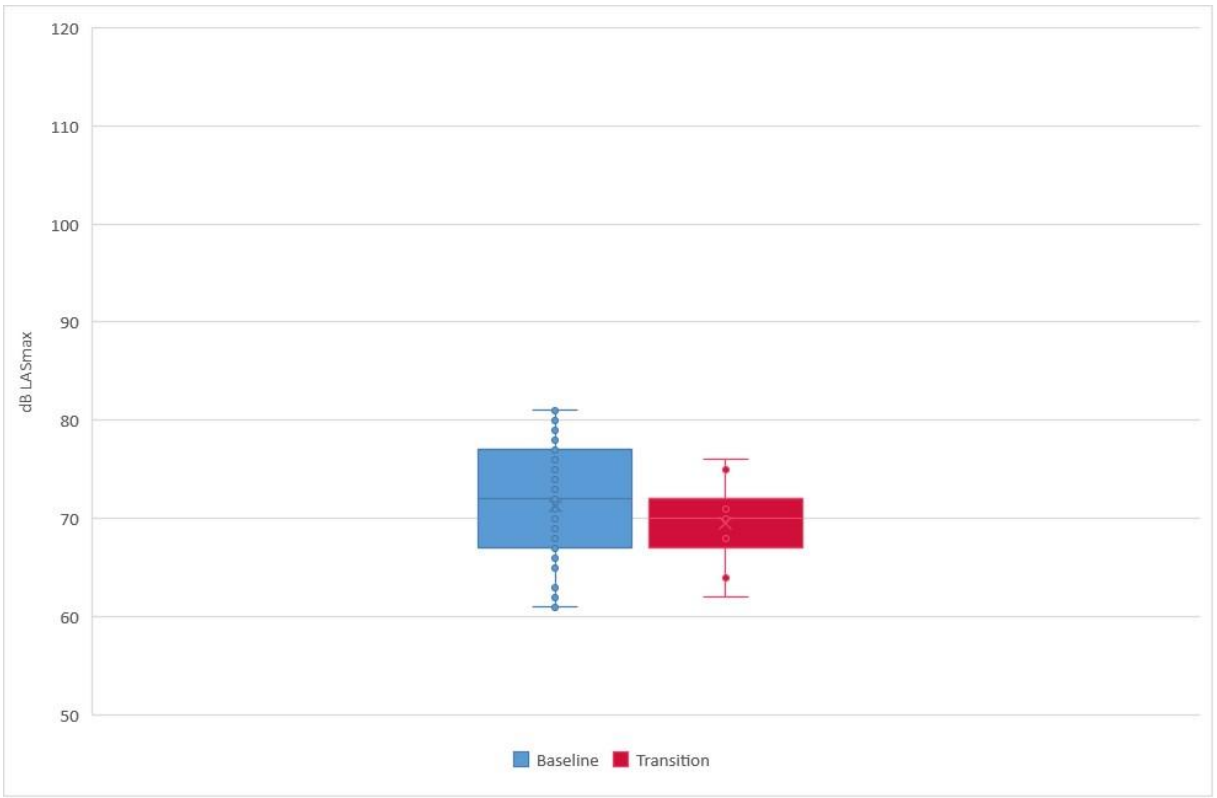
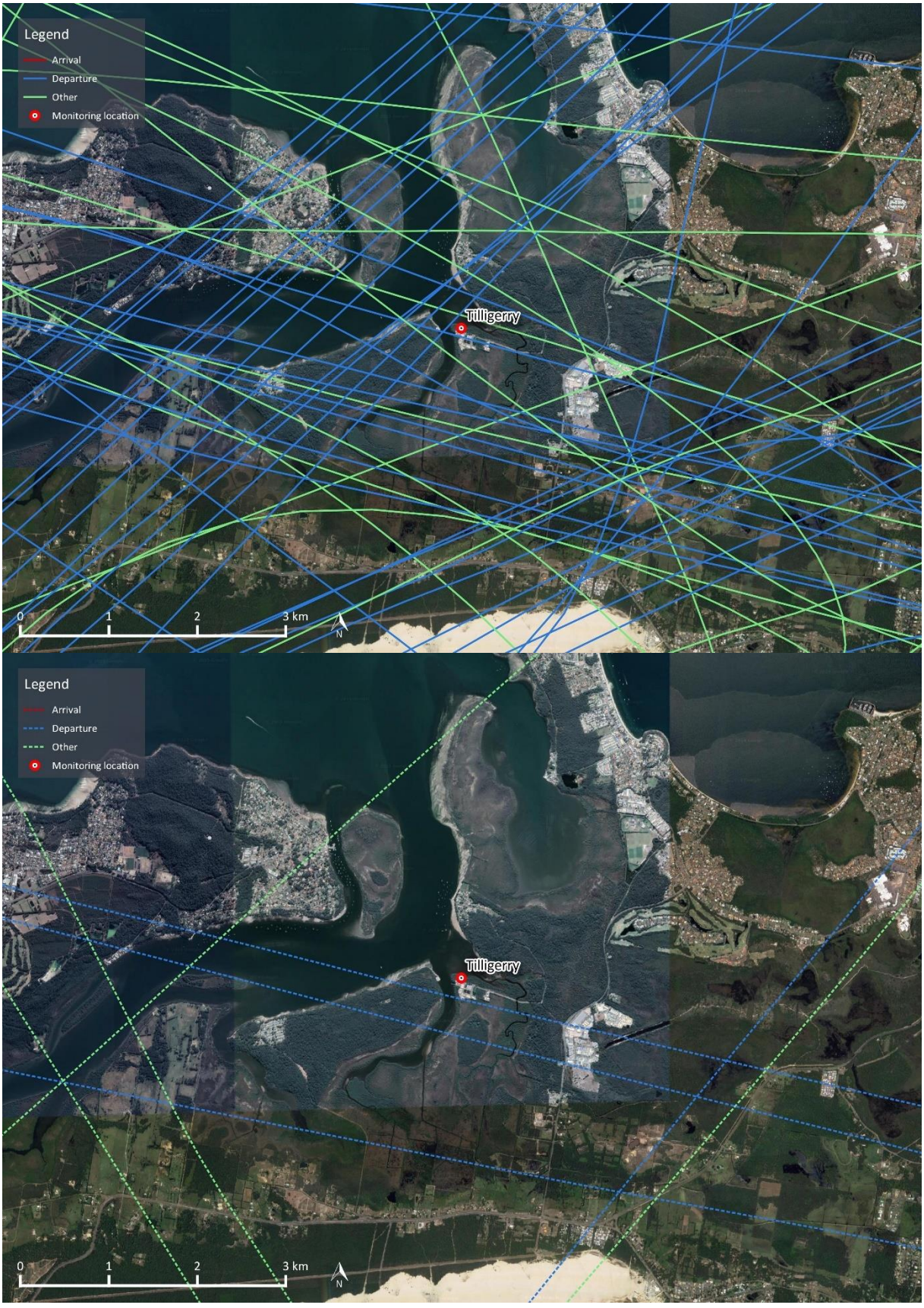


