Australian Government

Department of the Environment and Heritage
Australian Antarctic Division

- DRAFT -

Initial Environmental Evaluation

Air Transport System

Development and operation of an ongoing air transport system including inter-continental flights between the Australian and Antarctic continents and intra-continental flights between Antarctic stations

Public Consultation Process

The Australian Antarctic Division (AAD) will make this draft Initial Environmental Evaluation (IEE) available for public comment for a minimum period of five weeks. A notice of the availability in Australia of the draft IEE will be published in the *Commonwealth of Australia Government Notices Gazette*. Copies of the evaluation may be obtained from:

The Environment Officer
Australian Antarctic Division
Channel Highway
KINGSTON TAS 7050

A copy of the evaluation will be published on the Internet at the following address:

http://www.aad.gov.au/

The public consultation process will also involve circulation of the evaluation to interested parties for comment. The interested parties will include, but not be limited to; relevant sections of the AAD, any national program that may be affected by the activity, relevant non government and government organisations, and the Approvals and Wildlife Division (AWD) of the Department of the Environment and Heritage. Additional consultation will be undertaken with the AWD to ensure that all obligations under the *Environment Protection and Biodiversity Conservation Act 1999* are met. A copy of the draft evaluation will be sent to the Executive Secretary of Council of Managers of National Antarctic Programs (COMNAP).

To assist with providing this information to the public, Chapter 14 of this document provides detailed overview of the environmental assessment of the air transport system.

Interested persons may submit their comments on the evaluation to:

Air Transport IEE submission
The Director
Australian Antarctic Division
Channel Highway
KINGSTON TAS 7050.

Front Page Photo: C212 aircraft (courtesy EADS CASA)

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GLOSSARY OF TERMS

AAD	- Australian Antarctic Division
AAT	- Australian Antarctic Territory
ASAC	- Antarctic Science Advisory Committee
AT(EP) Act	- *Antarctic Treaty (Environmental Protection) Act 1980* (Cth)
ASPA	- Antarctic Specially Protected Area
AWD	- Approvals and Wildlife Division, Department of Environment and Heritage
AWS	- Automatic weather station
BOM	- Bureau of Meteorology
C130	- Hercules C130 aircraft
C212	- CASA 212/400 turbo prop aircraft
Casey Runway	- Snow capped glacial blue ice runway for inter-continental operations
CH_4	- Methane
CO_2	- Carbon dioxide
COMNAP	- Committee of Managers of National Antarctic Programs
Comms mast	- Communications mast
CRREL	- US Army Cold Regions Research and Engineering Laboratories
Cumulative impacts	- Combined impact of past, present, and reasonably foreseeable activities. These activities may occur over time and space and can be additive or interactive/synergistic (COMNAP, 1999)
EMAU	- Environmental Management and Audit Unit, AAD
EMP	- Environmental Management Plan
EOI	- Expression of Interest
EPBC Act	- *Environment Protection and Biodiversity Conservation Act 1999* (Cth)
IEE	- Initial Environmental Evaluation
Gg CO_2-e	- Gigagrams (1000 tonnes) of carbon dioxide equivalents
g/MJ	- gram of greenhouse gas per mega-joule of fuel combusted
GPS approach	- using GPS instrumentation to assist with landing in times of poor visibility
GWP	- Global warning potentials
M4	- Macquarie Wharf 4
MJ/L	- Mega-joules per litre of fuel, unit of specific energy content
NGGIC	- National Greenhouse Gas Inventory Committee
N_2O	- Nitrous oxide
PAPI	- Precision Approach and Path Indicator lighting system
PNR	- Point of no return
RFP	- Request for proposal
PRC	- Peoples Republic of China
RTA	- Return to Australia
Sastrugi	- Wavelike ridges of hard snow formed on level surface by the action of the wind. The ridges are parallel to the direction of the prevailing wind.
Skiway/s	- Sea ice or snow based landing strips for intra-continental flights
STOL	- Short take-off and landing
US EPA	- United States Environmental Protection Agency
VFR	- Visual flight rules

1 EXECUTIVE SUMMARY

This Initial Environmental Evaluation (IEE) has been prepared by the Australian Antarctic Division (AAD) in accordance with the provisions of the *Antarctic Treaty (Environment Protection) Act 1980* for the development and operation of an ongoing air transport system including inter-continental flights between the Australian and Antarctic continents and intra-continental flights between Antarctic stations (Casey, Davis and Mawson).

The system will transport scientists and support personnel as part of the Australian Antarctic Program during the Austral summer (September to March), moving up to 400 passengers per season, with capacity to expand to 600 over time. The system will also provide a year round capability to respond to emergencies. Approximately 25 to 40 inter-continental flights from Hobart to Casey will be conducted each season. Intra-continental flights will link each of the Antarctic stations and field camp locations.

The aircraft services will be provided by a Sydney based aviation company, Skytraders Pty Ltd, who were selected after a competitive tender process. The aircraft selected for the system are the Falcon 900EX jet for inter-continental operations and the ski equipped CASA 212/400 (C212) turbo prop for intra-continental operations.

A 4000m snow capped ice runway will be constructed 65km east of Casey station to support inter-continental wheeled aircraft operations. All skiway surfaces used in Antarctica are either snow or ice. Surface grading will be required for construction and maintenance. Existing skiways and support infrastructure will be utilised at stations for intra-continental flights, in areas where they are currently available and suitable for the aircraft.

It is planned that the air transport system will be introduced over the next three Antarctic summers. In the 2003/04 summer, construction equipment and other associated infrastructure will be shipped down to Casey in preparation for the introduction of the C212 operations in 2004/05. Subject to the necessary approvals, the Antarctic air transport system should be fully operational in 2005/06, with the introduction of the Falcon 900EX.

There are many benefits that an air transport system will bring to the Australian Antarctic Program (AAP), including:

- Increased flexibility and responsiveness in deploying scientific and support personnel
- Increased frequency of access
- Increased capacity to support remote area research and airborne research
- Decreased unproductive travel times
- Improved marine science opportunities
- Increased ability to respond to emergencies
- Increased ability to collaborate with other national Antarctic programs
- Increased flexibility in logistic support for the entire program

The air transport system has the potential to cause adverse environmental impacts. However, these impacts will be minor and/or transitory and are controlled by mitigation measures incorporated into the project design. Some minor and transitory impacts that are potentially unavoidable are considered to be worthwhile to achieve the significant long term benefits to the Australian Antarctic Program. Potential adverse impacts and the associated mitigation measures are summarised in Table i.

An Environmental Management Plan (EMP) will be developed for the project. The EMP will document procedures to ensure that best environmental practice is achieved. The AAD will monitor the condition of the environment to detect any adverse environmental changes that may be caused by the air transport system.

As part of the Australian Antarctic Division's (AAD) legal requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a referral was submitted to the Department of the Environment and Heritage to determine if additional assessment under the EPBC Act was required. The resulting decision by the Minister for the Environment and Heritage was that the action would not require further assessment providing that it be undertaken in a specified manner (ie. Non-controlled action-specified manner). This IEE report addresses those specified manner requirements.

Table i: Summary of Impacts and Mitigation Measures

Key Value/Impact	**Mitigation measures**
Air quality emissions	- Aircraft engines and maintenance equipment will be maintained in good condition at all times to minimise emission levels. -Alternative energy sources will be investigated for the provision of power to field locations as technology develops.
Vegetation Emissions	-Aircraft engines and maintenance equipment will be maintained in good condition at all times to minimise emission levels. -Alternative energy sources will be investigated for the provision of power to field locations. -Preferred flight paths have been or will be established for all regular landing sites to minimise disturbance to wildlife and other sensitive areas. -A monitoring program for biological and chemical impacts will be developed and maintained.
Vegetation Contaminants	-Preferred flight paths have been or will be established for all regular landing sites to minimise disturbance to wildlife and other sensitive areas. -Continuing on from baseline data collections, moss samples analysis will be part of the monitoring program
Surface Disturbance	-Use of snow and ice runway and skiways -Pre-existing facilities and previously used fuel storage sites will be used wherever possible -To the maximum extent possible, all construction vehicles will keep to established roads and access routes. -Protocols for assessing additional temporary or long term airfield sites will be developed to ensure minimal impact on the surrounding environment. -Surface contaminants will be removed and processed through the oil/water separator at the nearest station or returned to Australia
Snow/ice quality Contaminants	-Aircraft selected for Inter-continental operations require minimal support infrastructure, including fuel, in Antarctica. Fuel used or intra and inter-continental operations will follow developed procedures to minimise the risk of spills -All wastes produced at remote landing sites will be returned to a nearby station for processing or return to Australia -Contingency response plans for environmental incidents -Surface contaminants will be removed and processed through the oil/water separator at the nearest station or returned to Australia
Snow/ice quality Fuel spill	-Existing refuelling protocols and procedures to be followed -Additional contingency response plans for environmental incidents including fuel spills will be developed, where required -Surface contaminants will be removed and processed through the oil/water separator at the nearest station or returned to Australia -In cases where fuel is stored in other than 205 litre drums, secondary containment will be provided. -All sites where refuelling will occur will be fitted with spills kits and correct procedures as described in the fuel management plan will be followed.
Birds/Seals Disturbance	-Site selected for Inter-continental runway 22kms from nearest ice free land -A separation distance of 750m will be observed by aircraft near wildlife concentrations -Due to the sensitivity of the Southern giant petrel, overflights of known breeding areas will not be made. -A monitoring program for biological and chemical impacts will be developed and maintained.
Birds/Seals Bird strike	-A separation distance of 750m will be observed by aircraft near wildlife concentrations -Skiways are to be inspected for wildlife prior to aircraft operations. -All bird strikes will be reported to Environment Advisor, Operations Branch.
Quarantine Introduced organisms	-Current quarantine measures will apply. -Quarantine measures will be developed to prevent the transfer of organisms to and within Antarctica. - Aircraft, passenger clothing/boots and other equipment/cargo will be cleaned of dirt and other contaminants prior to being transported to Antarctica

2. AUSTRALIAN ANTARCTIC DIVISION POLICY CONTEXT

2.1 Advancing Australia's Antarctic Interests

The Australian Government has identified four goals for the Australian Antarctic program:

- maintaining the Antarctic Treaty System and enhancing Australia's influence in it;
- protecting the Antarctic environment;
- understanding the role of Antarctica in the global climate system; and
- undertaking scientific work of practical, economic or national significance.

The Australian Antarctic Division (AAD) as a division of the Department of the Environment and Heritage plays an integral role in meeting these Antarctic program goals. The AAD seeks to advance Australia's Antarctic interests in pursuit of its vision of having "Antarctica valued, protected and understood". It does this by conducting Antarctic research and other activities aimed at achieving the Government's Antarctic goals, and by administering and maintaining a presence in Australian Antarctic and subantarctic territories. The AAD manages Australian government activity in Antarctica, provides transport and logistic support, maintains the four permanent Australian research stations, and conducts and manages scientific research programs both on land and in the Southern Ocean.

One of the priority activities in 2003-04 includes the development of infrastructure and organisational elements in support of the proposed inter and intra-continental Antarctic air transport system.

The proposed air transport system will greatly assist the AAD in meeting its goals and objectives, through providing a better passenger transportation system and enabling a wider variety of science to be undertaken. The new system is also consistent with the Madrid Protocol, incorporating a thorough environmental design in to its operation.

2.2 Legislative background

Activities in Antarctica (the area south of 60° south latitude) are subject to the provisions of the *Antarctic Treaty (1959)*, the *Protocol on Environmental Protection to the Antarctic Treaty (1991)* and other international agreements, collectively known as the Antarctic Treaty System. The *Antarctic Treaty (Environment Protection) Act 1980* (AT(EP) Act) gives effect to these obligations in Australian law. The AAD is required to conduct an environmental assessment of the air transport system under the provisions of the AT(EP) Act.

The AAD is also subject to statutory requirements under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In September 2002, an EPBC referral for the air transport system was made to the Australian Government, Department of the Environment and Heritage (as administrators of the EPBC Act). During the public comment period on the referral, no comments were received from the public. In October 2002, the Minister for the

Environment and Heritage determined that the action was deemed to be a non-controlled action on the proviso that it is undertaken in a specified manner (Appendix 1). This decision essentially meant that the proposal did not require EPBC approval prior to its implementation. These 'specified manner' requirements include:

- Operational flight paths and flight requirements will be developed and implemented to minimize the potential for wildlife disturbance or impacts on sensitive marine and Antarctic environments.
- Modelling of noise footprints for aircraft, to aid in assessing noise related impacts and planning of operations, will be undertaken to assist in development and implementation of flight operational protocols and guidelines to minimize disturbance to fauna.
- The requirements for interacting with cetaceans within the Australian Whale Sanctuary (Part 8, Division 8.1, Clause 8.05 of the *Environment Protection and Biodiversity Conservation Regulations 2000*) will be incorporated into flight operational protocols and guidelines, as appropriate.
- Monitoring programs to ensure impacts remain within any required limits will be developed and implemented.
- The monitoring program will also specifically address the potential for noise disturbance to the Southern giant petrel and the Wilson's storm petrel and any measures needed to avoid impacts
- The flight operational protocols and guidelines will be reviewed and updated against the results of the monitoring programs on an annual basis, for the first five years of operation, and thereafter on a five yearly basis.
- Flight operational protocols and guidelines, and monitoring programs relevant to identification and minimization of environmental impacts, will be developed in consultation with relevant expert agencies, including Environment Australia.

All of the above items specified under the EPBC instrument are within the current scope of the project and are discussed throughout this document. The Department of the Environment and Heritage has played an important role in developing this report by providing comment and guidance on the environmental impact of the system.

Under the AT(EP) Act, a Preliminary Assessment for the air transport system was submitted in February 2003. It was determined by the Delegate for the Minister for the Environment and Heritage in March 2003 that the activity is likely to have a minor and/or transitory impact on the environment and in accordance with the AT(EP) Act, an Initial Environmental Evaluation (IEE) must be prepared.

Following the submission of the final IEE, it will be determined if the activity needs further assessment or if it can be authorised to proceed, subject to certain conditions.

3. DESCRIPTION OF THE PROPOSED ACTIVITY

3.1 Background

An air transport system aimed at transporting expedition scientists and support personnel quickly and frequently between Australia and Antarctic destinations, including the Australian stations Casey, Davis and Mawson, and field locations has been proposed for more than three decades by the Australian Antarctic science community. Such a system would also provide the infrastructure and capability to provide flights directly in support of science.

Investigations into runways suitable for inter-continental wheeled aircraft in Australian Antarctic Territory (AAT) commenced during the 1970s when (i) consideration was given to a rock runway in the Davis region, and (ii) Russell-Head and Budd (at the University of Melbourne) in collaboration with Mellor (at US Army Cold Regions Research and Engineering Laboratories (CRREL)) commenced preliminary examination of the feasibility of using compressed snow as a runway surface. An estimate of cost (M$6) and environmental considerations in the early 1980s was provided as evidence to rule out further consideration of an inter-continental rock runway construction in the AAT.

During the 1980s Russell-Head and Budd carried out further laboratory and field feasibility studies of compressed snow as a runway medium (Russell-Head & Budd 1989). Mellor at CRREL and Klokov at the USSR Arctic and Antarctic Institute (Leningrad) also carried out similar studies. In particular, the Australian field studies concentrated on an area of snow between 12 and 15 km inland of Casey near sites designated S1 and Lanyon Junction. Russell-Head and Budd concluded that the snow in this region could be compressed to a suitable hardness and smoothness to form a runway suitable for wheeled aircraft such as the Hercules C130. Due to the range capability of the C130, additional fuel and an alternative runway were necessary elements of this proposed system. In the late 1980s a trial runway was constructed, but bad weather prohibited a proof flight that had been planned.

During the mid 1980s Mellor (now deceased) and a co-worker, Blaisdell at CRREL, began investigating hard glacial ice as an alternate runway surface. A UK glaciologist, Swithinbank also carried out a survey of potential glacial ice sites around Antarctica. A private company, Adventure Network International (ANI) commenced operations into a glacial ice runway in West Antarctica.

Currently in Antarctica, there is a number of operating glacial ice runways. The United Kingdom and United States operate glacial ice runways. Other glacial ice runways are located at Dronning Maud Land and Patriot Hills.

3.2 Purpose and need

In late 1996, the Government requested the Antarctic Science Advisory Committee (ASAC) to undertake a 'foresight analysis' of Australia's Antarctic Program and to provide advice and recommendations on, among other things, "the infrastructure and logistical support most appropriate to support the Antarctic Program".

In its October 1997 report Australia's Antarctic Program Beyond 2000: A Framework for the Future, ASAC concluded "that the current dependency upon a single multi-purpose ship restricts the flexibility of the science program, severely limits the number of scientists who are able to work in Antarctica, and imposes substantial unproductive travelling times. An inter-continental air-link coupled to an intra-continental distribution service would provide the transportation flexibility which an innovative and responsive future Antarctic Program requires."

Consistent with its conclusion, ASAC specifically recommended, "In support of a responsive, productive and versatile Antarctic Program, Australia develop a light aircraft intra-continental air transportation system in support of scientific research and for dispersing scientists and their support within the AAT. This system should operate from a single terminus in the AAT which would be served by an inter-continental air link from Australia."

In May 1998 the Government accepted ASAC's advice that "compared to other significant Antarctic nations Australia's reliance on ship-based transportation … imposes significant inefficiencies." The Government also accepted the "desirability of the Australian Antarctic Program possessing an inter-continental air transport capability that is cost-effective, meets the highest environmental standards, and does not cause significant adverse environmental impacts." The Government therefore asked, "the Antarctic Division, using consultants as appropriate, to prepare a scoping study of inter-continental air transport options which addresses the environmental and practical considerations including costs."

A taskforce was established to undertake the scoping study, to coordinate the inputs and activities of a range of interested groups and individuals and subsequently, to carry out investigations in Antarctica, including examination of foreign air transport operations, of different airfields and of different aircraft alternatives. The taskforce operated under the broad direction of, and reported to, the Director of the AAD. It produced two reports. A scoping study was completed in 1999 http://www.aad.gov.au/goingsouth/airlink/scoping_9900/default.asp (Shevlin & Johnson 1999). The scoping study considered technical, financial and environmental issues, and recommended further investigation of a number of options. All of the recommended options involved the use of ice or snow surfaces as airfields.