Figure 20: Tilligerry flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)



5.3.6 Swan Bay

The mean and upper 90th percentile SEL and maximum noise levels of the baseline and transition period surveys did not differ by more than 3 dB at this location. Therefore, any difference in these statistics is considered to be marginal given the range of measured aircraft noise levels throughout the surveys.

Figure 21 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Swan Bay monitoring location.

The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the two datasets.

The longer "whiskers" for F/A-18A/B Hornet noise events, indicates a greater variability in noise levels while the F-35A aircraft noise events exhibited less variation.

As shown in Figure 22, the variation in noise level primarily relates to the limited number of correlated F-35A aircraft events at this location during the transition period survey.

The limited number of F-35A aircraft correlated events and range of operations means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft.

Figure 21: Box-whisker plot of sound exposure levels and maximum noise levels

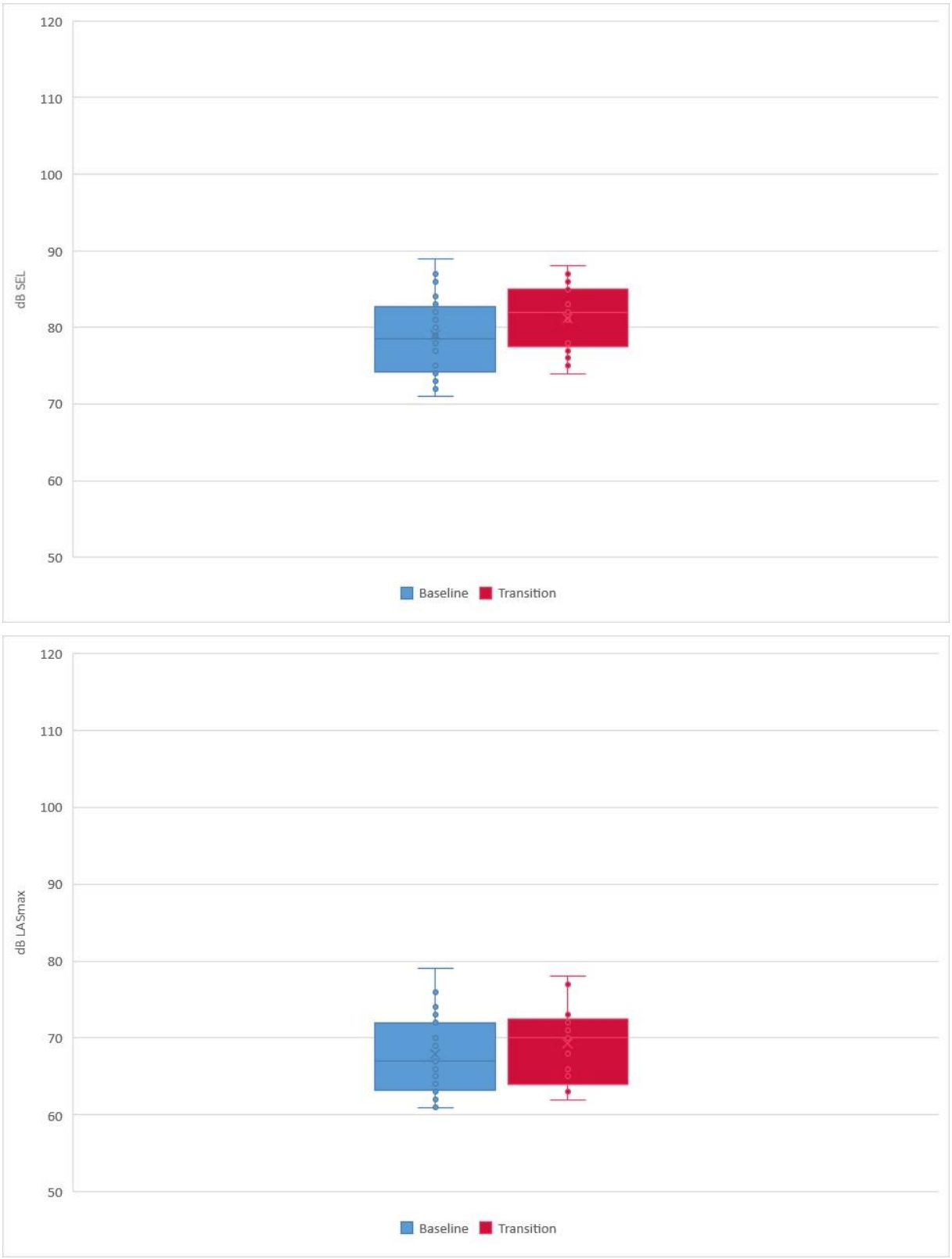


Figure 22: Swan Bay flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)

Note: Figures do not show all correlated aircraft noise events (some flight paths are beyond the bounds of the figures)

5.3.7 Myall River (Pindimar)

Only three (3) F-35A aircraft noise events were captured at this location during the transition period survey. Such a low number of events for a highly variable noise source significantly limits the conclusions that can be drawn from the dataset and from a comparison of the datasets.

The mean SEL and maximum noise levels of the baseline and transition period surveys did not differ by more than 3 dB at this location. Therefore, any difference in these statistics is considered to be marginal given the range of measured aircraft noise levels throughout the surveys.

The 90th percentile SEL and maximum noise level values measured during the transition period survey were lower than those measured during the baseline survey at this location.

Figure 23 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Myall River (Pindimar) monitoring location.

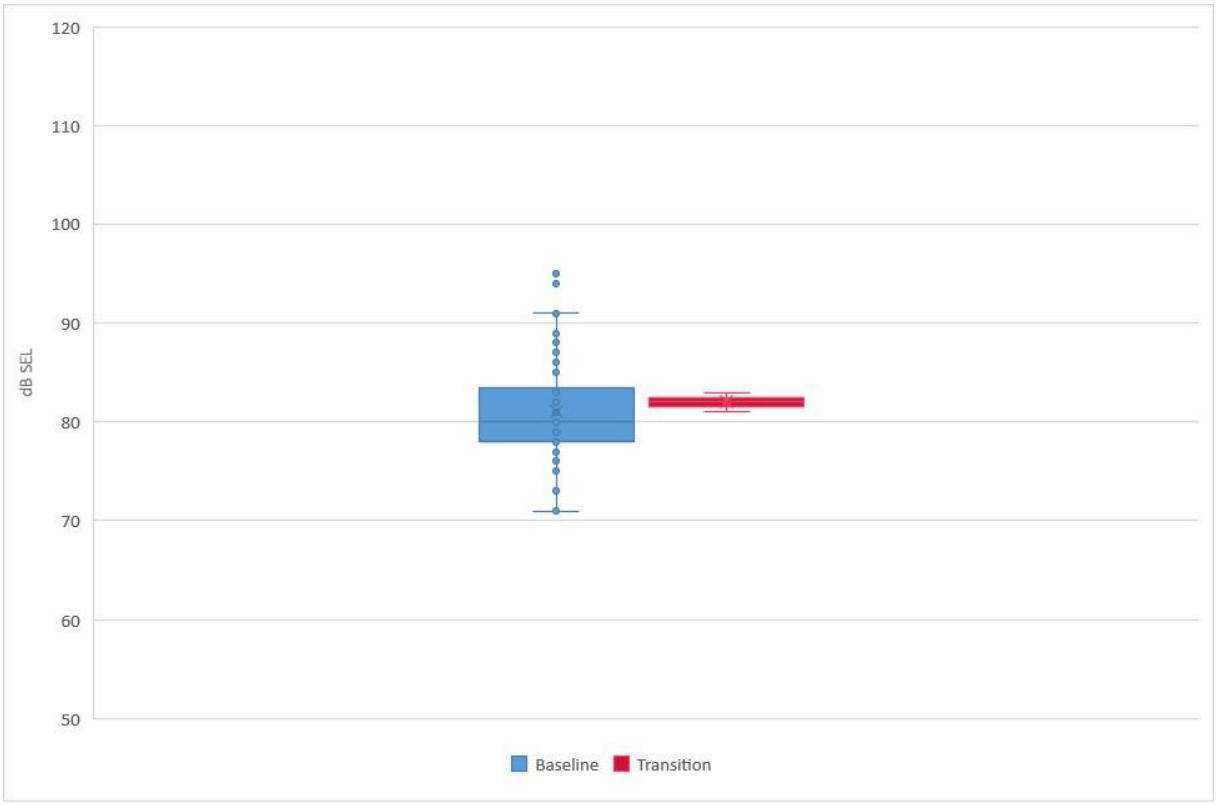
The F-35A aircraft median noise levels for both the SEL and L_{ASmax} lie within the upper and lower quartile of the F/A-18A/B Hornet noise levels. This indicates there is *unlikely* to be a difference between the two datasets.

The longer “whiskers” for F/A-18A/B Hornet noise events, indicates a greater variability in noise levels while the F-35A aircraft noise events exhibited less variation, albeit due to much lower number of events.

As shown in Figure 24, the variation primarily relates to the range of operations obtained during the baseline survey, compared with the limited number of correlated F-35A aircraft events during the transition period survey.

The limited number of F-35A aircraft correlated events and range of operations means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft.