A subsequent Air Transport Report was published in 2000 http://www.aad.gov.au/goingsouth/airlink/report_00/default.asp

The task force recommended implementation of a long-term Australian Antarctic air transport system that would include inter-continental flights between Australia and Casey Station, Antarctica. Intra-continental flights in smaller ski/wheel equipped aircraft would service Davis and Mawson from Casey. A glacial-ice landing site at Bunger Hills would serve as an alternative to Casey (in the event of bad weather) and as a refuelling site between Casey and Davis. The task force recommended an environmental impact evaluation in accordance with Australian and Antarctic Treaty requirements. It also recommended detailed cost-benefit and risk assessments to determine the type of supporting infrastructure most appropriate for an Australian Antarctic air transport system.

Field investigations since publication of the scoping studies have included visits to the Casey station area during the 2000/2001 and 2001/2002 seasons. Investigations (i) located and surveyed a site that is believed suitable for construction of a compressed snow runway able to handle large wheeled aircraft, and (ii) located and surveyed a site consisting of hard 'blue-ice' that, on early indications, appeared suitable for construction of a blue-ice runway capable of handling large wheeled aircraft.

On 11 June 2000, the then Minister for Environment and Heritage, Senator the Hon Robert Hill, agreed that the AAD would test the market for the provision of an air transport system. A two-stage process has been followed to select a company suitable to provide the air transport link.

First, an Expression of Interest (EOI) stage (i) asked organisations to express their interest as prospective service providers, (ii) facilitated an assessment of the ability of respondents to provide the required services, and (iii) established a shortlist of those respondents who are able to demonstrate their ability to provide the required services. Eight companies were short-listed as a result of the EOI.

Following this process, the eight short-listed companies were asked to respond to a Request for Proposal (RFP). The RFP process was designed to establish whether a financially acceptable and long-term contractual arrangement with a suitable service provider or service providers might be implemented.

After due consideration of all proposals and thorough compliance and economic evaluations, Skytraders Pty Ltd were invited to enter into negotiations to develop a contract for the provision of the air service. The Skytraders proposal includes provision of an inter-continental component using a Dassault Falcon 900EX jet to provide an air link between Hobart and Casey in Antarctica, and an intra-continental component using two CASA 212/400 turbo-prop aircraft (C212) equipped with a ski/wheel undercarriage, to provide the service between Casey to Davis and Mawson. This option was judged by the Evaluation Panel to be the best from a technical, environmental and financial point of view.

The selected system differs from the options investigated in the Antarctic Air Transport Scoping Study, and the Air Transport Report 1999/2000, and certain aspects of those reports therefore do not apply. In particular, the system does not require the development of an alternate inter-continental airfield in Antarctica, does not require large volumes of fuel in Antarctica for the inter-continental component of the operation, and uses an inter-continental aircraft with a high speed and full return range and is therefore safer and more efficient.

3.3 Current transport system

The AAD currently uses ships and aircraft to support its operational and scientific programs to and within Antarctica and the sub Antarctic islands (Macquarie Island and Heard Island).

Typically, the shipping season is between September and March and involves carriage of all cargo, including station fuel, and expeditioners over 6-10 voyages, usually departing and arriving from Hobart. During travel between Hobart and

Antarctica pack ice is required to be transited and delays and increased costs due to besetment in ice are not uncommon. The AAD relies primarily on ice strengthened vessels chartered specifically for this purpose. Tourist and other vessels are also used as required. Dedicated marine science voyages are routinely conducted over this period and occasionally, as required, during winter.

Early season voyages often need to use helicopters to transport passengers and some cargo over sea ice as ice conditions prevent ships reaching stations. Fixed wing aircraft and helicopters are currently utilized by the AAD annually to undertake a variety of scientific and operational tasks, such as:

- Station and field based support of science and operational programs
- Ship to shore and shore to ship transfer of cargo and expeditioners
- Ship based marine science
- Ice reconnaissance for shipping.

Fixed wing aircraft are used on an as-required basis on the continent to assist with specific science programs. The aircraft that are used are twin engined aircraft capable of landing on minimally prepared ice/snow surfaces. They are generally able to carry a larger payload further than the helicopters used by the AAD. Supporting remote field camps and geophysical survey are typical tasks. Fuel to support aircraft operations is stored at stations and in remote fuel depots. Remote fuel depots are also required to supply short range helicopters.

Hours flown by fixed wing aircraft and helicopters are recorded and presented as a State of Environment indicator;
(Indicator 60 - http://aadc-maps.aad.gov.au/aadc/soe/list_of_indicators.cfm)

3.4 Key benefits/objectives

There are many benefits that an air transport system will bring to the Australian Antarctic Program, including:

- Increased flexibility and responsiveness in deploying scientific and support personnel
- Increased frequency of access
- Increased capacity to support remote area research
- Increased capacity to support airborne research
- Decreased unproductive travel times
- Improved marine science opportunities
- Increased ability to respond to emergency situations
- Increased ability to collaborate with other national Antarctic programs
- Increased flexibility in logistic support of the entire program

3.5 Principal characteristics

The AAD proposes to develop and operate an ongoing air transport system delivering inter-continental flights between the Australian and Antarctic continents, intra-continental flights between the Australian Antarctic stations, and all support functions. The system will transport scientists and support personnel as part of the Australian Antarctic Program. The inter-continental airfield will be a snow capped glacial blue ice runway (Casey runway) utilised by the Falcon 900EX. Intra-continental operations will utilise the C212 on both groomed and unprepared snow and ice surfaces (skiways). The system will also support field locations however these activities will be subject to their own environmental assessments as required.

The system will operate between the Antarctic and Australian continents over the Southern Ocean and between Casey, Davis and Mawson stations, and throughout Antarctica (Map 1 and Table 1) as required. The majority of the associated air transport activities will take place within the AAT.

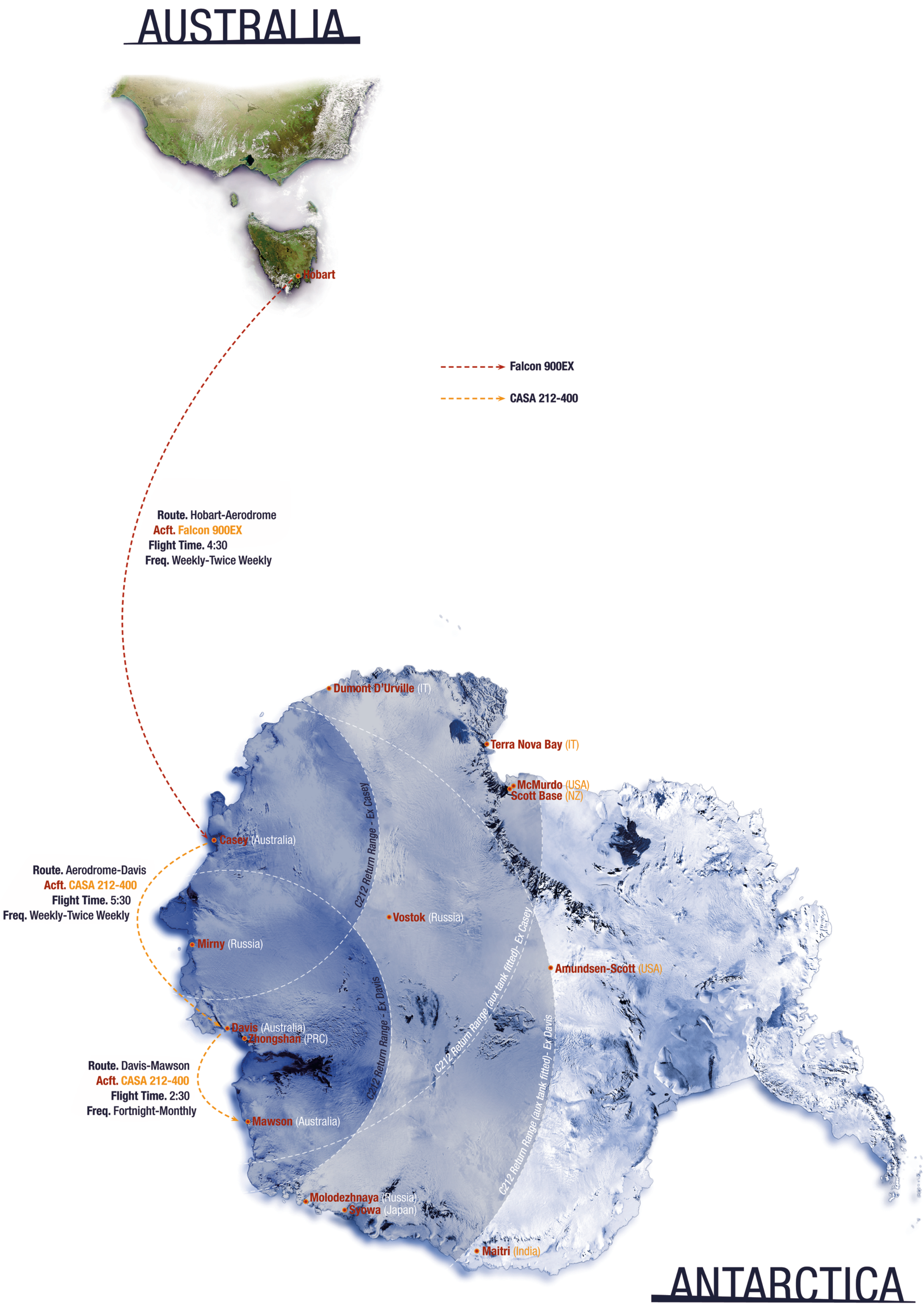
Table 1: Approximate flight route distances

Service	Route/distance	Travelling time
Inter-continental	1855nm / 3437km (Hobart / Casey)	4.3 hours
Casey station link	65km (Casey runway / Casey station)	20 mins (by air) or 2 hours (by over snow vehicle)
Intra-continental	756 nm / 1401km (Casey / Davis) 342nm / 633km (Davis / Mawson)	5.1 hours 2.4 hours
Helicopter link	19nm / 35km (Davis plateau / Davis station)	15-20 mins (by air)

When air transport services are established, ship transport will still be required for the Australian Antarctic Program, for the transport of fuel and cargo, and for marine science. Air transportation of personnel may however provide better opportunities in ship charter and scheduling, and is likely to result in a reduced requirement for shipping or an increase in ship time allocated to scientific work. The introduction of the air transport system will also allow AAD to rationalise its remote fuel depots and reduce the need for conducting long-distance oversnow traverses. In particular, the system will greatly reduce the need for passengers to be flown to a station by helicopter from early season voyages.

It is envisaged that the air transport system will be utilised by other Antarctic nations. It may also allow the shared use and cost of logistic resources.

Areas physically modified for air operations will include the ice and snow surfaces required for runways, aprons, and service facilities (Table 2). Some ice free land within existing station boundaries will be required for storage or facilities. Areas of land for station based storage and other air transport related activities will be chosen to be free from vegetation or wildlife habitat and not within any protected areas.



AUSTRALIA
Hobart
Falcon 900EX
CASA 212-400
Route. Hobart-Aerodrome
Acft. Falcon 900EX
Flight Time. 4:30
Freq. Weekly-Twice Weekly
Dumont D'Urville (IT)
Terra Nova Bay (IT)
McMurdo (USA)
Scott Base (NZ)
Casey (Australia)
Route. Aerodrome-Davis
Acft. CASA 212-400
Flight Time. 5:30
Freq. Weekly-Twice Weekly
C212 Return Range - Ex Casey
Vostok (Russia)
Mirny (Russia)
C212 Return Range (aux tank fitted)- Ex Casey
Amundsen-Scott (USA)
Davis (Australia)
Zhongshan (PRC)
C212 Return Range - Ex Davis
Route. Davis-Mawson
Acft. CASA 212-400
Flight Time. 2:30
Freq. Fortnight-Monthly
Mawson (Australia)
C212 Return Range (aux tank fitted)- Ex Davis
Molodezhnaya (Russia)
Syowa (Japan)
Maitri (India)
ANTARCTICA

Table 2: Affected areas

Operational location	**Airfield surfaces (approx.)**	**Support services (approx.)**
Casey groomed glacial ice	Runway 4000m by 200m (80ha) Aprons (2ha)	200m by 100m (2ha)
Casey intra-continental skiways	Skiway 2000m by 60m (12ha) Aprons (2ha)	100m by 100m (1ha)
Davis sea ice skiway (seasonal)	Skiway 2000m by 60m (12ha) Aprons (2ha)	Small temporary area (<1ha)
Davis plateau skiway	Skiway 2000m by 60m (12ha) Aprons (2ha)	100m by 100m (1 ha)
Mawson sea ice skiway (seasonal)	Skiway 2000m by 60m (12ha) Aprons (2ha)	Small temporary area (<1ha)
Mawson plateau skiway	Skiway 2000m by 60m (12ha) Aprons (2ha)	100m by 100m (1ha)

The environmental assessment of the proposed air transport system is being assessed specifically with the Falcon 900EX and C212 as the chosen aircraft. If alternative aircraft are to be used in addition or as a replacement of either of the chosen aircraft, separate environment assessment will be undertaken.

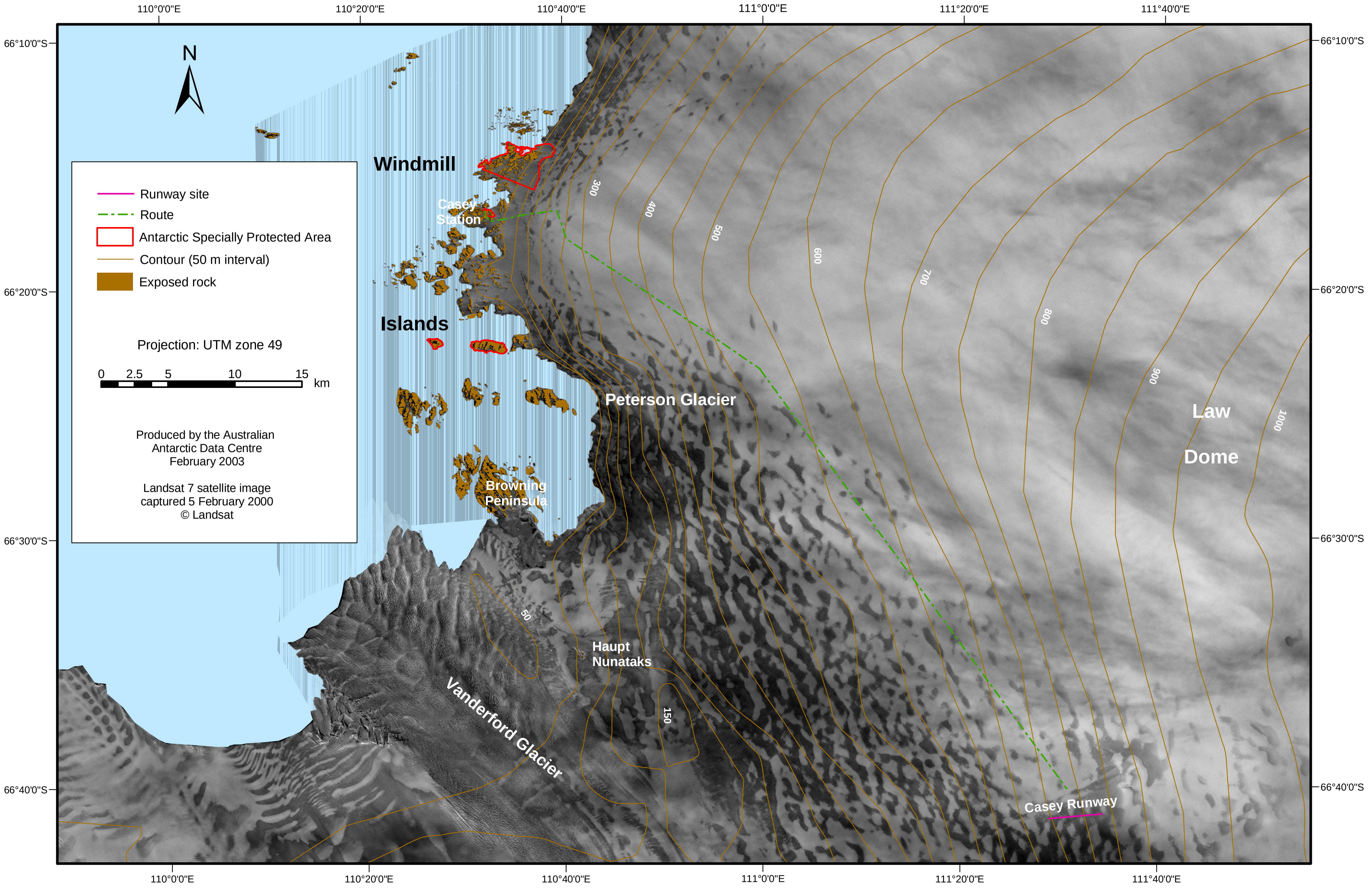
The air transport system will provide AAD with an opportunity to allow an overall increase in the number of scientists participating in the Australian Antarctic Program. While it is expected that more scientists will visit Antarctica, the average time spent by each in Antarctica will be reduced, thus the total number of 'person days' spent in Antarctica is not expected to increase significantly resulting in more efficient use of existing facilities.

3.6 Inter-continental flights

An inter-continental service to the Casey station region requires a hard surface runway. The selected site is a glacial blue ice airfield located about 65km southeast of Casey and will be approximately 4000m long (Map 2). The western end of the runway is at 66° 41.4' S, 111° 29.2' E and the eastern end of the runway is at 66° 41.5' S, 111° 34.6'E. The location is approximately 30km distant from ice free land, and is in a zone of low snow accumulation, with a surface of hard glacial ice and a variable snow cover. The location is on the inland ice plateau, at around 750m elevation and south of the Windmill Islands. No crevasses or melt streams are evident in the immediate area. The underlying glacial ice is approximately 500m thick. Appendix 2 documents the design layout for the inter-continental runway, while section 3.12 provides details on the construction method to be used.

Australian Antarctic Air Transport System
Map 2: Casey Runway location

Australian Antarctic Division



The specific aircraft chosen for operating the inter-continental flights is the Falcon 900EX. The Falcon 900EX is a long range high performance wide-body business jet aircraft. For the air transport system, the aircraft is primarily intended to move 16-18 passengers. The aircraft is capable of flying Casey - Hobart - Casey without requiring fuel in Antarctica under most conditions. This enhances safety (removes the need to fly beyond a PNR {point of no return}), and minimises risk to the environment by removing the need to provide large amounts of fuel for the inter-continental operation. An alternate inter-continental runway (Bunger Hills) is not required, as Hobart acts as an alternative for the duration of the flight, in accordance with regulatory requirements. The high speed of the aircraft will reduce the time weather forecasts need to hold for each journey to Casey. Further information on the aircraft is available at www.falconjet.com.

Photo 1: Falcon 900EX (courtesy Dassault Falcon Jet Corporation)

Specifications:

- Three turbofan engines (Honeywell TFE731-60)
- 4500nm range
- fuel capacity 11 865 litres
- 370-350 knots maximum operating speed
- maximum operating altitude 51 000 feet
- operating temperature, sea level -54°C to 50°C
- 16-18 passengers

Benefits include:

- efficiency and effectiveness – because this aircraft is small and fast, it is able to provide rapid, frequent transport to Antarctica more effectively and efficiently than larger aircraft
- safety – in the event of poor weather at Casey, the aircraft can return to Australia rather than attempting landing;
- safety – the three engined configuration and aircraft performance allow the aircraft to operate within normal civil aviation regulations;
- reduced reliance on long-range weather forecasting - the short travel time (4 hrs 20 min) reduces the risk of arriving in bad weather or having to turn around, leading to cost savings;
- environmental – the aircraft only requires refuelling in Antarctica by exception;
- environmental and cost – because the aircraft can return to Australia in the event of unfavourable conditions at Casey, the requirement for development of a second alternative airfield in Antarctica (e.g. at Bunger Hills), is eliminated
- fuel cost savings – there is no need for expensive transport of large quantities of fuel to Antarctica by ship for the inter-continental component;
- rapid response to environmental, medical and other emergencies;

- a new ability to take a role in emergency response rather than requiring the support of other Antarctic operators.

The transportation of expeditioners from the inter-continental runway site to Casey station will be either by helicopter/fixed wing aircraft (C212) or over ice using tracked or wheeled vehicles. Commuting between the runway and Casey station will take approximately 20 minutes by aircraft or 2 hours by land vehicle. The method of transport to and from station will be dependent on the number of passengers and the availability of aircraft and land vehicles. No formed roads will be required however periodic grading of the snow surface may be required to assist with oversnow access between runway and station.

The Falcon 900EX will not be over-nighting at the Casey runway. Other than in emergency situations, all Falcon 900EX flights to Casey will return to Hobart the same day.

A distinct advantage of an air transport system linking Antarctica to Australia is the potential for the aircraft to carry small amounts of critical cargo (eg. medicines, machinery parts, and scientific equipment). Although there will be size restrictions on the cargo that can be carried, this ability is an aspect of Antarctic operations that has previously been very limited due to shipping schedules and travel time.

3.7 Intra-continental operations

Intra-continental operations will use CASA 212/400 (C212) aircraft (ski equipped), which can operate from suitable snow or ice surfaces, including sea ice and plateau or glacier locations. Sea ice operations depend on the presence of fast ice (unbroken sea ice joined to the land) which is generally present early in the season (December). Such locations are expanses of thick (>2m) sea ice between coastal land and offshore rocks, islands or grounded icebergs. Sites for plateau operations are flat glacial ice or snow surfaces, relatively distant from ice free land.

The C212 aircraft is a twin turboprop, fixed undercarriage STOL (short take-off and landing) aircraft with a rear cargo ramp/door. This configuration makes it suitable for general Antarctic operations including transport of cargo, transport of up to 18 passengers, or use as a scientific platform. The aircraft can be rapidly converted from one configuration to another. The payload/range characteristics make it suitable for the long distances between stations in Antarctica. In particular, the range of the C212 eliminates the need for refuelling between Casey and Davis (which is currently required for Twin Otter operations). Two ski-equipped C212 aircraft are proposed. Information on the CASA 212 series can be found at www.eads.net.

Photo 2: C212 aircraft (courtesy EADS CASA)

Specifications:

- 1375nm range (maximum)
- 800nm range with 2000kg payload
- maximum payload 2900kg
- fuel capacity 3000 litres (with underwing auxiliary tanks)
- 195 knots maximum speed
- 10-16 passengers

Details of C212 internal dimensions are shown in Diagram 1.

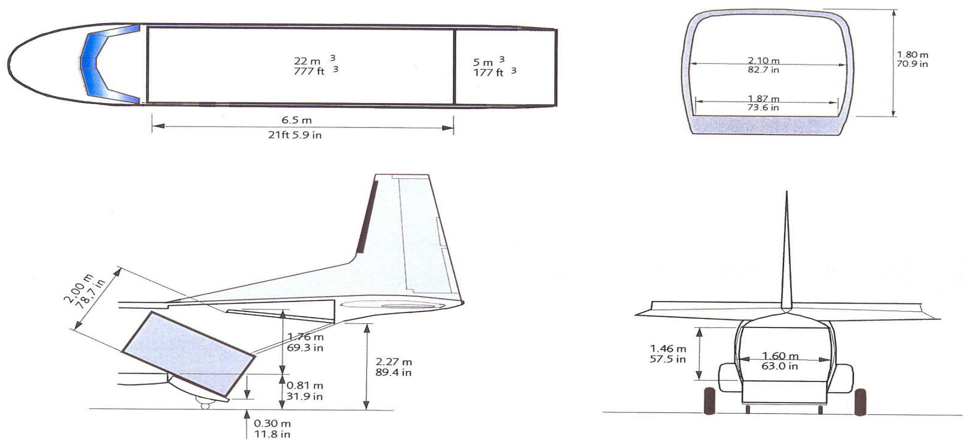


Diagram 1 – Internal dimensions of the C212

At the beginning of each flying season, C212 aircraft will be deployed from Hobart to the Casey runway. On arriving in Antarctica, the C212 aircraft will be fitted with custom made skis. These skis have been specially designed to enable the aircraft to land on ice using its wheels and snow using skis. At the end of the season, skis will be removed and the aircraft will be returned to Australia.

Through the season, flight routes will be over the sea (sea ice or open water), ice shelves, and in some places over ice free land. Flights to field locations throughout Antarctica will depend on the needs of science programs as they arise, and will remain responsive to changes in demand. During the season, C212 aircraft will overnight at Casey station, Casey runway or Davis skiway, or in field locations if necessary. Under the current design of the air transport system there is no requirement for hangars within the AAT.

Minimal preparation will be required to prepare the ice or snow landing areas. All skiway locations will have skiway markers and a wind sock. Depending on the surface conditions and skiway locations, surface grading may be required. Grading will be undertaken using a tractor, bulldozer or other land vehicles. It will be necessary to vary the site of the skiways used at regular destinations (including Davis and Mawson stations) according to prevailing conditions and operational considerations. The AAD will therefore develop a standard operating procedure for selecting intra-continental skiway locations to ensure that environmental impacts are minimised.

Table 3 summarises the air transport system for each station.

3.7.1 Casey station

A skiway for intra-continental aircraft close to Casey station will be required. Two previously used skiway locations are preferred due to their distance from wildlife concentrations and access to the station. Map 4 shows the location of the two preferred skiways for Casey Station (broad coordinates being 66°17'40"S, 100°32'50"E and 66°17'15"S, 110°37'40"E). Alternative locations will be considered if operational, safety or seasonal reasons require. A site selection protocol (in the form of a standard operating procedure, including assessment of environmental impacts of each location) will be followed in selecting skiways. Flight paths and skiway locations have been developed to ensure that environmental and safety aspects have been taken into consideration.

3.7.2 Davis station.

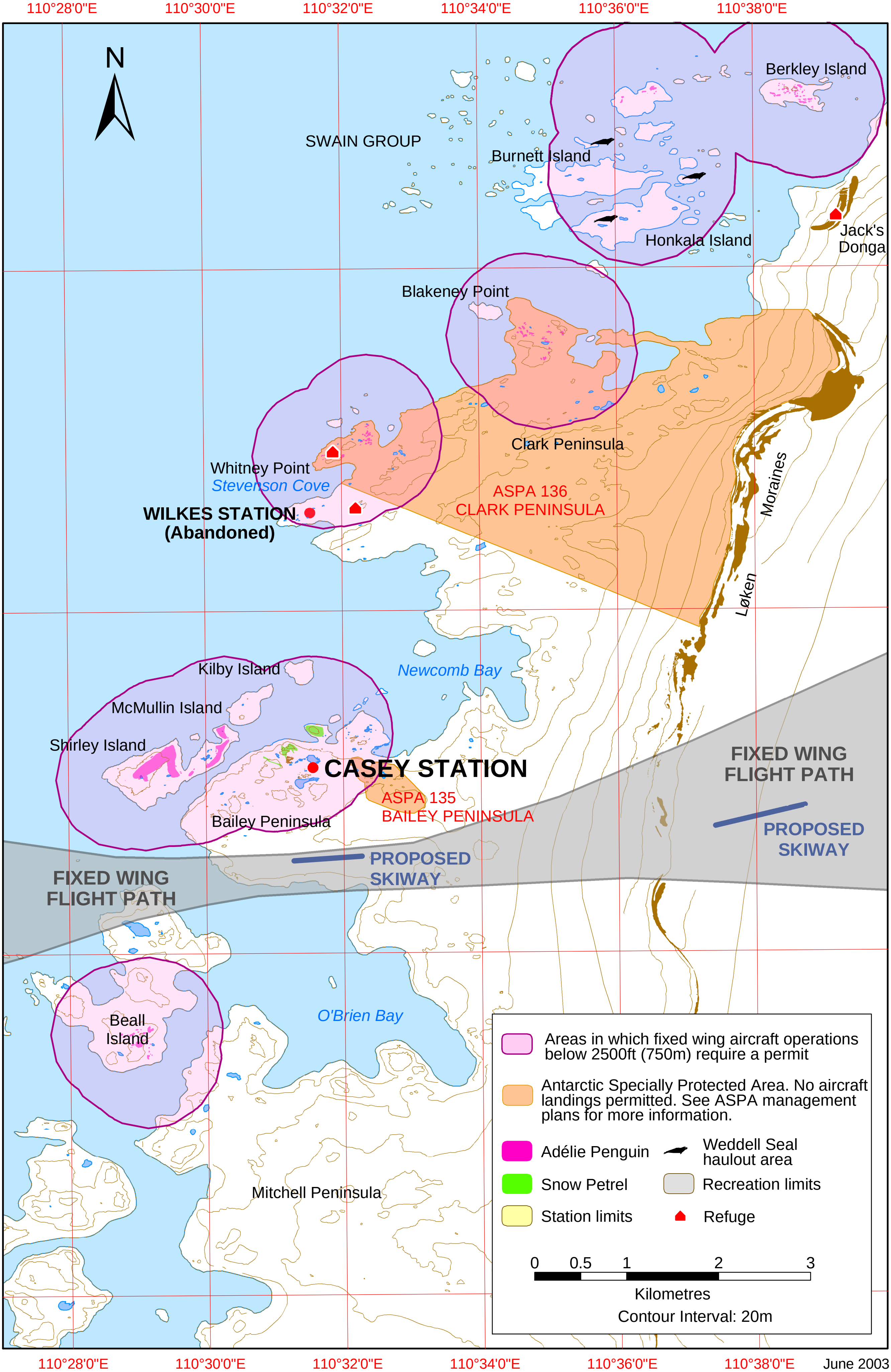
A sea ice skiway close to Davis station will be utilised in the early part of the season, while sea ice conditions remain suitable for aircraft operations. Locations to be considered, among others, include north of Davis station (68°34'30"S, 77°57'E), approximately 750m from Davis station (Map 5). This location has been chosen and orientated to avoid nearby wildlife concentrations. After early summer, when sea ice is no longer present or is unsuitable for aircraft operations, a previously used skiway on the inland ice plateau (68°33'41"S, 78°47'29"E), approximately 30km east of Davis will be used (Map 6). Other suitable locations are nearby if required. Infrastructure associated with the plateau skiway will be removed to station at the end of the flying season, with the exception of some fuel and an automatic weather station.

3.7.3 Mawson station.

A sea ice skiway will be utilised close to Mawson station early in the season, while the sea ice conditions remain suitable for aircraft operations. One proposed sea ice skiway is located 1.6 km north of Mawson (Map 7), although others may be identified and considered. During summer, when sea ice is not present or is unsuitable, a skiway on the inland ice plateau will be required. A suitable site for mid-summer aircraft operations is a previous used skiway site; 1.2km south of Mawson is 67° 37' 20.6" S, 62° 52' 06.2" E (also known as Gwamm), and other suitable sites are known to exist further inland.

The location of suitable flight paths and skiways has been developed with safety and environmental factors taken into consideration. Any new locations will also apply these factors in the formulation of intra-continental flight operations. All skiway infrastructure will be removed at the end of each season (see Table 6).