Figure 23: Box-whisker plot of sound exposure levels and maximum noise levels



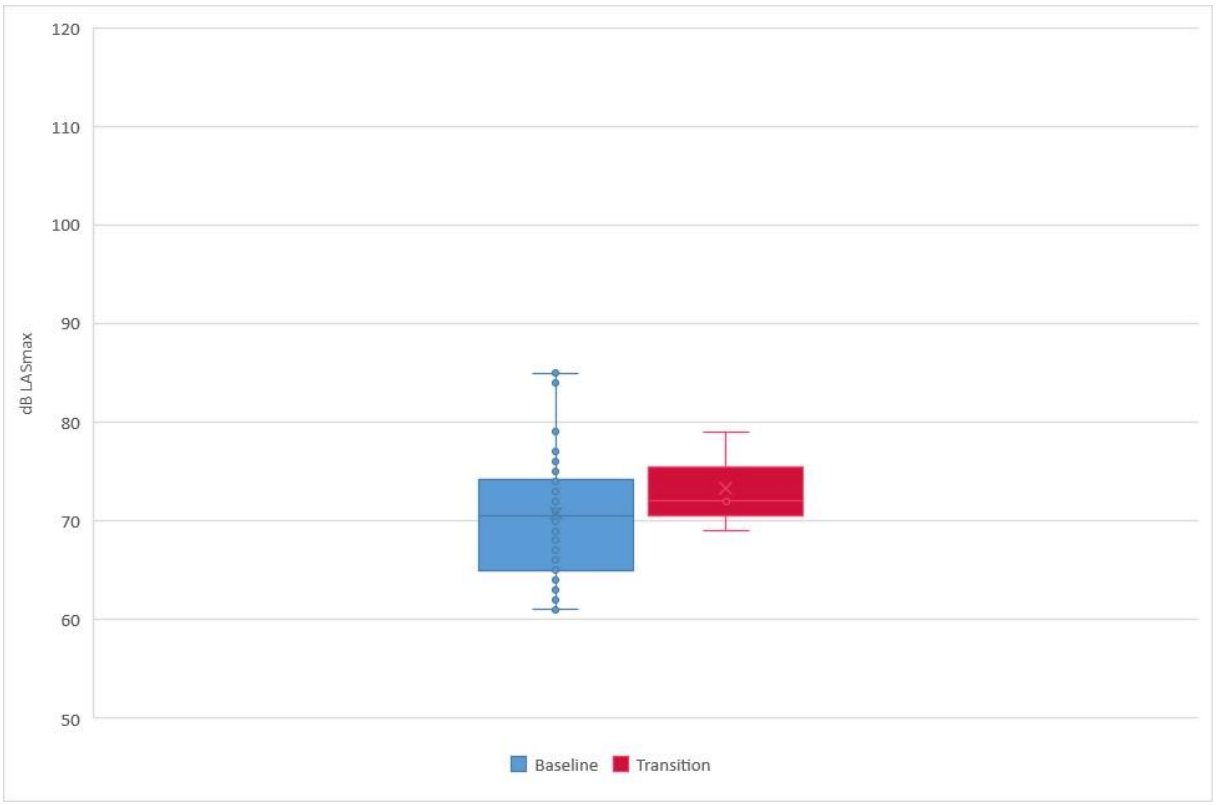


Figure 24: Myall River (Pindimar) flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)

Note: Figures do not show all correlated aircraft noise events (some flight paths are beyond the bounds of the figures)

5.3.8 Cabbage Tree Island

Only three (3) F-35A aircraft noise events were captured at this location during the transition period survey. Such a low number of events for a highly variable noise source significantly limits the conclusions that can be drawn from the dataset and from a comparison of the datasets.

The mean and upper 90th percentile SEL and maximum noise levels of the transition period survey were 11 to 12 dB lower than those of the baseline survey at this location.

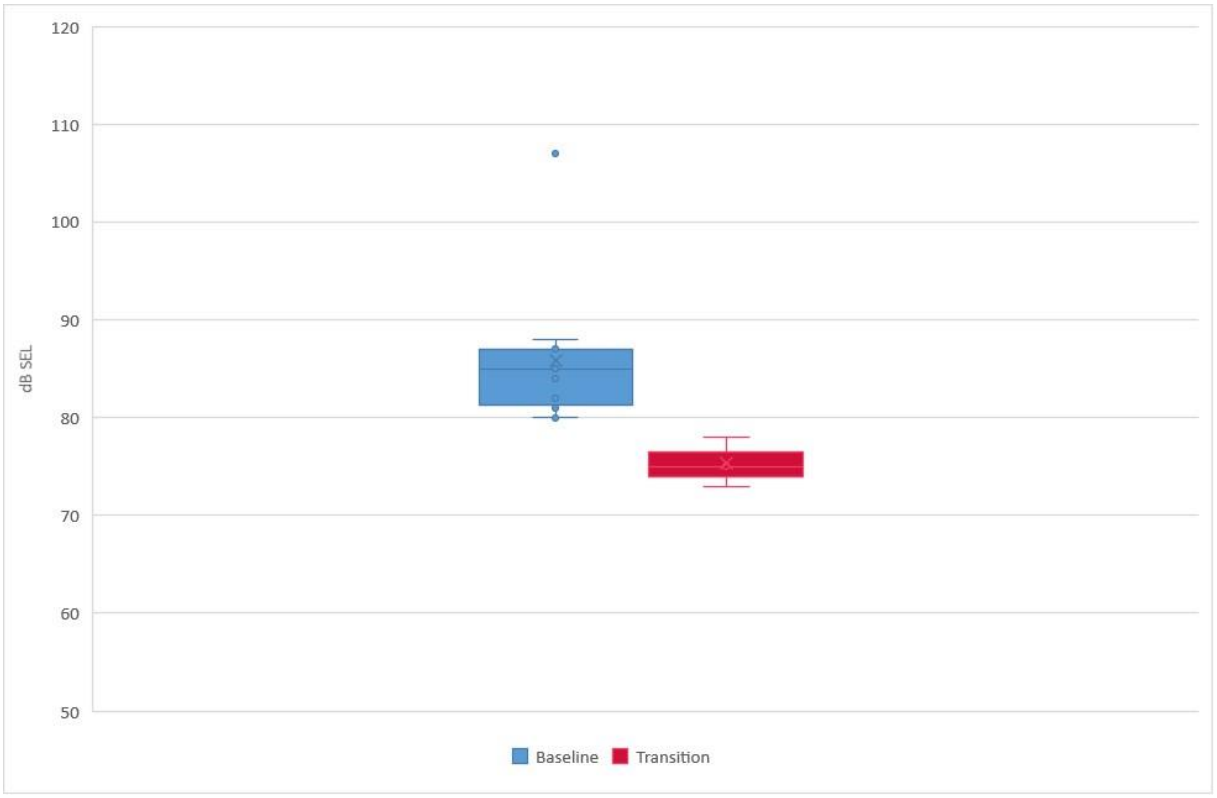
Figure 25 presents a comparison of the baseline survey F/A-18A/B Hornet and transition period survey F-35A aircraft correlated noise events at the Cabbage Tree Island monitoring location.

The F-35A aircraft noise levels for both the SEL and L_{ASmax} are below the upper and lower quartile of F/A-18A/B Hornet noise levels. This indicates there is *likely* to be a difference between the two datasets; i.e. the measured F-35A noise levels at this location are lower relative to the baseline F/A-18A/B Hornet noise levels.

As shown in Figure 26, a range of operations and events were recorded during the baseline survey, compared with the limited number of correlated F-35A aircraft events during the transition period survey.

The limited number of F-35A aircraft correlated events and range of operations, means it is not possible to conclude whether there is a system difference in noise levels associated with like-for like operations of the two aircraft.