Casey fixed wing suggested flight paths



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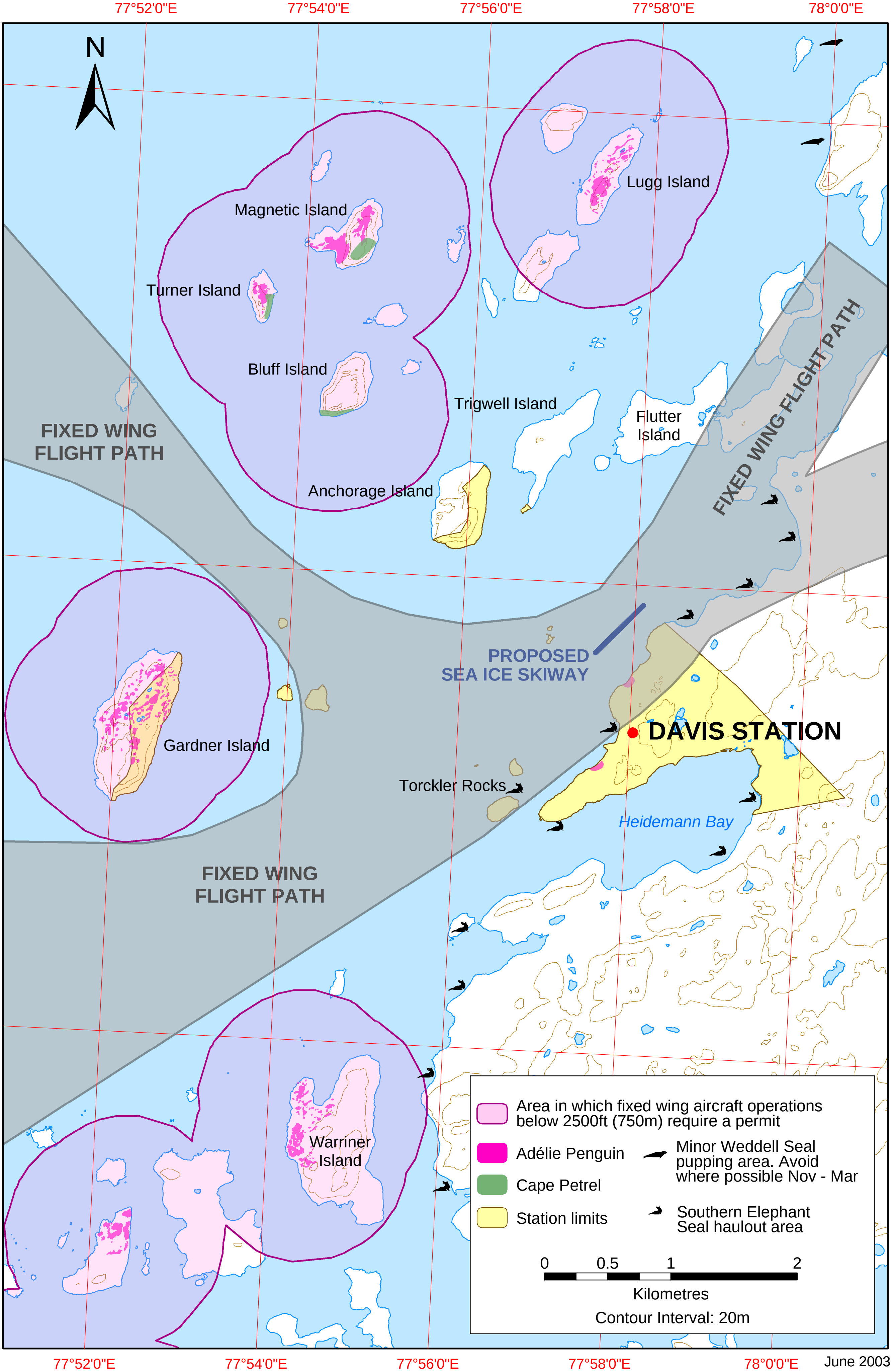
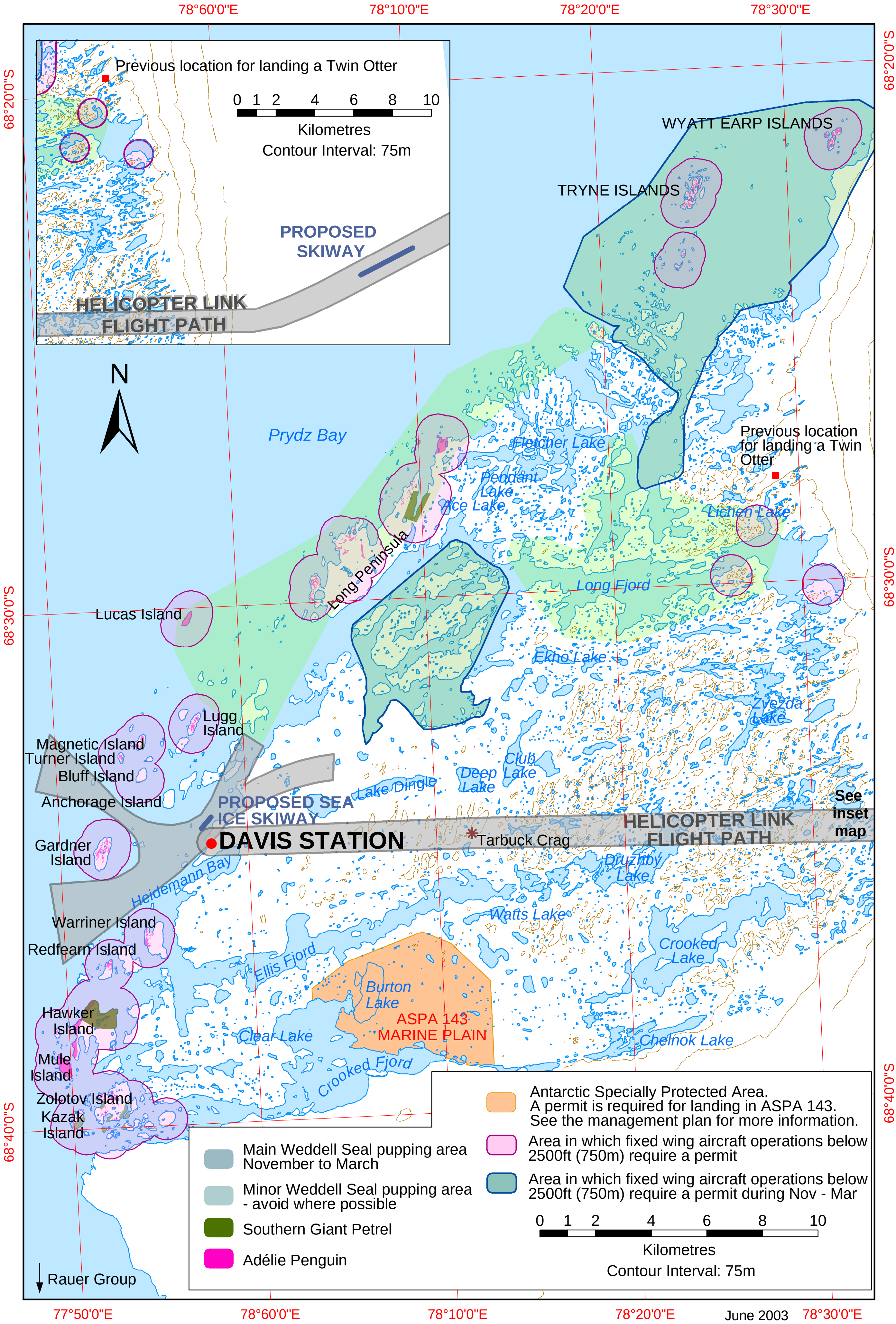
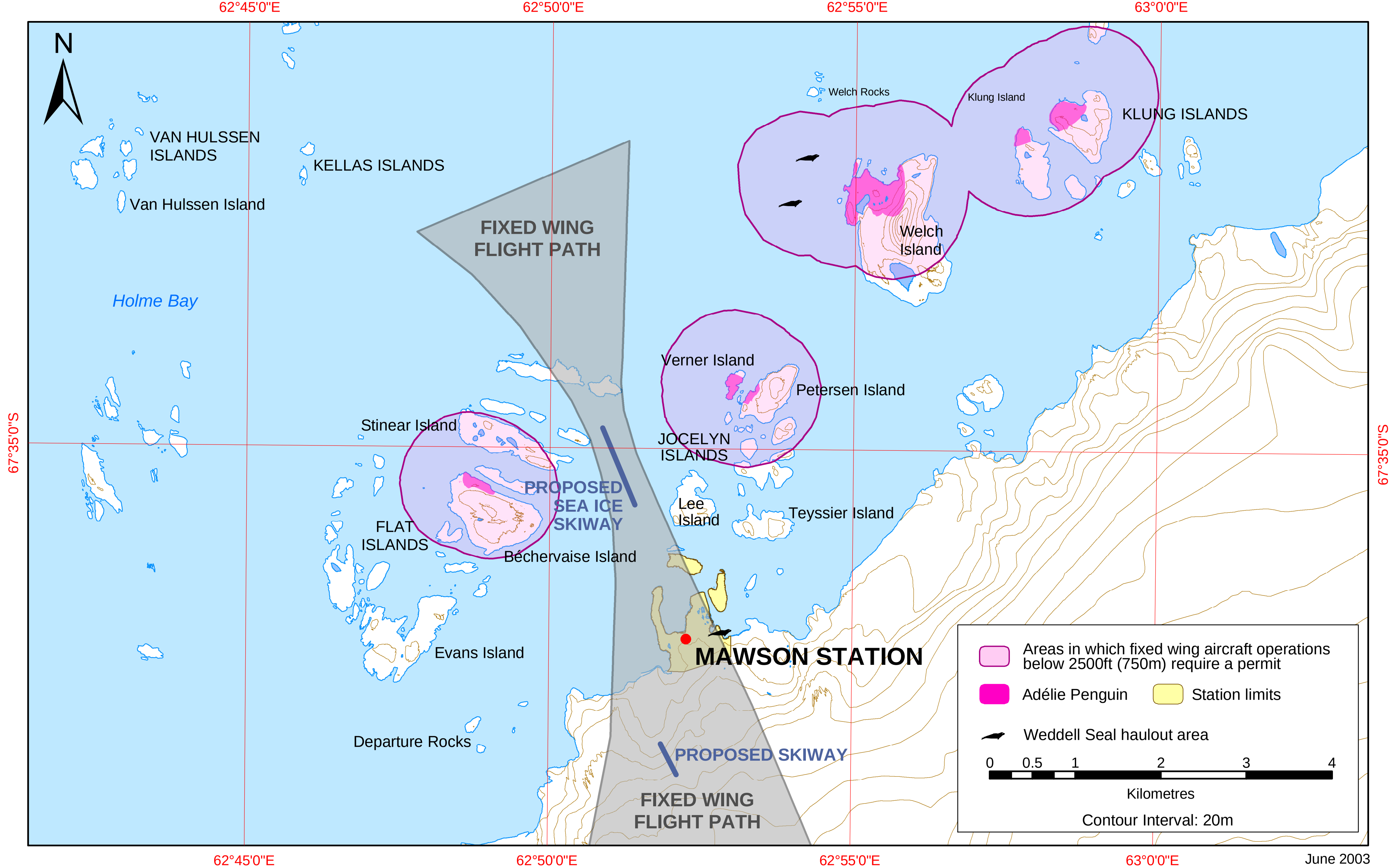
Davis fixed wing suggested flight paths



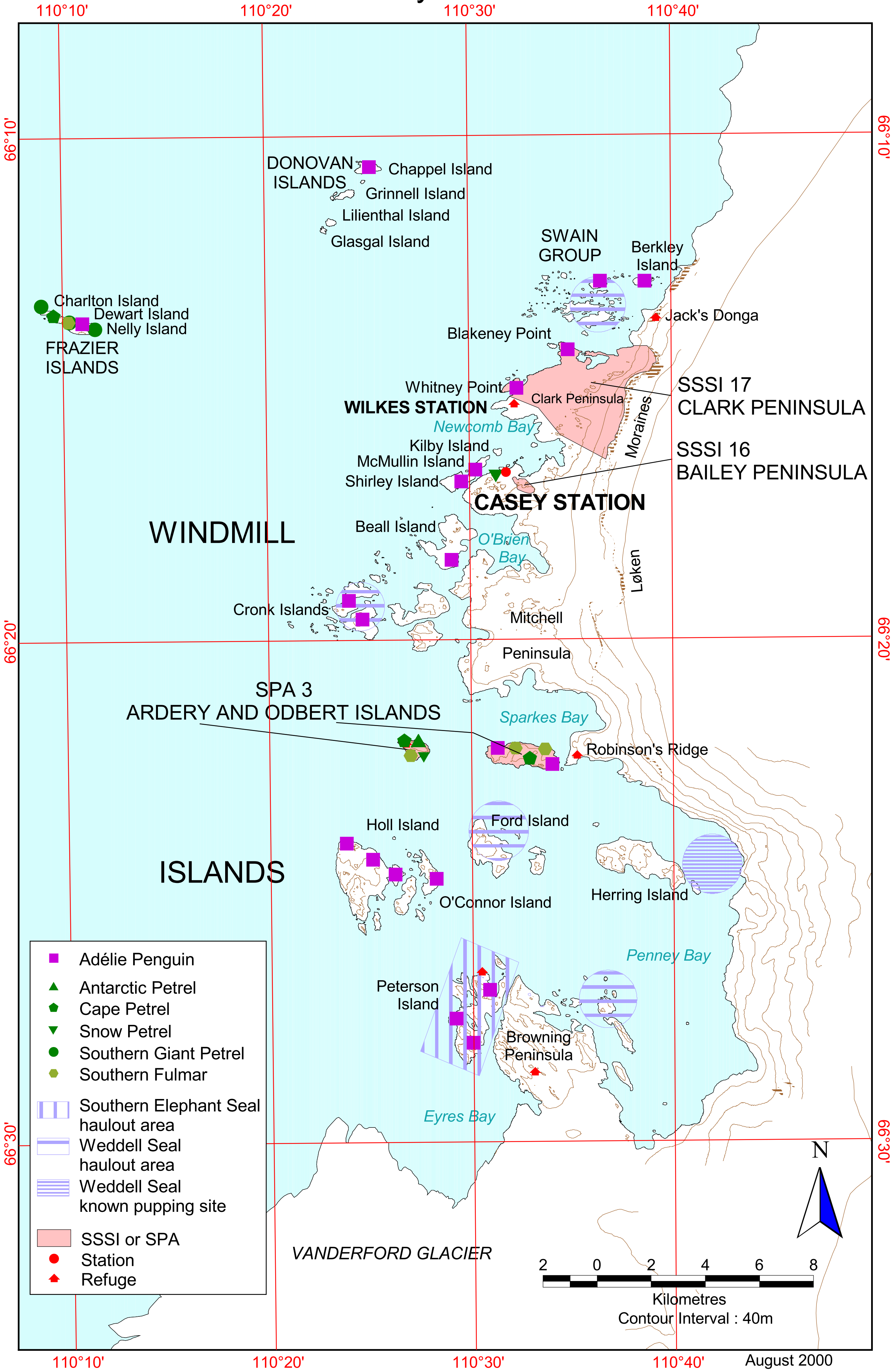
Vestfold Hills separation distances for fixed wing



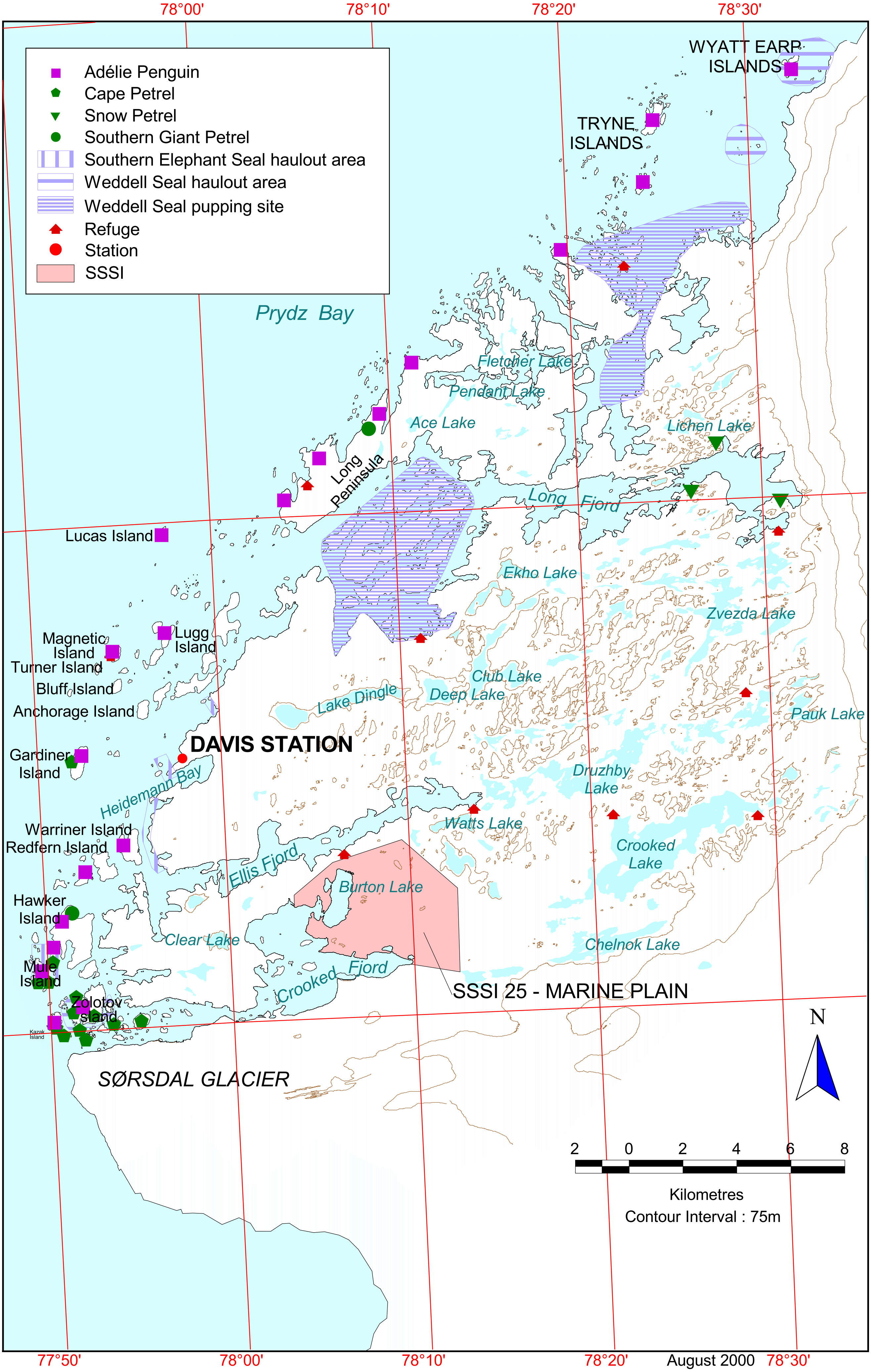
Mawson fixed wing suggested flight paths



Windmill Islands and Casey - main wildlife concentrations



Vestfold Hills and Davis - main wildlife concentrations



August 2000

Mac.Robertson Land coast and Mawson - main wildlife concentrations

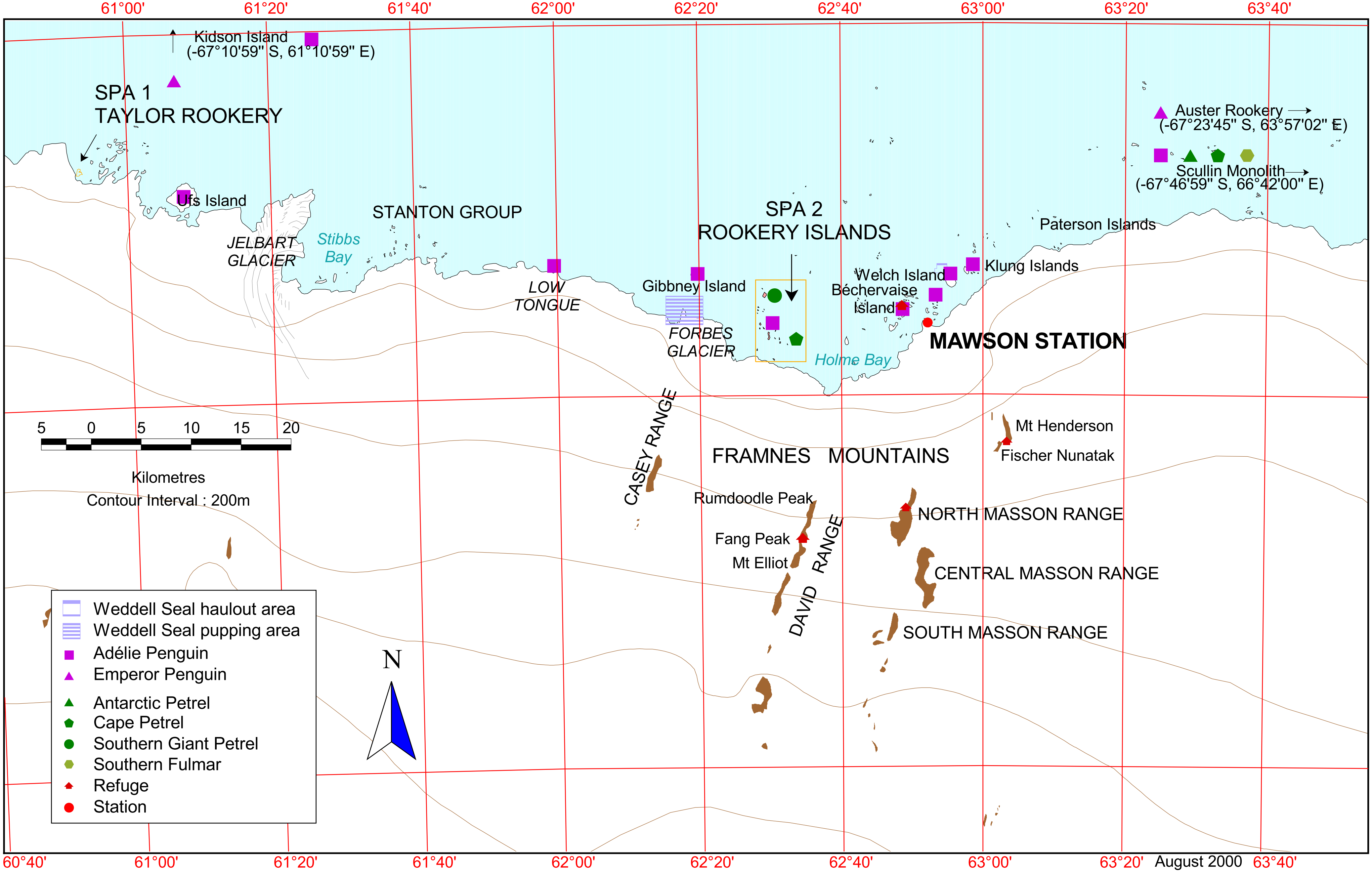


Table 3: Summary of air transport system

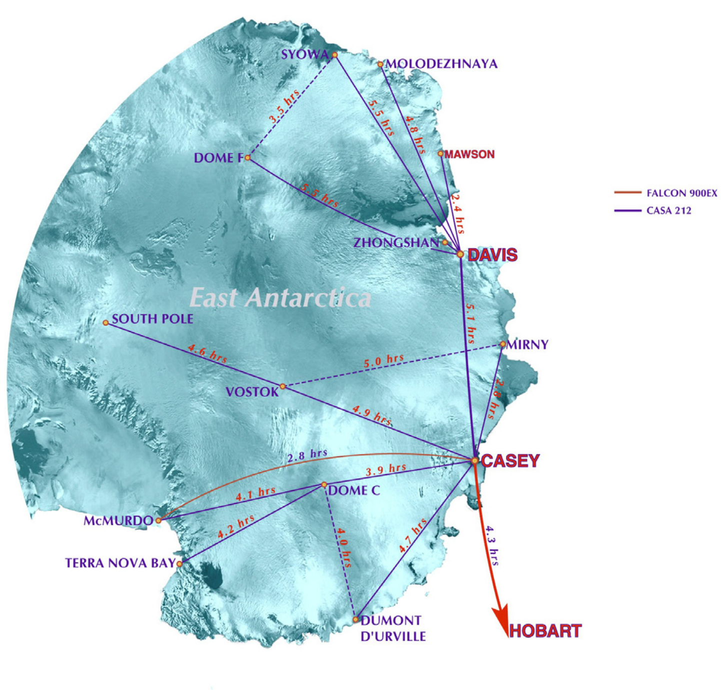
Location:	**Tasmania**	**Casey**		**Davis**		**Mawson**	
Runway/ skiways:	Hobart	Runway	Plateau skiway/s (varying sites)	Sea Ice Skiway (varying sites)	Plateau Skiway (site may vary)	Sea Ice Skiway (varying sites)	Plateau Skiway (site may vary)
Role:	Hobart International airport.	Receive wheeled inter-continental aircraft, C212 operations	Service Casey station	Service Davis station in early season	Service Davis station in mid/ late season	Service Mawson station in early season	Service Mawson station in mid/late season
Surface:	Pavement	Glacial (blue) ice runway with a protective compressed snow cap	Snow, groomed when necessary	Sea ice, groomed when necessary	Snow, groomed when necessary	Sea ice, groomed when necessary	Snow, groomed when necessary
Aircraft:	Falcon 900EX C212 – start and end of season	Falcon 900 EX C212 Helicopter (Casey link)	C212	C212	C212 Helicopter (link to Davis station)	C212	C212
Maintenance:	n/a	- grading required at the start of season with grader/dozer and laser leveller - further grading on an as-required basis	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season
Distance to station:	n/a	65 km	1-5 km	750m-8km	Approx 30km	1 - 6 km	1.2 km
Travelling time:	4.3 hours (to Casey runway)	20 mins by air (to Casey station) 4.3 hrs to Hobart 5.1 hr to Davis	5.1 hours (to Davis station)	2.4 hours (to Mawson station) 5.1 hours (to Casey runway/station)		2.4 hours (to Davis station)	
Transport to station:	n/a	Oversnow vehicle (2 hrs) or aircraft (20 min)	Oversnow vehicle (10min)	Oversnow vehicle (10min – 1 hour)	Helicopter (10-15min)	Oversnow vehicle (15 mins)	Oversnow vehicle (10min)
Frequency (average):	Once to twice weekly	Weekly to Davis		Weekly to Casey 1-2 per month to Mawson		1-2 per month to Davis	

3.7.4 Other locations and national Antarctic programs

Ski-equipped C212 aircraft will be used to deploy and retrieve scientific parties at field locations throughout Antarctica according to the needs and priorities of scientific programs. Operations to field locations will utilise naturally occurring flat areas of snow, ice on the polar plateau or glaciers, and sea ice, and may include locations throughout Antarctica. C212's may also be utilised for scientific programs including aerial surveys and airborne research. All scientific based activities will require separate consideration of environmental impacts and will not be assessed as part of this report.

At times, there may be a request made to AAD from the Antarctic programs of other nations to utilise the proposed aircraft and/or air transport infrastructure. These requests will be assessed on an as-required basis and environmental implications will be considered separately.

Intra-continental flights to the stations of other Antarctic programs are likely to occur. Australia's Antarctic program co-operates on logistic activities with other nations, and associated personnel will be transported as part of this cooperative arrangement. Possible flight paths are shown on Map 3. Unless additional fuel tanks are fitted, all typical flights between Casey and Davis will be PNR flights (i.e. point of no return). If sudden bad weather presents at the destination skiway, an alternative skiway will be utilised. If Casey skiways are unsuitable for landing, the Casey runway could be used. When en route to Davis, alternative landing sites could be at the Russian Base, Mirny, PRC base at Zhongshan on the sea ice, or at the Bunger Hills. The same standard operating procedures will apply to any additional site selections for alternate skiways.



Map 3 – Potential travel times and routes

3.7.5 Tourism

At present, the AAT is visited infrequently by tourist ships (http://www.aad.gov.au/goingsouth/tourism) operated by private companies. A program of Boeing 747 sightseeing overflights from Australia to Antarctica, including parts of the AAT, has been operated by Croydon Travel of Melbourne each summer since 1994/95. The air transport system is not related to these activities.

It is not proposed to use the air transport system for tourism purposes, or to make available associated facilities such as airfields for non-governmental operations. Any such use would only occur after government direction, and would require separate assessment of environmental impacts.

3.8 Timing and flight frequency

The air transport system will be introduced over the next three Antarctic summers. In the 2003/04 summer, construction equipment and other associated infrastructure will be shipped to Casey in preparation for the introduction of the C212 operations in 2004/05 and for future Falcon 900EX operations. Possible test flights of the Falcon 900EX late in the 2004/05 season are scheduled; however this is dependent on the availability of the aircraft. Subject to the necessary approvals, the air transport system should be fully operational in 2005/06 (Table 4).

Table 4: Operating schedule

Description	**Summer** 2003/2004	**Summer** 2004/2005	**Summer** 2005/2006
Casey runway construction works	Minor works		
Introduction of C212		C212	
Falcon 900EX Flights		Potential test flight	
Fully operating system			

The air operating season will be from around mid-September until mid-March each year. Flights may occur outside of this period for specific science programs or emergency evacuations. The system is intended to operate indefinitely. Current estimates indicate that the new air transport system will meet the needs of the Australian Antarctic Program for the next 12-20 years.

The pattern and number of personnel movements will respond to the requirements of Australia's Antarctic program. As a guide it is likely that initially 200, with the potential for up to 600 inter-continental return passenger movements will occur each season. The upper limits of the potential number of passengers flying to Antarctica are limited by station infrastructure and the high cost of field based science. Between 20 and 43 return flights each season of a Falcon 900EX three-engined jet aircraft (capacity up to 16 passengers) will occur (Table 5). Of the total number of passengers moved to Antarctica, 45% will be to and from Casey, 45% to and from Davis, and 10% to and from Mawson.

Table 5: Proposed flight frequency

	Hobart – Casey	Casey link	Casey – Davis	Davis plateau link	Davis – Mawson
Average Frequency	Once to twice weekly	Dependent on availability of C212 or helicopter	Weekly	4 to 6 helicopter flights per C212 landing	1-2 per month
Seasonal total	Approx. 25 flights per season each way (increasing over time to 40 flights per season)	Dependent on availability of C212 or helicopter	19-25 flights per season each way	Only when plateau site is used	8 flights per season each way

(Please note: These figures are approximate and actual figures may alter as the system responds to demand)

3.9 Support Infrastructure

Table 6 summarises the infrastructure associated with the air transport system at each runway/skiway location.

3.9.1 Runway/skiway infrastructure

All runways and skiways will require the installation of wind socks and runway boundary markers, which will be removed over winter. Automatic weather stations (AWS) will be required at some skiway locations, and a 10m AWS mast will replace the 4m existing mast at the Casey runway site. It is envisaged that an AWS (4m) will be required at the Davis Plateau site.

The inter-continental runway will be fitted with a portable strobe and PAPI (Precision Approach and Path Indicator) lighting system for visual glide slope reference on landings. These will be positioned at one end of the runway and the start of each season and may be removed during periods of inactivity or bad weather, although a position reference marker will be left throughout the season to indicate the siting for the equipment. Power for these lights will be provided by small portable generators (up to two 2.4 kVa units) Appendix 2 details the design layout of the Casey runway which is in the process of being approved by the Civil Aviation Safety Authority (CASA).

All items of equipment required for the system including construction equipment will be transported by ship to Antarctica. Over-snow vehicles, helicopters transport or fixed wing aircraft will be used to take items to destinations outside of station limits. No additional voyages are required to establish operations.

3.9.2 Staffing, accommodation and storage

C212 aircraft will normally overnight at Casey station, Casey runway or Davis skiway. On occasion, aircraft may remain overnight in field locations. The aircraft will be anchored to the ice or snow overnight as a precautionary measure in the event of high winds. At this stage, no requirement for hangers has been identified. If operational experience indicates that hangers are necessary, separate environmental assessment will be required.

Additional operational personnel will be required in Antarctica for the air transport system. Support staff required for airfields and operations will be up to six equivalent full-time personnel (for the season) at the Casey runway, and up to six additional people operating intra-continental aircraft (pilots and engineers). Numbers will vary throughout the season depending on the work required. There will be a subsequent reduction in the number of helicopter pilots required (exact numbers are unknown at this stage).

Short term increases of personnel may also occur as people transit through stations. Emergency accommodation will be provided to cater for all personnel including transiting passengers in the event of delays.

As outlined in Table 6, buildings associated with the air transport system vary between runway/skiway sites, depending on their function and proximity to a station. Support facilities sufficient for transiting personnel and airfield operations staff will be required at the Casey runway, and at plateau skiway locations. Other accommodation, living services and general facilities are available at Casey, Davis and Mawson stations.

Changes to current station occupation patterns are expected with personnel changes occurring more regularly, however, the total number of person days at the stations is not expected to greatly change as a result of air transport. There is no plan at this stage to substantially expand the Antarctic science program. Short term peak loads at stations may occur, particularly at Casey station as transit passengers await flights to Australia or other stations. Accommodation will be required for transit passengers if flight delays are encountered. Present facilities are adequate to cater for the typical levels of use, and additional temporary emergency accommodation will be provided to remote runway/skiway locations and stations.

If accommodation, waste treatment, power generation, water production, and other services require enhancement, then these activities will be subject to their own environmental assessment and will not be assessed as part of this proposal. At this stage of the proposal, modifications are not expected.

3.9.3 Over-snow access

An over snow access route between Casey and the inter-continental runway is required which will be a simple route identified with marker canes. Depending on the location of the intra-continent skiways at other stations, other new over snow routes may also be required.

3.10 Fuel management

Fuel will be required at Hobart Airport and in the AAT for flight operations. Additional fuel for power generation, construction and operational vehicles, heating, and other functions will also be required. As part of the existing AAD Operations Manual, fuel transfer procedures cover fuel handling, spills, training and equipment.

Table 6: Summary of Infrastructure

Station	Location	Surface	Landing strip/ Apron	Fuel storage (approx.)	Buildings	Station/field location accommodation numbers (typical)	Other infrastructure	Wintering buildings/ equipment
Casey	Runway (65km SE of station)	Glacial blue ice with a protective compressed snow cap	4000m x 200m 2ha apron	Up to 200 kL aviation fuel. Stored in bulk at the station, with smaller holdings at the skiway and runway.	Up to 10 removable buildings : -accommodation for six* - Power/ablutions -Kitchen/mess -Work areas -Maintenance -Storage -Emergency facilities (footprint: 4600m²)	Up to 6 (with emergency accommodation for transit passengers)	-Fuel storage -Runway markers -Wind sock -PAPI -AWS -Vehicle access markers -Comms mast -Poss. overnight aircraft	AWS Some fuel
	Skiway/s (1-5 km distant from station)	Snow	2000m x 60m 2ha apron	30 kL ground fuel (footprint: 800m²)	No buildings – infrastructure supplied for each flight by Hagglund and removed - footprint: 400m²	53 beds at Casey station (with emergency accommodation for transit passengers)	-Fuel storage -Runway markers -Wind sock -Vehicle access markers -Poss. overnight aircraft	nil
Davis	Skiway (750m-1500m can vary with ice/weather)	Sea ice	2000m x 60m 2ha apron	Up to 300 kL aviation fuel. Up to 30% of this will be stored at the plateau site while the remainder will be at the station.	No buildings – infrastructure supplied for each flight by quad bike and removed - footprint: 400m²	81 beds at Davis station (with emergency accommodation for transit passengers)	-Fuel storage -Runway markers -Wind sock -Vehicle access markers -Poss. overnight aircraft	nil
	Plateau (approx. 30 km NE	Snow	2000m x 60m 2ha apron		-tent accommodation for six* and emerg. accomm. -supplies and communication equipment -maintenance equipment -footprint: 4000m² (all equip. sledded up early in season)	Up to 6 (with emergency accommodation for transit passengers)	-Fuel storage -Runway markers -Wind sock -Vehicle access markers -Poss. overnight aircraft -Comms mast	AWS Some fuel
Mawson	Skiway (1.6 km – location can vary with ice/weather	Sea ice	2000m x 60m 2ha apron	Seasonal dependent (approx 10kL kept at station)	No buildings - infrastructure supplied for each flight by quad bike and removed -footprint: 400m²	51 beds at Mawson station (with emergency accommodation for transit passengers)	-Runway markers -Wind sock -Vehicle access markers	nil
	Plateau (1.2 km S)	Snow	2000m x 60m 2ha apron		No buildings - infrastructure supplied for each flight by quad bike and removed -footprint: 400m		-Runway markers -Wind sock -Vehicle access markers	nil

** - most runway/skiway staff will be shared between the Casey and Davis stations*

Building from this information, the AAD will develop and maintain additional management protocols and contingency response plans for fuel and other contaminants and these will be incorporated in to an Environmental Management Plan (EMP) for the air transport system. The inter-continental aircraft will only require minimal fuel in Antarctica in order to increase return flight safety margins. Approximately 16kL will be available on site for this purpose. The majority of fuel required for the system is for intra-continental operations.

Total fuel requirements each year will vary proportionately to the amount of passengers moved. The initial annual consumption is anticipated to be approximately 100kL at Casey (split between the runway and the skiway), 142kL at Davis station, 43kL at the Davis Plateau skiway and 10kL at Mawson. Table 6 summarises the anticipated fuel storage capacity at each runway/skiway site considering annual variations. Calculated into the fuel storage figures is additional storage as part of the systems contingency plan.

AAD is investigating several options for fuel distribution that includes market testing the system as a whole and in part. Any distribution system will be consistent with all applicable Australian standards and Civil Aviation Safety Authority requirements. Any future fuel system is likely to include a combination of storage mediums including 205 litre drums, 25kL ISO tanks, custom made double-skinned tanks (1-10kl) and commercial bulk fuel installations. Part of the fuel system investigations could include an additional contingency fuel plan. AAD presently has fuel management systems for existing fuel requirements, and considerable experience in managing large quantities of fuel for station operations and for aviation use. With the introduction of the air transport system, there will be a reduced need for remote fuel depots as short range helicopters will not be used as regularly.

3.11 Waste management

The management of waste is regulated by the *Antarctic Treaty (Environment Protection) (Waste Management) Regulations 1994*. Wastes will be managed in accordance with the AAD environmental policy and Environmental Code of Conduct for Australian Field Activities in Antarctica (see http://www-new.aad.gov.au/default.asp?casid=1344). Additional waste management protocols will be developed where required for any new waste types or handling processes that may be required, consistent with the requirements of the Madrid Protocol, Australian law, and AAD policy.

All waste generated from the activities relating to the air transport system will be processed/managed at nearby stations and follow existing waste management procedures. Current procedures for the management of waste at stations are detailed in AAD's Operations Manual, covering:

- unpacking supplies;
- waste collection and sorting;
- incineration, storage of RTA (return to Australia) waste;
- labelling and recording containers for RTA;
- treatment of liquid waste, and
- treatment of solid waste.

Additional waste that is likely to be generated by Casey runway personnel/transit passengers includes the following categories:

- Human faeces
- Human urine
- Grey Water from kitchen sinks, laundry facilities and bathrooms
- Fuel / oil waste from workshop and refuelling activities
- Kitchen Food Waste - Hazardous wastes / chemicals. (most likely to include industrial solvents, paints and compressed gases)
- Solid domestic waste. (includes recyclable and non recyclable waste from normal domestic activities)

Other waste generated by the air transport system to be returned to station for processing includes:

- Aviation fuel samples
- Oils and lubricants
- Repair parts
- Packaging materials
- Minor spill recovery
- Contaminated snow

All solid and liquid wastes will be processed at nearby stations or returned to Australia.

3.12 Construction

Construction of the Casey inter-continental runway will be undertaken in the 2004/05 season, with minor surface preparation being undertaken in 2003/04.

Photo 3: Trial runway construction 2002/03 (George Blaisdell)

Following the trial runway construction program undertaken in 2002/03, finalising the Casey runway to an operational standard will require the grading and levelling of the remaining 600m and application of a snow-cap surface preparation of 4000m x 60m to reduce the amount of solar energy absorbed by the ice. This will also enable the surface condition to be more easily maintained and for any contaminants to be contained and easily removed for treatment. Wind blown snow will be collected on the runway for this purpose. Temporary snow fences may be required in order to accumulate wind blown snow. Good weather conditions during the 2003/04 season may enable some or all of the snow cap to be prepared. The runway is to be constructed using standard plant equipment including graders, bulldozers and rollers.