Figure 25: Box-whisker plot of sound exposure levels and maximum noise levels



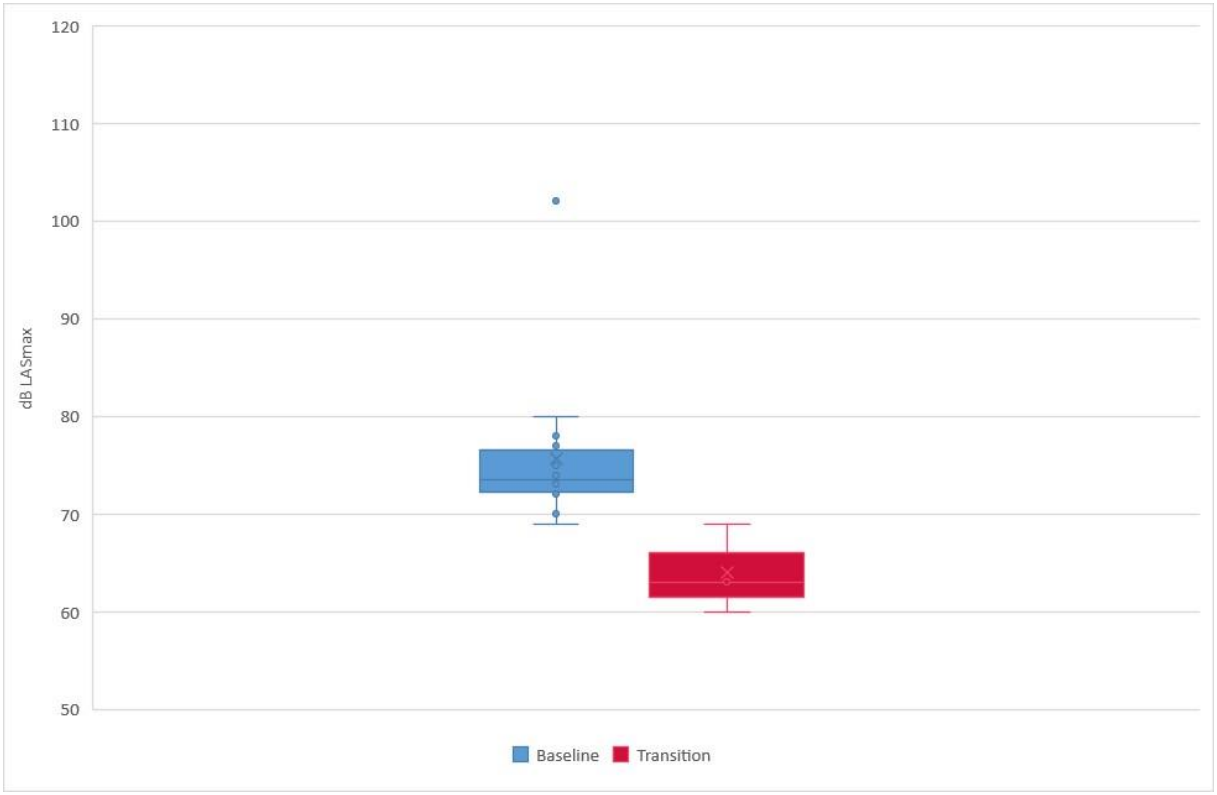


Figure 26: Cabbage Tree Island flight tracks - Baseline (F/A-18A/B Hornet) v Transition period (F-35A aircraft)

Note: Figures do not show all correlated aircraft noise events (some flight paths are beyond the bounds of the figures)

5.4 Salt Ash Air Weapons Range flying operations

The Swan Bay and Myall River (Pindimar) monitoring locations are likely to be subject to noise from military fast jet operations at SAAWR, 8 km east of the Base.

The baseline noise survey report noted that there were no F/A-18A/B Hornet operations at SAAWR during the monitoring period. Therefore, no baseline noise level data from F/A-18A/B Hornet operations at SAAWR was collected as part of that survey.

A review of the military flight scheduling data provided by Defence and radar and flight track data during the transition period noise survey indicated that there were no F-35A aircraft operations at SAAWR during this monitoring period.

Therefore, there is no data for either the baseline or transition period surveys to compare operational noise levels of the two (2) aircraft.

6.0 STUDY OUTCOMES

The comparison of noise metric statistics at the three (3) monitoring locations that had the highest number of correlated F-35A aircraft events during the transition period survey, Fullerton Cove, Stockton Sandspit and Swan Bay, did not indicate a meaningful increase in F-35A aircraft noise levels relative to F/A-18A/B Hornet noise levels.

The comparison of noise metric statistics identified either:

- A minor difference in noise levels between the baseline and transition period surveys; or
- Where larger differences in noise metric statistics were noted, the differences can be attributed to considerable differences in flight paths and operation types between F/A-18A/B Hornet and F-35A aircraft operations during their respective surveys.

The transition period data for these three locations therefore did not demonstrate an exceedance of the baseline data. However, as a result of the difference in the operations occurring during the baseline and transition period surveys, it is not possible to conclude that this outcome is representative of other operating conditions.

At the remaining locations (Kooragang Island, Hexham Swamp, Tilligerry, Myall River, Cabbage Tree Island), there were a limited number of correlated F-35A aircraft noise events during the transition period survey for comparison against the F/A-18A/B Hornet noise events of the baseline survey. The primary reason being that despite the increased transition period survey duration, there is a low number of F-35A aircraft based at the Base and hence low rate of movements that currently occur.

Section 4.2 of the FMP states the following in relation to the duration of noise surveys:

> *To enable a meaningful comparison of baseline and transition period noise levels, it will be necessary for the survey duration to capture a range of operating and atmospheric conditions. The duration of noise measurements at each location shall extend over a period of two months for both baseline measurements and during the transition period.*

At the time when the FMP was prepared, it was envisaged that noise surveys in the order of two (2) months would enable a sufficient number of aircraft noise events to be captured for the analysis. However, due to the limited number of F-35A aircraft operating at the base at the time of the transition period survey, an extended survey period of three (3) months still resulted in a low number of events.

A low number of F-35A aircraft noise events, with high variation (approximately 20 to 25 dB at some locations) means that the noise level statistics, particularly the 90th percentile, feature uncertainties that limit the conclusions that can be drawn from a comparison with the F/A-18A/B Hornet baseline survey data.

The comparison of baseline and transition period surveys demonstrate a high level of variation in aircraft noise levels that is inherent to military fast jet operations away from well-defined flight tracks. As a result of this variation, minor differences in noise levels that are solely attributable to the change in aircraft type cannot be isolated.

The difference in flight tracks, operation type, likely power settings and hence aircraft noise levels between the two datasets means it is not possible to conclude whether there is a systematic difference in noise levels associated with like-for like operations of the two aircraft. The differences are primarily indicative of variation in noise levels associated with different operations during the transition period survey rather than differences between the two aircraft types.

The available data for the transition period does not demonstrate an exceedance of the baseline data and hence the need for further noise measurements and concurrent fauna observations as detailed in Stage 4.2 of the FMP.

However, as a result of the difference in the operations occurring during the baseline and transition period surveys, combined within the limited number of events identified at the majority of locations during the transition period survey, it is not possible to conclude that this outcome is representative of other operating conditions. The FMP does not provide any guidance on the actions to be undertaken for such circumstances.

Further noise monitoring, preferably at a time of when a greater number of F-35A aircraft numbers and movements are expected, would be required to definitively compare F-35A noise levels to the results of the baseline period survey.

Further, in the absence of identified exceedances, and as a result of the variations in operations between the baseline and transition period, comparison of the results with the noise modelling results presented in the EIS (as referenced in the FMP) is not warranted for the available dataset.

APPENDIX A GLOSSARY OF TERMINOLOGY

Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
Box-whisker plot	Five (5) number summary of a dataset, including the minimum, first quartile, median, third quartile, and maximum.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
L_{Aeq}	The A-weighted equivalent continuous sound level. This is commonly referred to as the average noise level and is measured in dB.
L_{ASmax}	The A-weighted, slow time-weighted maximum noise level. The highest noise level which occurs during the measurement period.
SEL	Sound Exposure Level The A-weighted sound level of one second duration which has the same amount of energy as the actual noise event measured. Usually used to measure the sound energy of a particular event, such as a train pass-by or an aircraft flyover

APPENDIX B REFERENCES

Coffey Environments Australia Pty Ltd, 2016, *Fauna management plan - RAAF Base Williamtown Flying Operations of the F-35A Lightning II*, reference ENAUABTF11616_1_v3, dated 5 February 2016

International Organization for Standardization, 2017, *Acoustics — Description, measurement and assessment of environmental noise – Part 2: Determination of sound pressure levels*, ISO 1996-2.

Marshall Day Acoustics, 2019, *Rp 001 05DRAFT 20181180 Monitoring and Documenting F-35A Noise Effects on Fauna - Baseline Noise Survey*, dated 16 April 2019

Standards Australia, 2018, *Acoustics – Description and measurement of environmental noise,* AS 1055.

Standards Australia/International Electrotechnical Commission, 2019, *Electroacoustics - Sound Level Meters - Part 1: Specifications*, AS IEC 61672-1.

Standards Australia/International Electrotechnical Commission, 2017, *Electroacoustics - Sound calibrators*, AS IEC 60942.

APPENDIX C TRANSITION PERIOD NOISE SURVEY INSTRUMENTATION

C1 Details

Table 8: Noise monitor instrumentation summary

Item	Description
Equipment type	Automated/unattended integrating sound level meter
Make and model	01dB CUBE
Instrumentation class	Certified to Type1 / Class 1 (precision grade) standards in accordance with AS IEC 61672-1 (Standards Australia/International Electrotechnical Commission, 2019)
Instrumentation noise floor	Less than 20 dB
Time synchronisation	Internal GPS clocks
Wind shielding	Proprietary primary wind shield

Table 9: Noise monitor installation records

Location ID	Make/model	Serial number (SN)	Calibration date [1]	Calibration drift [2,3]
Fullerton Cove	01dB CUBE	10652	18.01.2019	0.03
Stockton Sandspit	01dB CUBE	11276	20.02.2018	NA[4]
Kooragang Island	01dB CUBE	10510 / 11289	21.08.2018 / 20.02.2018	0.44 / 0.56
Hexham Swamp	01dB CUBE	11296	20.02.2018	0.46
Tilligerry	01dB CUBE	10423 / 10515	13.05.2019 / 07.08.2018	0.31 / 0.86
Swan Bay	01dB CUBE	10512	09.05.2019	0.68
Myall River (Pindimar)	01dB CUBE	10657	29.05.2019	0.01
Cabbage Tree Island	01dB CUBE	10518	29.05.2019	0.18

Notes (1) Independent (laboratory) calibration date to be within 2 years of measurement period as per AS 1055 (Standards Australia, 2018)
(2) Difference between reference level checks during deployment and collection of instruments
(3) Calibration drift should not be greater than 1 dB as specified in AS 1055 (Standards Australia, 2018)
(4) Due to noise monitor technical fault, post measurement calibration could not be obtained

Table 10: Weather instrumentation installation records

Location ID	Make/model	Serial number (SN)	Location
Fullerton Cove	Vaisala WTX520	H5020012	Within 5 m of noise monitor, 1.5 m AGL
Swan Bay	Vaisala WTX520	K2920006	Within 5 m of noise monitor, 1.5 m AGL

C2 Noise monitor technical faults

Kooragang Island

The original noise monitor (SN: 10510) was replaced by another unit (SN: 11289) on 10 July 2019 due to evidence of the deterioration of the internal battery resulting in the occasional loss of data in the early hours of the morning (outside the times of F-35A aircraft operations).