All buildings that will be required on-site during construction will be returned to Casey at the end of the season. Waste and fuel management at the construction site will follow current AAD policies, protocols and procedures. Storage of equipment at the stations will be within station boundaries on previously disturbed sites or may be located 5-6 km from the station on the edge of the plateau. This plateau location may be utilised to remove the need to transport equipment down the slope to the station.

Transport of equipment and personnel will be by ship to Casey station during the construction phase, on normal scheduled ship voyages. Equipment and personnel will transfer through Casey station, using existing logistic support and accommodation. An over-snow route will be used to access the Casey runway. Mobile plant items will be driven to the site. Living vans and other equipment will be towed on sleds to the runway. Helicopters may be used to transport equipment or personnel.

It is envisaged that little site preparation will be required for the skiways. Existing skiway sites will be utilised at stations for intra-continental flights where they are suitable for the C212 aircraft. Aircraft activities at station and field locations will be undertaken in accordance with the AAD's Operations Manual (Section 7.4, Aircraft Operations-Station/Field Based).

Depending on the type of fuel storage, some minor construction works may be required for the installation of footings for large fuel tanks.

3.13 Maintenance and equipment

The Casey runway will require grooming and/or rolling at the start of the season and during the season as conditions dictate. The start of the season will also require the transportation and establishment of runway infrastructure from storage at Casey. The end of the flying season will necessitate runway infrastructure to be removed from the Casey runway and stored at its wintering location.

Most major equipment maintenance will be carried out at the existing Casey station workshop facility. Minor field maintenance of plant will occur at the runway site. Breakdown repairs will be carried out on site if required.

A compressed snow pavement will be maintained on the blue-ice runway surface to protect the blue ice from solar energy absorption, sticky drifting snow, and contaminants. The snow-cap can be easily removed and replaced, unlike the blue-ice surface. Human activity contaminants will generally be in high use areas, such as take-off/landing zones of the runway, refuelling and around building and maintenance sites. The compressed snow pavement will become darker with the introduction of contaminants and will need to be removed to prevent solar radiation affecting the blue-ice surface. It is envisaged that only small isolated snow-cap removal will be required in these high use areas.

Given its distance from the station, the Davis Plateau skiway will require fuel, runway infrastructure and work/accommodation facilities moved up to the site early in the season, taking advantage of over-snow access. A helicopter will be required to provide the plateau-station link at Davis for passengers and some equipment, once the sea ice skiway is no longer suitable.

Skiway maintenance equipment required for other intra-continental operations will be stored at nearby stations and will comprise of existing standard plant items, such as tractors, bulldozers, graders, or simple chain or beam drags. At the commencement of each season, skiway sites will be inspected and graded if required. Runway markers will be placed along the skiway. Most equipment will be removed at the end of each season (see Table 6 for details).

3.14 Plans for future developments

The proposed air transport system has been developed to cater for the scientific and operational needs of AAD for the next 12-20 years therefore no further developments of this type are planned in the foreseeable future. The AAD is continually reviewing its operations to ensure safety, minimise impacts on the environment and to ensure cost effectiveness. The AAD intends to work in collaboration with other Antarctic nations in relation to the utilisation of the air transport system. The system will not be made available for tourist activities.

4 ALTERNATIVES

As discussed in Chapter 3, the concept of an air transport system linking Australia and Antarctica, and its stations has been investigated over many years. Over this time, various aircraft, runway surfaces and locations have been investigated for their suitability, environmental impacts and cost. In 1999, a scoping study was completed which considered technical, financial and environmental issues, and recommended further investigation of a number of options (Shevlin & Johnson 1999). All of the recommended options involved the use of ice or snow surfaces as airfields. The scoping study can be found on the AAD's website on http://www.aad.gov.au/goingsouth/airlink/scoping_9900/default.asp.

The below tables (Table 7 - 10) summarizes the various options that have been considered in the development of the proposed air transport system. For the purposes of this report, the 'do nothing' option assumes AAD will continue to transport personnel to Antarctica by ship and utilise helicopters and/or fixed wing aircraft for station and ship activities.

4.1 Transportation options (including 'do nothing' option)

Traditionally, AAD has transported its scientists and other personnel by ship. Usually, these voyages would operate between Hobart, Tasmania and one or more of AAD's four Antarctic/sub-Antarctic stations.

A comparison between sea and air transport is shown in Table 7.

Table 7: Comparison of sea and air transportation to Antarctica

Method	Location	Time	Significant Environmental impacts	Conclusions
Current Sea Travel[1] 'do nothing'	All stations	8-20 days in good weather (delays up to 40 days can occur) 6-10 voyages per season	-Green-house emission. - potential for ocean oil spills -Potential wildlife impacts with helicopter station link	- Time consuming - Inefficient - Costly ice delays - Inflexible
Proposed air transport system	Into Casey or Davis and accessing all Antarctic stations (excluding Macquarie Island)	4.3hrs (extra time required for accessing other stations) -approximately 20 to 40 inter-continental flights per season	-Fuel storage issues -Wildlife impact potential -impacts would vary with type of air transport system	-Better flexibility, access, travel time -Medivac capability, better range over AAT

(Nb. Many of the initial environmental concerns associated with an Antarctic air transport system have been resolved by the current choice of aircraft {Falcon 900EX and C212} and the utilisation of snow/ice runway/skiways)

[1] Cargo will continue to be transported by ship. The number of voyages per season are expected to be reduced by one third as a result of the introduction of air transport.

If the AAD were not to provide an air transport system and continue with a sea-based operation, then the current limitations on the flexibility of the system and responsiveness in deploying scientific and support personnel would continue. This would result in continued unproductive travel times as well as time spent at station waiting on infrequent ship visits. If the new system is not introduced, the AAD's capacity to support airborne or remote area research is limited and there would be no improvement in responding to emergency situations. One of the significant associated environmental impacts with the proposal not proceeding is the continuation of current fuel consumption in ship-based transportation. However, if transportation by ship continues as the only transport to the AAT, the proposed additional fuel storage facilities associated with the air transport system would not be required and the minor and transitory impacts on snow/ice surfaces and potential wildlife disturbance would not occur to the proposed degree.

4.2 Inter-continental landing surface and location options

Over the many years that the AAD has considered air transport as a potential mode of transport to Antarctica, various runway surfaces have been investigated. Table 8 summarises the three main runway surfaces examined.

Table 8 - Inter-continental runway surface options

Surface	Location	Cost	Significant environmental impact	Conclusions
Rock runway	Davis station	Construction costs would be significant	-Permanent rock structure -Pot. wildlife disturbance -Potentially large fuel storage required	-Not a viable option - significant cost in surface preparation required - permanent structure
Compressed snow	Casey station	Higher construction/ maintenance costs than glacial blue ice runway	Distant from wildlife, less transit fuel required, more maintenance fuel required	-Surface prep and ongoing maintenance significant -Closer to station
Glacial blue ice with snow cap	65km SE Casey station	Lower construction/ maintenance cost	Runway distant from wildlife, minimal surface preparation and less emissions caused by construction and maintenance	-Non-permanent structure -minimal surface preparation and ongoing maintenance -need to consider transport to station

As further investigation demonstrated the suitability of snow/ice runways, it was apparent that the inter-continental rock runway at Davis was no longer a viable option, based on cost and environmental grounds. Snow/ice runways had the capacity to be cheaper to construct and maintain, and would be a far less permanent fixture on the landscape.

When the AAD commenced a two-staged tender process to select an air service provider, various air transport systems were possible including the need for an alternative runway at Bunger Hills. However, the successful tenderer, Skytraders proposed a system that was more effective, safer and with potentially less environmental impacts.

Hard glacial ice is found at locations where there is little or no snow accumulation, and where ice from deep within the Antarctic continent has arrived nearer to the coast through glacier flow, at the surface of the ice sheet. Because it is hard, near pure ice, it does not require compaction to form a runway. A glacial ice runway therefore requires less preparation, less maintenance, and is cheaper than a compressed snow runway. Areas of flat smooth glacial ice are however relatively rare (compared with snow suitable for development as a compressed snow runway).

Surface glacial ice only occurs within 100 km of the coast and/or at relatively low elevations in Antarctica where air temperatures are often not far below (or even above) ice melting point during the summer season. In addition, glacial ice is "blue" rather than white, thus it absorbs more solar heat, while (white) snow reflects heat. Thus a glacial ice runway is susceptible to melt during the summer season. This is unacceptable for operation as an airfield. Melt-water can destroy a runway by creating puddles and streams across the surface. It is essential therefore to keep a glacial ice runway clean (i.e. of any dark coloured objects, including dust), and if possible, a technique for keeping the surface white will help protect it from melt. A method recently (2001/2002) adopted by Blaisdell at the US Antarctic airfield, Pegasus, at McMurdo, is to cover the glacial ice surface with a thin layer of (white) snow, and then to compact this snow to a hard coating over the surface. Advantages are (i) the snow is white, so solar heat is reflected, (ii) the snow acts as a dust cover, keeping dirt off the glacial ice underneath – the snow cover can be removed when it gets dirty and replaced by a new cover, (iii) if any damage does occur due to a particularly hot day with substantial melt, the damage is to the snow cover rather than to the ice surface below, (iv) the snow surface provides a higher coefficient of friction, reducing the likelihood of aircraft cross-slip in the event of a cross-wind. While grading and rolling of a thin snow cover over a hard glacial ice base adds to the overall cost of airfield development and maintenance, it is substantially cheaper than compressed snow runway construction and maintenance.

Apart from runway condition, another very important consideration for aircraft operation and for placement of a runway is weather. The Bureau of Meteorology (BOM) had advised that visibility in the vicinity of the proposed compressed snow site was likely to often be poor. BOM advised (based on observations and computer modelling results) there was a good chance of better weather conditions (i.e. higher cloud base and therefore better visibility) more often at a location ~ 20 to 50 km south-east of Casey.

4.3 Intra-continental skiway options

The successful tenderer for the air transport system, Skytraders, proposed the use of the C212 aircraft for the intra-continental component of the air transport system. With the aircraft type chosen, suitable alternative locations for intra-continental skiways were investigated.

The system required aircraft access to Casey, Davis and Mawson stations. At each station, various locations and skiway surfaces were investigated. Table 9 summarises these alternatives.

Table 9: Alternative Intra-continental skiway options

Station	Surfaces	Location from station	Time	Construction/ maintenance cost	Significant environmental impact	Conclusions
Casey Runway	Glacial blue ice	65km SE of Casey	5.1hrs Davis	Use of inter-continental infrastructure	No wildlife issues, fuel management issues	Location of Casey runway Practical, convenient, and suitable for purpose
Casey station	Snow	1km south	5.1 hrs Davis	Low	Temporary seasonal skiway, close to wildlife	Previously used location. Close to station, minimal surface preparation, flight paths to avoid wildlife
	Snow	4.5km east	5.1 hrs Davis	Low	Nearby wildlife	Previously used location Late season flights may need to use skiway of slightly higher altitude
Davis station	Sea ice	750m north (location can vary)	5.1 hr Casey 2.4hr Mawson	Low	Nearby wildlife	Previously used location. Early season use only. Minimal preparation and infrastructure required, close to station
	Snow	Davis Plateau 30km east	5.1 hr Casey 2.4hr Mawson	Low construction cost Significant expense in transporting equipment, fuel and personnel to location Imposes cost on shipping flexibility as voyages to deliver and return helicopter for link to station	Nearby wildlife, fuel storage needed at Davis Plateau,	Previously used location. Distant from wildlife For use when sea ice not available, distant from wildlife High logistic costs in transportation of supporting infrastructure
	Rock surface-	Dingle Rd Davis 2km east	5.1hrs - Casey 2.4 hrs - Mawson	Greater construction costs, reduced fuel use, reduction in infrastructure duplication	Permanent modification of rock surface, distant from wildlife (6km), pre-disturbed location (further investigation required)	Not chosen. Environmental and economic considerations make this option currently unsuitable. Site is not required for the proposed air transport system.
Mawson station	Sea ice	1.6km (location can vary)	2.4hrs Davis	Low	Positioned to reduce wildlife impacts	Previously used location. Close proximity to station.
	Snow	1.2km	2.4hrs Davis	Low	Inland of main wildlife concentrations, no large fuel storage required	Previously used location (known as Gwamm). Suitable location when sea ice not available, close to station

In determining an appropriate location for skiways at each of the stations, a number of key factors were considered. The main areas of consideration include potential disturbance of wildlife concentrations, distance from a station, weather conditions and suitability of snow or ice surface for aircraft landings.

Taking wildlife concentrations and season variability into account, a selection of snow and sea ice location have been proposed to support the intra-continental operations. All proposed skiway locations for the intra-continental operations have previously been used for fixed wing aircraft operations and are known for their suitability.

The rock runway option on Dingle Road has been discounted as it is not a required component of the proposed air transport system.

4.4 Station/skiway links

Depending on the skiways used and weather conditions, it will be necessary to transport passengers between station and skiway. These links will be especially required for the Casey runway and the Davis plateau skiway. Various land and air based transportation options have been considered. These are summarised in Table 10.

Table 10: Summary of transportation options for station/skiway link

Location	Mode of transport	Vehicle/ Aircraft	Time	Distance	Significant Environmental impact	Conclusions
Casey runway/ station link	Over snow vehicle access	Hagglund Modified utility	2hr to Casey station	65km	Nil significant impact	-Time consuming -low impact -no formed road required
	Fixed wing	C212	20 mins	65km	Wildlife present in vicinity of station skiway	Will depend on availability of C212 -flight paths to avoid wildlife
	Helicopter	Squirrel	20 mins	65km	Potential wildlife disturbance	-Helicopter use will depend on its availability -using existing infrastructure -following flight paths to avoid wildlife
Casey station/ skiways link	Over snow vehicle access	Hagglund Modified utility (or by foot)	10-15 mins	1-5km	Nil significant impact	Very suitable for nearby skiways
Davis station/ skiways	Over snow vehicle access	Hagglund (or by foot)	10-15 mins	1-5km from sea ice skiway	Nil significant impact	Very suitable for nearby skiway

link	Helicopter	Squirrel	15-20 mins	30km from Plateau	Potential for impacts as flights pass over Vestfold Hills	Low establishment costs – using existing infrastructure
Mawson station/ skiways link	Over snow vehicle access	Hagglund (or by foot)	10-15 mins	1-5km	Nil significant impact	Very suitable for nearby skiways

Links to stations have been developed with environmental impacts, effectiveness, and cost being the key components. The close proximity of most skiways to nearby stations will mean that passenger access will be either by foot or Hagglund or other oversnow vehicles. No other alternatives are being explored.

In 2002/03, a Ford F250 was utilised by the trial runway team for transportation between Casey runway and Casey station. It was proven to be a viable ground access vehicle and has been recommended as an alternative link between the runway and station.

Depending on their availability, both C212 and helicopter operations have the potential to provide a suitable link between the Casey runway and station.

A helicopter link between Davis station and the Plateau skiway is the only viable option as there is no oversnow or sea ice access to the plateau site from mid to late summer. As discussed in Chapter 3, unless a helicopter will be wintering at Davis, an early and late ship voyage will be required to supply and retrieve the Davis Plateau helicopter. The late voyage can only occur at the end of the flying season when helicopter services are no longer required.

4.5 Choice of preferred option

After analysis of the alternatives, the following conclusions were reached:

1. An air transport system is needed to assist with the efficient transportation of operational and scientific personnel to assist with the Antarctic Scientific Program.
2. It has been recommended that construction of a inter-continental rock runway anywhere within AAT be ruled out on cost and environmental grounds.
3. A snow capped glacial ice runway is a superior surface in all respects (cost of construction, maintenance and performance) to a compressed snow runway. The Falcon 900EX particularly (because it is a small jet rather than a large cargo aircraft) will be more suited to the harder glacial ice runway. The capability of this aircraft also removes the need to construct an alternative runway.
4. A glacial ice site 65 km south east of Casey has been identified as suitable for runway construction. The greater distance from the coast and consequent distant from any wildlife also reduces environmental impacts
5. Previous station based skiways are likely to be used.

6. The delivery of supporting infrastructure and personnel to and from the Davis Plateau skiway does exhibit some problems, however, at this stage of the project it is the only viable option.

7. The new air transport system will enable AAD to meet its key objectives for the project:

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 Casey runway (inter-continental runway)

5.1.1 Physical characteristics

5.1.1.1 Location – The inter-continental airfield will be inland of Casey station on the ice plateau, distant from ice free land, 65 km SE of Casey station, between 720m and 775m ASL (Map 2). The runway site itself has an overall longitudinal slope of 1.6% with consistent uniformity over a 5 km length. From the coastal fringe, the ice surface rises to the summit of Law Dome (1395m). Topographic features located to east-northeast provide for an obstacle-free approach and departure (Photo 4).

Photo 4: Proposed runway site: flat ice plain with minor sastrugi (George Blaisdell)

5.1.1.2 Glaciology – The area is glacial ice with some areas of snow cover (minor sastrugi). Site verification and technique trials in 2002/03 confirmed that more than 50% of the area is exposed glacial ice, while thin (< 20 cm) patchy snow covers the rest of the runway area. The ice thickness at the blue ice runway site is approximately 500m and it is moving at a rate of 10m/year towards the coast (Jacka J pers comm.).

5.1.1.3Lakes, tarns and fjords - Meltwater lakes or drainage lines are not evident on-site or in satellite imagery. The ice remains hard and firm all year at the elevation proposed for airfield use (~750m) and significant summer melt is unlikely.

5.1.1.4 Landforms - A prominent ridge of gentle ice hills is located slightly to the north off the eastern end of the proposed runway. This ridge has an approximate north-south trend and is about 5 km away and perhaps 75 to 100 m above the eastern end of the runway. The ridge is notable for the several large and obvious east-west trending crevasses straddling its highest peak (Blaisdell, weekly report, unpublished). There are no known crevasses in the immediate area.

Photo 5: Ridge as seen looking due east from proposed runway (Blaisdell, G.)