Upon retrieval of the noise monitor on 24 September 2019, the unit was found leaning against an adjacent fence on an approximate 45° angle to ground level instead of 90°. It is not clear on what date this occurred. The only difference relates to position and orientation of microphone, with differences in noise levels that may occur at individual frequencies of sound, but not expected to significantly alter total noise levels. Therefore, given there was no evidence of physical damage and that a valid calibration of the microphone was obtained, the noise data was considered to be valid for this assessment.

Figure 27: Kooragang Island noise monitor

Stockton Sandspit

Upon retrieval, the noise monitoring unit could not be calibrated at the conclusion of the monitoring period due to the presence of water/moisture found within the microphone/preamp assembly. A ring of silt on the windsock indicated that the unit had recently fallen over into a shallow puddle of water. The unit failed its acoustical calibration check. Further inspection revealed that moisture had entered the microphone/preamp assembly, significantly corroding the internal circuitry of these components to a degree not previously encountered by MDA, and causing them to fail.

A review of the noise data and daily internal system checks indicated clearly that the failure of the microphone/preamp occurred after 17 September 2019. A review of weather records indicated there were sustained high winds and rainfall on the 17 and 18 September 2019.

It is therefore expected that the noise monitor mast was blown over by unprecedented high winds, with the impact of the fall compromising the integrity of the weather seals of the microphone and preamplifier. The high rainfall resulted in moisture ingress to the damaged components, possibly due to the pooling of rainwater around the fallen mast. It is suspected that personnel at the Stockton Centre righted the noise monitor at some point following the storm without informing MDA of the incident.

Of the 14 weeks of monitoring during the operational noise survey, only the final week of monitoring was affected and therefore excluded from the analysis.

Tilligerry

Due to poor remote connectivity, the original noise monitor (SN: 10423) was replaced by another unit (SN: 10515) with an improved external antenna on 10 July 2019.

APPENDIX D NOISE MONITORING LOCATIONS

Location and noise monitor serial number

Fullerton Cove – Cube 10652

Distance to FMP nominated monitoring location: 410 m

Stockton Sandspit – Cube 11276

Distance to FMP nominated monitoring location: 700 m

Location and noise monitor serial number	
Kooragang Island – Cube 10510 / Cube 11289	Distance to FMP nominated monitoring location: 3.4 km. A secure location on the island with regular surveillance could not be arranged for the baseline noise survey. The location selected was within 300 m of the island. For consistency, the same location was used for the transition period noise survey.
	
Hexham Swamp – Cube 11296	No specific measurement location nominated for the Hexham Swamp area specified in the FMP
	

Location and noise monitor serial number	
Tilligerry – Cube 10423	No specific measurement location nominated for the Tilligerry area specified in the FMP
	
Swan Bay – Cube 10512	Distance to FMP nominated monitoring location: 760 m
	

Location and noise monitor serial number	
Myall River (Pindimar) – Cube 10657 	Distance to FMP nominated monitoring location: 760 m 
Cabbage Tree Island – Cube 10518 	No specific measurement location nominated for Cabbage Tree Island specified in the FMP 

APPENDIX E AIRCRAFT EVENT DATA DETECTION AND CORRELATION

The following section details the aircraft event detection and correlation with noise data procedure used for the transition period noise survey. The procedure is identical to that used for the baseline noise survey (Marshall Day Acoustics, 2019).

Potential aircraft noise events using measured noise levels

The noise monitors were configured to continuously measure noise levels in 0.5 second intervals.

The noise level time traces were analysed such that potential aircraft noise events were coded for instances where the measured noise levels increased above ambient noise and reduced again as if an aircraft was flying past the monitor.

An event was coded if there was a rise in noise level over a given maximum noise level threshold (e.g. 55 dB, 60 dB, 65 dB or 70 dB depending on ambient noise conditions at each monitor), the noise level remained above that threshold for a minimum of 10 seconds but no longer than 160 seconds, then fell below the threshold.

These coding thresholds and durations were selected for each monitoring location following an engineer's review of a sample of potential aircraft events and a review of several audio recordings.

Flight track and radar data

Geospatial flight track and radar data was supplied by EMS Brüel & Kjær, the operators of the Noise Flight Path and Monitoring System (NFPMS). From this, a list of aircraft pass-by events was established for data within a nominal distance of each of the noise monitors. The information included the aircraft type, runway and operation type (arrival, departure, touch and go), altitude, airspeed as well as the time of closest approach and minimum distance to the noise monitors for each individual flight.

EMS Brüel & Kjær has advised on the known limitations with the radar data for military fast jets, summarised as follows:

- Sections of flight paths can be missed by the radar if aircraft fly at particularly low altitudes. Some arrival and departure flight paths were considerably short and terminated relatively close to the Base;
- For some types of formation flying, only the lead aircraft of the formation may be recorded by the NFPMS system, and no data is recorded for other aircraft. EMS Brüel & Kjær has advised that there is no means of establishing alternative geospatial data for the incomplete or missing NFPMS data;
    - In addition, Department of Defence advised that for the majority of departures, formations are the same aircraft type e.g. 2x, 3x or 4x F-35A. However, sometimes certain training will necessitate the need for dissimilar aircraft types (i.e. occasionally 2 or 3 aircraft of different types, 1x F-35A and 1x F/A-18A/B Hornet). In such instance, the lead aircraft will be squawking the ATC assigned mode 3 IFF code, so if the F/A-18A/B Hornet was leading the F-35A, then the code you would see would be the F/A-18A/B Hornet;
    - This concept is similar for arrivals (recoveries), however, mixed formation recoveries (e.g. 2x F-35A and 2x F/A-18A/B Hornet) are a little more common than mixed departures;
    - Such limitation means if a particular F-35A is not squawking the ATC assigned mode 3 IFF code, the particular aircraft will not be identified and therefore not correlated to a noise event;
    - Correlated noise events during mixed formation flying will include contributions from multiple aircraft types (including F-35A), however the 'event' may be incorrectly identified as a single aircraft;
- There are also limitations with the NFPMS classification of aircraft events. There are instances where a military fast jet's departure, training operations away from Base and the subsequent arrival are logged as one flight path and classified as one operation type – usually a touch and go operation; and

- The NFPMS data classified this flight path as only one touch and go movement, which is a training exercise where an aircraft approaches the Base and touches down on the runway, then immediately increases thrust to lift off the runway and depart the Base without coming to a stop.