5.1.1.5 Meteorology – The mean annual temperature at the site is approximately -13˚C to -14˚C (Law Dome -21˚C, Casey Station -5.6˚C). There is no evidence of surface or subsurface melting. During January of the 2002/03 season, only three days were recorded as unsuitable for flying. An automatic weather station (AWS) has been placed at the runway site and is continually collecting and relaying data to the Bureau of Meteorology (BoM) in Australia.

5.1.2 Biota Fauna and flora are not resident in the runway area.

5.1.2.1 Birds - Wildlife is not present in the area of the proposed Casey runway. The nearest known breeding locations for seabirds are on Peterson Island, approximately 45km to the northwest in the Windmill Islands region. On Peterson Island, extensive colonies of Adélie penguins (approximately 25,000 pairs) are present, with nesting by southern fulmars, cape and snow petrels and Wilson's storm petrels also recorded. There are no census data currently available for these seabird populations on Peterson Island. Snow petrels and Wilson's storm petrels may nest on Haupt Nunatak (a small rock exposure protruding through the ice plateau), approximately 35 km from the runway site (see Map 2) but attempts to reach Haupt Nunatak to undertake seabird surveys in 2002/03 were unsuccessful. It is believed that if present, breeding numbers would be low. There have been occasional sightings of flying seabirds inland of the Windmill Islands but they are typically single birds for brief periods. There is a near-zero risk of bird strike on aircraft, accommodation facilities or objects associated with runway support, if flying birds visit the location. The area of operations is sufficiently distant from areas of breeding habitat to ensure that disturbance of wildlife through noise will not occur.

In the Windmill Islands area, ice free land hosts populations of breeding seabirds (penguins and flying birds), and terrestrial plants, and provides seal haul out areas. Southern giant petrel (*Macronectes giganteus)* (EPBC listed migratory and endangered species) breed on the Frazier Islands (IUCN vulnerable/endangered). Wilson's storm petrel (*Oceanites oceanicus)* (EPBC listed migratory) breed throughout the Windmill Islands ice free area. Antarctic skua (*Catharacta maccormicki)* (EPBC listed migratory species) breed throughout the Windmill Islands ice free area at widely dispersed nests, generally near penguin colonies. Southern elephant seal (*Mirounga leonina)* (EPBC listed vulnerable species) haul out on beaches in the area of Browning Peninsula and on Peterson Island. The coastal and offshore sea ice and marine environment support marine wildlife populations.

5.1.2.2 Terrestrial flora – There is no known terrestrial flora at the Casey runway site.

5.1.3 Current land use

Prior to the 2002/03 season, the proposed runway site was an undisturbed section of partly exposed blue ice. There are currently no buildings at the site and the only current infrastructure is an automatic weather station which has been installed for the air transport project. The population at the site during trial construction work (2002/03) was approximately six staff.

The over ice access route to the Casey runway site follows an existing route to Price's Corner, approximately 25km from Casey station. From this point the access route heads in a south-east direction to the runway site.

Other proposed infrastructure and logistical support has been discussed in Chapter 3 of this report.

5.1.4 Special values of the area

The area does not contain any specific scientific importance as it is part of a vast area with similar features. The Casey runway being located 65km from the station has created some interest in relation to collecting biological and chemical baseline data around the Casey region for the purpose of developing a monitoring program. The area does not have any scenic or recreational importance specific to that location. There are no protected areas or areas of special value in the immediate region.

It should be noted that all of the AAT is listed on the Register of National Estate.

5.1.5 Flight path between runway and station

The flight path linking the runway and station follows an NW/SE orientation and will be above the 750m vertical height (as discussed in Appendix 3) until just prior to landing. Most of the environment between the runway and station is uninhabited ice and snow. Areas nearer the coast and in ice free locations host wildlife and Antarctic flora, however flight paths are available that avoid any wildlife areas or ice free land until reaching the Casey station skiway..

5.2 Casey station

While some more general information is also provided, discussion in this section is largely focused on issues which relate specifically to the proposed surface preparation and operation of the intra-continental flights in and out of Casey Station (Map 4 and Map 8). General information on the existing environment, scientific programs and activities in the Casey station area is included in the Casey Station Management Plan (http://www.aad.gov.au/default.asp?casid=3578).

Photo 6: Casey station (Grant Dixon, 1998)

5.2.1 Physical characteristics

5.2.1.1 Location - Casey station (66° 17' S, 110° 32'E) is situated on Bailey Peninsula on the extreme western edge of Law Dome, a small and almost circular ice cap 200 km in diameter rising to a height of 1395 m, 110 km inland. Bailey Peninsula is a rocky outcrop of approximately 6 km^2 bounded by the sea to the north, west and south and the polar ice cap to the east. Also projecting from the Law Dome ice cap near the coast are the Loken Moraines, Robinson Ridge, five nunataks and the exposed rocks of the Clark, Browning and Mitchell Peninsulas. In combination with the Windmill Islands which are located off this part of the Budd Coast, this coastal strip is the largest area of ice-free terrain for approximately 400 km of coastline east or west. Map 8 shows the location of Casey station within the Windmill Islands area.

5.2.1.2 Geology - There are no special or unique geological features in the area in which will be associated with construction and operation of the new air transport system. No geological features should be affected by subsequent flying operations.

5.2.1.3 Lakes, tarns and fjords - The proposed location for the activity at Casey is some distance from any of the melt lakes in the vicinity. The closest is the station water supply lake located approximately 1300 metres {south east} of the nearest proposed skiway. Approach paths for aircraft operations to Casey station will be developed to avoid overflights of any melt lakes.

5.2.1.4 Landforms - There are no landforms of particular significance in the vicinity of the proposed landing strips. No landforms would be affected by flying operations.

5.2.1.5 Meteorology - Temperatures range from an average daily maximum of +2.9°C in January to an average daily minimum of -19.2°C in August, with recorded extremes of +9.2°C and -41°C. Winds are generally from the east and east-north-east off Law Dome, and from the south. Although the average wind speed at Casey is 20 km/hr, blizzards can set in with very little warning and rapidly reach wind speeds well in excess of 150 km/hr which can last for several days. Gusts of up to 100 km/hr are common, with the highest recorded wind speed being 291 km/hr. Regular katabatic winds are not a feature of the area, and consequently there are many calm days.

General characteristics of the coastal climate of Greater Antarctica, to which this area is subject, are high cloudiness throughout the year, very low absolute humidity, low precipitation (falling mainly as snow), with frequent periods of intensified winds, drifting snow and low visibility associated with the passage of major low pressure systems from the west.

5.2.1.6 Sea ice - Sea ice near Casey is very unstable because of the high winds and general absence of downwind inshore islands. What does form usually breaks up and is carried out between December and February. At times, the winter ice edge can be as close as the shoreline of the Bailey Peninsula. The ice usually attains its greatest extent and stability in August and September at an average thickness of 80 cm.

5.2.2 Biota

Appendix 4 (Species list) provides information on fauna in the region.

5.2.2.1 Birds - Four species of seabirds are known to nest in the vicinity of Bailey Peninsula and offshore islands. These are:

Adélie penguin (*Pygoscelis adeliae*)	Breeding colonies on many of the Windmill Islands and at Whitney Point on Clark Peninsula - the nearest breeding colony is Shirley Island about 2 km west of the station with approximately 10,000 breeding pairs.
Snow petrel (*Pagodroma nivea*)	Breeds throughout the Windmill Islands area, including Reeve Hill. Current estimates are for approximately 100 pairs within the Casey station area.
Wilson's storm petrel (*Oceanites oceanicus*)	EPBC listed migratory species. Breeds throughout the Windmill Islands area. There are no current census data for the breeding population; the estimated breeding population is between 100-400 pairs.

Antarctic skua (*Catharacta maccormicki*)	EPBC listed migratory species. Breeds throughout the Windmill Islands area at widely dispersed nests on most if not all islands and at several mainland locations, mostly near Adélie penguin colonies. There are approximately 10 breeding pairs of skuas on Shirley Island and none within the immediate Casey station area.

Other birds that breed in the Windmill Islands but not in the immediate vicinity of Bailey Peninsula include the Southern giant petrel (*Macronectes giganteus*) (EPBC listed migratory and endangered species), the Cape petrel (*Daption capense*), the Southern fulmar (*Fulmarus glacialoides*), and the Antarctic petrel (*Thalassoica antarctica*). The Emperor penguin (*Aptenodytes forsteri*) colony on Peterson Bank is approximately 60km NNW of Casey (2000 pairs in 1994). Ardery and Odbert Islands are major breeding sites for Adélie penguins, Cape petrels, Southern fulmars and Antarctic petrels. These islands are designated as an Antarctic Specially Protected Area (ASPA No 103) under the Antarctic Treaty and Australian legislation (Map 8).

Situated 16 km west-north-west of Casey Station, the Frazier Islands have been designated as an Antarctic Specially Protected Area (APSA No. 160) as they contain the largest known breeding population of Southern giant petrels (*Macronectes giganteus*) in continental Antarctica, approximately 250 pairs (2001/02 survey).

5.2.2.2 Seals - No seals are found in the immediate proximity of the proposed activity, although when the sea ice breaks out Weddell seals *(Leptonychotes weddelli)* are seen regularly hauling out around the Bailey Peninsula (Murray and Luders, 1990). These seals are seen year round in the Windmill Islands and their main breeding area is on the sea ice between Herring Island and the continent. A secondary pupping site is in the Swain Group. Browning Peninsula and Peterson Island (about 20 km south of Casey) are the main haul out areas for Southern elephant seals *(Mirounga leonina)* (EPBC listed vulnerable species)in the Windmill Islands. The majority of the animals are immature males that haul out to moult during summer, but there have also been observations of mature bulls and mature and immature cows. The Windmill Islands is the only known place in continental Antarctica where Southern elephant seals have been observed pupping (Murray, 1981). Small numbers of Crabeater seals *(Lobodon carcinophagus)* are also sighted in the Windmill Islands area during summer. Leopard seals *(Hydrurga leptonyx)* are often sighted during the summer, particularly in the vicinity of the Adélie penguin colonies on Shirley Island and Whitney Point, Clark Peninsula.

5.2.2.3 Terrestrial invertebrates - There is limited knowledge of the numbers, species or distribution of invertebrates that exist in the soil or in association with plant communities on the Bailey Peninsula (Steverson, 1991). There are no known concentrations of terrestrial invertebrates in the vicinity of the proposed activity. While a small number of invertebrates have been found within the station area it is likely that these are also to be found elsewhere on Bailey Peninsula and within the Windmill Islands.

5.2.2.4 Terrestrial flora - The Bailey and Clark Peninsulas support some of the most extensive and best-developed plant communities in continental Antarctica (Pickard & Seppelt, 1984). The cryptogamic flora (or non-flowering plants) consist of at least five moss (including *Bryum spp., Ceratodon spp., Grimmia spp.*), one liverwort or hepatic (*Cephaloziella exiflora*), and more than 28 lichen taxa (including *Buellia spp., Caloplaca spp., Rinodina spp., Umbilicaria spp., Usnea spp.*) (Lewis Smith, 1986). The environment of Bailey Peninsula is not unique in Antarctica, however the Windmill Islands are unique in Antarctica due to the extent and density, though not diversity, of its flora.

The importance of the plant communities on Bailey and Clark Peninsulas has been reflected in the declaration of two Antarctic Specially Protected Areas (ASPA) numbers 135 (North-east Bailey Peninsula) and 136 (Clark Peninsula).

The area that would be affected by the proposed skiways and infrastructure has no known flora that cannot be found generally in the station area or elsewhere on Bailey Peninsula.

5.2.3 Current land use

5.2.3.1 History - The current Casey station is the third station built in the Bailey Peninsula/Clark Peninsula area. The first of these stations, Wilkes, was established on Clark Peninsula in 1957 by the United States of America for the International Geophysical Year (IGY), 1957-58, and came under Australian control in 1959. Replacement of Wilkes became necessary because of building deterioration and the original Casey station was constructed about 3 km to the south on Bailey Peninsula between 1964 and 1969. This station operated continuously until 20 December 1988 when it was vacated in favour of the currently operated station complex. The original Casey station buildings have been dismantled and removed from Antarctica.

5.2.3.2 Buildings - The current station complex, constructed as part of a rebuilding program involving all Australian Antarctic stations, is sited approximately 400 metres southwest of the site of the original Casey station. The current station covers an area of approximately 0.5 km^2.

5.2.3.3 Population – The Casey station over-winter population is between 15 and 25 persons. Typically over the summer period Casey station supports up to about 60 expeditioners (including field program scientists). With the air transport system in place, a worst case scenario for accommodation would be up to 80 people in the event of bad weather or other unforeseen delays. Emergency accommodation facilities will cater for these occasions. If additional permanent accommodation is found to be necessary at Casey, it will be subject to its own environmental assessment process.

5.2.3.4 Communications - Data and telephony links are provided via leased satellite circuits. These circuits provide for instantaneous monitoring of scientific projects and 24 hour communications by telephone, fax and email to Australia and international networks. Communication within Antarctica is also possible via HF radio. Local communications links are provided by VHF radio. The communication facilities utilise aerial arrays and a satellite ground station within the station area

5.2.3.5 Logistic support - Currently logistic support to the station is ship based for personnel and cargo. For many years, helicopters have remained on station during all or part of the summer season to support scientific and other programs.

5.2.3.6 Roads - Casey station area has approximately 1.5 kilometres of roadways and one heavy vehicle bridge.

5.2.3.7 Power supply - Power at the station is supplied by four 125 kW generators (with two slightly larger generators as back-ups in the Emergency Power House) which use around 500 kL of fuel annually. This fuel is stored in existing bulk storage tanks within the station area with a total capacity of 1200 kL. All these tanks are bunded.

5.2.3.8 Water supply - Water for the station is pumped from a large melt lake immediately to the south of the Domestic Building. The lake fills during the summer melt and is kept liquid beneath the surface ice during winter by recirculated water from the Tank House at slightly above 0°C.

5.2.3.9 Waste management - Solid waste generated at the station is separated on the basis of whether it can be reused, recycled, incinerated or whether the waste is to be returned to Australia for disposal. A portion of the waste that can be incinerated (specifically untreated wood, cardboard and paper) is stacked into a two stage, high temperature incinerator and burnt with kitchen waste. Incineration is acknowledged as an acceptable waste disposal option under the Madrid Protocol (Annex III, Article 3). Waste that can not be recycled or incinerated is returned to Australia.

All buildings are serviced by a reticulated sewage system. All human waste and waste water from the station complex passes through the Waste Treatment building, where it receives primary and secondary treatment in a two-stage rotating biological contactor (RBC). The total number of personnel on station at any point in time following introduction of the air transport system is not expected to exceed current maximum station population levels, except during unforeseen delays. The proposed activity should therefore not increase the demands on the waste treatment facilities. If alterations to the waste management system are required, then these will undergo separate environmental assessment.

5.2.4 Special values of the area

5.2.4.1 Scientific research - Casey is a key location in the network of Australian Antarctic research stations. The value of the station to science stems from two factors: the science conducted within station limits, and the role of Casey as a staging base for scientific activity elsewhere in the region (including Law Dome, Vanderford Glacier, the continental ice cap, Windmill Islands and Bunger Hills).

Station science includes biology, meteorology, upper atmosphere physics, magnetics and medical science. Science supported elsewhere in the region includes glaciology, biology and geology.

5.2.4.2 Scenic and recreational importance of the general area - Outside Casey station limits, the region is relatively undisturbed. Several regions of the rocky peninsulas and the confluence with the ice plateau offer a variety of terrain suitable for field training exercises and recreational activities such as hiking and skiing. There is the unique glaciological feature of the Loken Moraine which stretches for 14 km along the ice cap 2 km inland from the station. Grounded icebergs near the Swain Group of islands north of the station offer excellent photographic opportunities. Shirley Island, west of the station is often visit by station personnel to see the Adélie penguins colonies.

5.2.4.3 Historic importance - Casey is the youngest Australian Antarctic continental station but remains of historic importance. Features of the Casey area that are of historic significance include Wilkes station and a cairn on Mitchell Peninsula commemorating the first landing in the area by the 1948 US Navy Expedition. The proposed activity will not affect these sites in any way. The old Wilkes station is listed on the Register of National Estate.

5.2.4.4 Existing protected areas - The importance of the plant communities on Bailey and Clark Peninsulas has been reflected in the declaration of two Antarctic Specially Protected Areas (ASPA) numbers 135 (North-east Bailey Peninsula) and 136 (Clark Peninsula). Both these ASPAs were designated because of their vegetation: ASPA No. 135 due to the diverse assemblage of vegetation, including the extremely rich lichen and moss communities found there, and the fact that it is the main continental site for a liverwort, as well as being close to the station to facilitate research; and ASPA No. 136 because moss and lichen communities in the area are being used as control sites to monitor environmental impact at Casey. Long-term monitoring studies are also being conducted on Adélie penguin colonies at Whitney Point in ASPA No. 136. Studies commenced on these colonies in 1959/60.

Ardery Islands and Odbert Islands (ASPA No.103) which are about 9.5 km to the south of Casey station, have been set aside as an Antarctic Specially Protected Area under the Madrid Protocol and Australian legislation. These islands support several breeding species of petrel in abundance including the Antarctic Petrel.

5.2.5 Station/skiway passenger link

Access to the skiway locations will be over snow and/or existing station roads.

5.3 Davis station

5.3.1 General information on Davis area

General information on the existing environment, scientific programs and activities in the Davis station area is included in the Davis Station Management Plan (http://www.aad.gov.au/default.asp?casid=7329). Discussion in this section is limited to issues which relate specifically to the introduction of the air transport system.

5.3.2 Physical characteristics

5.3.2.1 Location - Davis station (68° 35' S, 77° 58'E) is located on the Ingrid Christensen Coast, Princess Elizabeth Land, on the edge of the Vestfold Hills. The Vestfold Hills are an extensive area (750 km²) of ice-free rock dissected by fjords, bounded by coastal waters, the polar plateau, and the Sørsdal Glacier (see Map 6 and 9). A number of islands extend into the waters of Prydz Bay, and a group of ice free islands (Rauer Group) lies to the south of the Sørsdal Glacier. The station is about 25 km from the ice plateau which may be reached by foot across the Vestfold Hills throughout the year, by oversnow vehicle on the sea-ice during the winter months, and by helicopter during the summer months. The Vestfold Hills are of low relief (maximum height 158 metres) broken only by low hills and valleys and penetrated deeply by fjords and lakes.