Figure 28 shows an example where a Hawk 127 lead-in fighter aircraft departs the Base to the northwest, turns southeast over the ocean, returns to Base along the coastline and approaches via an initial and pitch. This could be considered as three distinct movements: a departure, an overflight or training exercise, and an approach, however is identified as a single operation in the NFPMS data.

The implication of the missing aircraft data on the survey is that there may be aircraft noise events identified by noise monitors for which there is no corresponding NFPMS data. These potential noise events are therefore not classified as an aircraft noise event and are excluded from further analysis.

Figure 28: Example of a single flight path comprising multiple aircraft operations (Basemap: Esri World Imagery)

Figure 28 also demonstrates instances where the NFPMS is unable to capture segments of the flight path at lower altitudes. This is evident by missing parts of the initial and pitch turn and the turn over the ocean that result in a straight line displayed between data points that appears to 'cut' off a segment of the flight path curve.

A review of a sample of the radar data revealed:

- Flight paths classified as arrivals or departures were generally found to be correctly identified. However, there were instances where these flight paths would include training operations and overflights between training areas that were all classified as a single arrival or departure movement;

- There were instances where a departure, training operations away from the area and an arrival were classified as single touch and go movement (as per Figure 28); and
- There were instances where a departure, several touch and go movements and an arrival were classified as single touch and go movement.

The above limitations therefore identified aircraft noise events that may be incorrectly designated as an arrival or departure, when it was in fact transiting between training areas, or an event may be incorrectly designated as being a touch and go operation, when the aircraft was actually departing prior to, or arriving at the Base following a touch and go operation.

Additionally, the point of closest approach data of a flight path to a given noise monitor considers only a single point where the aircraft is closest the monitor.

This data therefore disregards instances when there may be other earlier or later instances during a flight where the aircraft passed close to the noise monitor resulting in a noise event that would not be assigned to an aircraft movement.

To address these issues, the NFPMS data was subjected to an automated process to better classify different segments of each flight path:

- The first and last spatial co-ordinate of each flight path was reviewed as to establish whether it was near to or far from the Base. This could be used to establish whether a movement was likely to be an arrival, departure or combination of movement types
- The single flight paths were then broken into segments of 10 consecutive co-ordinates. As a co-ordinate was generally recorded every five seconds, this generally represented 50 seconds of flight. This resulted in a database of shorter individual aircraft flight segments to be correlated against potential aircraft nose events. In instances where an aircraft passed a noise monitor multiple times in one flight (such as during touch and go training or transitions between different training airspaces), the different pass-by events could be identified
- Segments within the first 70 km of a departure flight path were tagged as a departure, whilst the remaining segments were tagged as an indicative departure. This was validated following a review of the flight path data that indicated the aircraft would have likely passed by all the monitoring locations after 70 km and may be transiting to or between designated training operations airspace
- Segments within the last 90 km of an arrival flight path were tagged as an arrival, whilst the remaining segments prior were tagged as an indicative arrival. This was validated following a review of the flight path data that indicated the aircraft would likely be returning to the Base in the last 90 km of their flight and passing the monitoring locations, and earlier segments may be due to aircraft cruising away from designated training operations airspace back towards the Base
- Flight paths that started and ended close to the Base were likely to be a combination of a departure and arrival operation. Therefore, the following was assumed:

– For a flight path that the radar data *had* identified as a touch and go, the first 70 km of segments were tagged as a departure as described above. The last 30 km of segments were tagged as an arrival on the basis that earlier segments may be due to touch and go circuits undertaken immediately before arrival at Base. The remaining intermediate segments were tagged as being either a touch and go or an overflight operation

– A flight path that the radar data *had not* identified as a touch and go that started and ended near the Base was very rare (less than five flight paths in three months). In this case, segments within the first 70 km were tagged as being an indicative departure, segments within the last 90 km of an arrival flight path were tagged as an indicative arrival and other segments were tagged as “other”

- Segments for any other flight paths that were not captured by one of the above categories were tagged with the original NFPMS movement, but also as being indicative.

The above process is acknowledged as not a being a definitive method of classifying an aircraft's activity during a flight, however it is an improvement on the simplified single NFPMS classifications for the complex flight paths and therefore provides a better indication of an aircraft's likely operation during an aircraft noise event.

The point of closest approach for each segment to each noise monitor was calculated. Of all the aircraft flight segments derived from the radar data, only segments that came within 7 km of noise monitors were retained for correlation with potential aircraft noise events, noting that there were typically two flight segments per flight path within these areas. A distance of 7 km was nominated as most of the noise monitors were within 7 km of a distinguishable flight corridor.

APPENDIX F IDENTIFIED AIRCRAFT EVENT LIST – TRANSITION PERIOD NOISE SURVEY

The spreadsheet attached details the complete list of correlated events at each of the eight (8) noise monitoring locations obtained during the transition period noise survey.

The following acronyms and shorthand notes have been used in the correlated aircraft events.

PCA	Point of Closest Approach of an aircraft flight path to the noise monitor (ground distance to monitor)
A	Arrival operation
D	Departure operation
T	Touch and go training circuit operation
O or OVF	Overflight segment
Indicative	Given the distance into the flight by the aircraft, there may be some uncertainty as to whether the aircraft at a cruising power setting is after completing a departure or prior to commencing an arrival. Refer to Appendix E for further details.
A/D segment of T	'Refers to a segment of a flight path that the NFPMS has tagged as being a touch and go operation, however the aircraft is more likely to be arriving at or departing from the Base

It is noted that during the transition period noise survey, additional data on F/A-18A/B Hornet aircraft operations was obtained. The data analysed and documented in the previous report provides the baseline for assessing the change in noise levels during the transition period. Accordingly, the additional F/A-18A/B Hornet data has not been analysed or assessed as part of this study.