Photo 7: Davis station (Neil Smith, 1998)

5.3.2.2 Geology - There are no special or unique geological features in the area which would be affected by air transport operations.

5.3.2.3 Lakes, tarns and fjords - The Vestfold Hills is characterised by low, rounded hills, and numerous freshwater and saline lakes.

Neither the station tarn nor any of the lakes in the Vestfold Hills area will need to be overflown at low level (below 750m), unless specifically required as part of a scientific program. Any such proposal would be the subject of a separate environmental assessment.

5.3.2.4 Landforms - There are no landforms of particular significance in the vicinity of the proposed activity. No landforms would be affected by flying operations.

5.3.2.5 Meteorology - Mean monthly temperatures range from +1°C in January to -18°C in July, with recorded extremes of +13°C and -40°C. Winds are predominantly (more than 80% in some months) from a direction between north and east. Long periods of relatively calm, fine conditions can be experienced throughout the year although gusts of over 200 km/hr have been recorded.

The Davis area is subject to frequently cloudy skies, very low absolute humidity, and a small amount of snowfall. Strong winds rarely cause blowing snow and the attendant poor visibility. Wind speeds in excess of 50 km/hr infrequently occur, ranging from 2% of occasions in January to 8% in spring. These general characteristics are typical of the coastal climate of the Antarctic continent, with the exception of wind velocity and associated blowing snow. The climate of Davis is less severe than most other locations in Antarctica because of the sheltering from katabatic winds provided by the Vestfold Hills.

Snowfall is low (up to 50 mm/yr). The majority of snow in the area is wind blown from the continental ice cap. On occasions, drift snow does cover large areas but this is usually blown away by strong winds, other than in the lee of protrusions. In summer, the snow drifts melt to form some minor streams and shallow ponds. Apart from several permanent ice banks, the hills are virtually snow free in summer and only lightly covered in winter.

5.3.2.6 Sea ice - Fast ice (sea ice attached to land) locations close to Davis suitable for operations of intra-continental aircraft early in the summer season will be used. Map 5 shows a suitable sea ice location, and others may be investigated. The ice at these times is thick (over 2m), with a flat surface and a cover of snow. Airfield locations, flight paths and distance guidelines/requirements have been developed to minimise impacts on nearby wildlife concentrations.

The extent of pack ice in September and October can reach as far north as latitude 55° south. The fast ice edge in winter is usually between 5 to 15 km north-west of Davis, and the ice attains its greatest extent and stability in August and September. The maximum thickness of 1.8 metres is reached in November. The fast ice breaks up and is carried out to sea, usually in January.

5.3.3 Biota

5.3.3.1 General - Johnstone et al (1973) noted that Antarctic oases such as the Vestfold Hills support very few species compared with other continents, and fewer than comparable regions of the Arctic. Permanently resident organisms include microbes, invertebrates, algae, lichens and mosses. Migratory species include those bird and seal populations that return each year to breed and/or moult.

Appendix 4 (Species list) provides information on fauna in the region.

5.3.3.2 Birds – The Wilson's storm petrel (*Oceanites oceanicus)* (EPBC listed migratory species) nests throughout the ice free areas of the Vestfold Hills and Rauer group. The southern giant petrel (*Macronectes giganteus)* (EPBC listed migratory and endangered) nests at Hawker Island (approximately 25 pairs in 1999/00). Antarctic skua *Catharacta maccormicki* (EPBC listed migratory species) breed throughout the Vestfold Hills and Rauer Group at widely dispersed nests, generally near penguin colonies.

Six species of birds are known to nest in the Vestfold Hills area. These are:

Adélie penguin (*Pygoscelis adeliae*)	Breeding colonies on most of outer islands (at least 17 islands) and at several locations on Long Peninsula - nearest breeding colony is Gardner Island about 3.7 km west of Davis station. Approximately 200,000 pairs in the Vestfold Hills and offshore islands and 100,000 pairs on the Rauer Islands.
Southern giant petrel (*Macronectes giganteus*)	EPBC listed migratory and endangered species. Breeds at Hawker Island only - about 7 km south-west of Davis station, approximately 25 pairs (1999/2000). This species is highly sensitive to disturbance.
Cape petrel (*Daption capense*)	Breeds on 13 islands - nearest colony is Bluff Island about 3.4 km north-west of Davis station
Snow petrel (*Pagodroma nivea*)	Breeds on many islands and at several localities on mainland - not known to nest within 3 km of the Davis station
Wilson's storm petrel (*Oceanites oceanicus*)	EPBC listed migratory species. Breeds throughout Vestfold Hills
Antarctic skua (*Catharacta maccormicki*)	EPBC listed migratory species. Breeds throughout the Vestfold Hills at widely dispersed nests on most if not all islands and at several mainland locations, mostly near Adélie penguin colonies

Of these species, only skuas and Wilson's storm petrels frequent the immediate station area although Adélie penguins and the other petrels are occasionally sighted within the station area.

5.3.3.3 Seals – A colony of non-breeding male Southern elephant seals *(Mirounga leonina)* (EPBC listed vulnerable species) moults in late summer on Davis beach about 350 metres west of the helipads. Southern elephant seals are also known to haul out at a large moulting area on the south-west shore of Heidemann Bay. Weddell Seals *(Leptonychotes weddelli)* breed on the inshore fast ice but are primarily restricted to Long Fjord, Weddell Arm, Shirokaya Bay and Tryne Fjord - all at least 5-7 km from Davis. Small numbers of Crabeater seals *(Lobodon carcinophagus)* and Leopard seals *(Hydrurga leptonyx)* are also sighted off the coast of the Vestfold Hills during summer.

5.3.3.4 Terrestrial invertebrates - There are no known concentrations of terrestrial invertebrates in the vicinity of the proposed activity. While a small number of invertebrates have been found within the station area it is likely that these are also to be found elsewhere on Broad Peninsula on which Davis is located.

5.3.3.5 Terrestrial flora - At least 82 species of terrestrial algae, six moss species and at least 23 lichen species are found in the Vestfold Hills. The terrestrial flora in the Vestfold Hills is not unique, being representative of most of continental Antarctica (Seppelt and Broady, 1988).

The area around Davis station itself is extremely arid. There are no moss or lichen assemblages present locally. The terrestrial community consists of bacteria, fungi and algae in sheltered places under quartz stones and in temporary snow drift melt areas.

5.3.4 Current land use

5.3.4.1 History - Davis station was established in 1957. The station was temporarily closed between January 1965 and February 1969, allowing concentration of the AAD's resources on the building of Casey as a replacement for Wilkes station in Wilkes Land, but Davis has been occupied continuously since. A brief history of human exploration of the Vestfold Hills prior to establishment of Davis station is provided in the Davis Station Management Plan.

5.3.4.2 Buildings - Station buildings are sited immediately to the east and southeast of the original buildings. The station now covers an area of around 0.5 km^2 and consists of approximately 20 buildings.

5.3.4.3 Population - Davis station over-winter population is normally between 15 and 25 persons. Over the summer period Davis station supports up to about 80 expeditioners (including field program scientists).

5.3.4.4 Communications - Data and telephony links are provided via leased satellite circuits. These circuits provide for instantaneous monitoring of scientific projects and 24 hour communications by telephone, fax and email to Australia and international networks. Communication within Antarctica is also possible via HF radio. Local communications links are provided by VHF radio. The communication facilities utilise aerial arrays and a satellite ground station within the station area (an additional small ground station has been installed for back-up purposes).

5.3.4.5 Logistic support - Logistic support to the station is ship based, with small craft, amphibious vehicles and helicopters being used from ship to shore. Helicopters remain on the station during all or part of the summer season to support scientific and other programs.

5.3.4.6 Roads - Davis station area has approximately two kilometres of roadways and three heavy vehicle bridges.

5.3.4.7 Power supply - Power at the station is supplied by six 125 kW generators (four in use and two as back-up) which use around 520 kL of fuel annually. This fuel is stored in existing bulk storage tanks within the station area with a total capacity of 1015 kL.

5.3.4.8 Water supply - Water for the station is provided primarily from a tarn using a reverse-osmosis plant. The resulting water is stored in two 600 kL bulk tank. This supply is supplemented by water from Station Tarn which is used for ablutions and washing.

5.3.4.9 Waste management - Solid waste generated at the station is separated on the basis of whether it can be reused, recycled, incinerated or whether the waste is to be returned to Australia for disposal. A portion of the waste that can be incinerated (specifically untreated wood, cardboard and paper) is stacked into a two stage, high temperature incinerator and burnt with kitchen waste. Incineration is acknowledged as an acceptable waste disposal option under the Madrid Protocol (Annex III, Article 3). Waste that can not be recycled or incinerated is returned to Australia.

Buildings are serviced by a reticulated sewage system. All human waste and waste water from the station complex passes through the Waste Treatment building, where it receives primary and secondary treatment in a two-stage rotating biological contactor. The total number of personnel on station at any point in time following introduction of air transport system is not expected to exceed current maximum station population levels. The proposed activity should therefore not increase the demands on the waste treatment facilities.

5.3.5 Special values of the area

5.3.5.1 Scientific research - Davis is a key location in the network of Australian Antarctic research stations. The value of the station to science stems from many factors including the role of Davis as a staging base for scientific activity elsewhere in the region (including the Vestfold Hills, the polar ice cap, the Larsemann Hills, and further south).

Station science includes meteorology, upper atmosphere physics, magnetics, monitoring of wildlife within the area, and medical science. The staging base role is a major function, particularly in summer when helicopters are used virtually full-time each day in support of the projects in earth sciences, limnology and biology in all its forms. The introduction of an air transport system would increase the geographic range of projects able to be supported from Davis.

5.3.5.2 Scenic and recreational importance of the general area - Outside Davis station limits, the region is relatively undisturbed. Several regions of the Vestfold Hills and the confluence with the ice plateau offer a variety of terrain suitable for field training exercises and recreational activities such as walking, rock climbing and skiing. There are a number of picturesque glaciological features such as moraines, melt lakes and windscours which offer excellent photographic opportunities. Gardener and Anchorage Islands are within station limits are popular recreation destinations.

5.3.5.3 Historic importance - Davis is the second oldest Australian Antarctic continental station. While a heritage strategy plan is yet to be prepared for Davis station at present, the AAD considers that the proposal will not diminish possible heritage values associated with any existing buildings nor any relationship between them. Davis station contains a number of sites listed on the Register of National Estate.

5.3.5.4 Existing protected areas - The nearest ASPA to Davis is the Marine Plain (ASPA No.143). It was designated for its vertebrate fossil fauna, including a recently discovered species, genus, and probably family of fossil dolphin. Burton Lake, within the site, represents a unique stage in the biological and physico-chemical evolution of a terrestrial water body from the marine environment

A Historic Monument (No 6 of the list of Historic Monuments), the cairn placed by Sir Hubert Wilkins at Walkabout Rocks, is located 35 km northeast of Davis station.

5.3.6 Passenger links between skiways and station

The flight path for helicopters linking the Plateau skiway and station follows an east-west orientation and will be above the 750m vertical height until just prior to landing. Most of the flight path covers an area of ice-free mainland rock and off-shore islands, known as the Vestfold Hills. The Vestfold Hills covers about 512 square km on the Ingrid Christensen Coast and consists of rounded hills mostly between 30 and 100 m above sea level, with a maximum height of 159 m. The lakes and tarns inland of Davis are known for their scientific values. Most wildlife concentrations are along the coastal strip and to the north of the station, in areas where there are significant Weddell Seal pupping areas (see Map 6). Access to the sea ice skiway location will be over the sea ice, snow and/or existing station roads.

5.3.7 Flight paths between stations

The flight path linking the skiways (Casey-Davis-Mawson) follows an approximate east-west orientation over the inland plateau and will be above the 750m vertical height until just prior to landing.

5.4 Mawson station

5.4.1 General information

General information on the existing environment, scientific programs and activities in the Mawson station area is included in the Mawson Station Management Plan (http://www.aad.gov.au/default.asp?casid=7044). Discussion in this section is limited to issues which relate specifically to the introduction of the air transport system.

5.4.2 Physical characteristics

5.4.2.1 Location - Mawson Station (67° 36' S, 62° 53'E) is built on the south-eastern shore of Horseshoe Harbour, which is located on the Mawson Coast of Mac. Robertson Land, on a small area of exposed land adjacent to the polar plateau (Map 7 and 10). The broader region is characterised by small coastal exposures of ice free land, and near shore ice free islands. The surface of the inland ice sheet rises steeply behind Horseshoe Harbour, attaining a height of some 1000 metres within 35 km of the coast. The Framnes Mountains protrude through the plateau to the south, comprising 36km² of ice free land in three major ranges (Casey, Masson and David) separated by expanses of exposed glacial ice.

Photo 8: Mawson station (Wayne Papps, 1999)

5.4.2.2 Geology - There are no special or unique geological features in the area affected by the proposed activity.

5.4.2.3 Lakes, tarns and fjords - Mawson Station area does contain some melt lakes in the vicinity. Little information is available on the biota inhabiting the pools on the eastern side of East Arm; in some cases they have been previously disturbed by run-off from old rubbish dumps and other human activities. Water in these ponds is sourced from fresh water melt and sea spray and is known to contain diatom species commonly found in sea water.

5.4.2.4 Landform - There are no landforms of particular significance in the vicinity of the proposed skiways. No landforms would be affected by flying operations.

5.4.2.5 Meteorology - The Mawson area is subject to frequently cloudy skies, very low absolute humidity, and a small amount of snowfall. Frequent (nearly 30% of occasions) winds in excess of 50 km/hr occur, often causing drifting or blowing snow and greatly reducing visibility. Violent winds and blizzards can be experienced throughout the area and can commence with little warning. Gusts of up to 300 km/hr have been recorded. Mean temperatures range from +0.1°C in January to -18.8°C in August, with recorded extremes of +10.6°C and -36°C. Winds are predominantly (nearly 90% of occasions) from a direction between east and south. The mean annual wind speed at Mawson is 39 km/hr. Sixteen kilometres inland the wind is about 90% stronger. This is largely the result of katabatic winds descending from the plateau, which usually increase after sunset and decrease around midday. The winds are mainly south easterly moving towards the west with the onset of bad weather.

5.4.2.6 Sea ice - Land-fast sea ice near Mawson is very extensive during winter and spring but usually breaks up and dispersed between December and February. Fast ice locations close to Mawson are suitable for operations of intra-continental aircraft early in the season. The ice at these times may be over 2m thick, with a flat surface and a cover of snow. The ice break-out in the immediate station area most commonly occurs in mid-January. The winter edge of the fast ice is usually between 60 and 120 km northward, and the ice attains its greatest extent and stability in August and

September. Near the station the maximum thickness of 1.4 to 2.0 metres is reached in October.

5.4.3 Biota

Appendix 4 (Species list) provides information on fauna in the region.

5.4.3.1 Birds –The Southern giant petrel *Macronectes giganteus* (EPBC listed migratory and endangered) nests on the Rookery Islands (part of ASPA No 102) in Holme Bay. Wilson's storm petrel *Oceanites oceanicus* (EPBC listed migratory species) breeds on the Rookery Islands and in other ice free areas. Antarctic skua *Catharacta maccormicki* (EPBC listed migratory species) breed throughout the ice free areas of the region at widely dispersed nests, generally near penguin colonies.

Airfield sites for intra-continental operations are proposed on the plateau inland of Mawson station and on fast ice close to the station (Map 7 and 10). On the plateau, airfield surfaces will be groomed or natural snow, or glacial ice. Melt streams may form in certain conditions, draining to Holme Bay. Faunal species are not resident on or near the plateau operating area, with the nearest sites being the David and Masson Ranges where snow petrels (*Pagodroma nivea*) nest. Other colonies and breeding sites in the ice free areas of Holme Bay are more distant from the operating area.

The Mawson region supports breeding colonies of nine species of birds. These are:

Adélie penguin (*Pygoscelis adeliae*)	Breeding colonies on many islands on the Mac Robertson Land coast including 13 islands of the Rookery Islands - nearest breeding colony is Bechervaise Island about 2 km west of Mawson. Approximate breeding populations: 45,000 pairs on Rookery Islands, 40,000 in Mawson area (E Woehler, pers comm).
Southern giant petrel (*Macronectes giganteus*)	EPBC listed migratory and endangered species. Breeds at Giganteus Island only - about 16 km west of Mawson (3 pairs in 1999/2000).
Cape petrel (*Daption capense*)	Breeds on small rock outcrops flanking the Forbes Glacier, 18 km to the west of Mawson; in the Rookery Islands
Snow petrel (*Pagodroma nivea*)	Breeds on Rookery Islands, the David Range, Casey Range, the Masson Range and at Mt. Henderson - a small number also nest in the station area
Wilson's storm petrel (*Oceanites oceanicus*)	EPBC listed migratory species. Breeds within station area and in rocky areas on islands and the coast

Emperor penguin (*Aptenodytes forsteri*)	Five breeding colonies on the Mac. Robertson Land coast - nearest colony at Auster Rookery 56 km east of Mawson (approximately 11,000 pairs) (E Woehler, pers comm).
Antarctic skua (*Catharacta maccormicki*)	EPBC listed migratory species. Breeds on Giganteus Island and probably on other islands near Adélie penguin colonies

Breeding colonies of other species such as Antarctic petrels (*Thalassoica Antarctica*) and Antarctic fulmars (*Fulmarus glacialoides*) are located along the Mac. Robertson Coast but at distances of over 100 km from Mawson.

Of these species, only small numbers of Snow petrels and Wilson's storm petrels have been known to breed within the station area. The number of Snow petrels nests has declined over the last two decades due to station activities including modification of habitat. The number of Wilson's storm petrels is difficult to quantify owing to the species' cryptic nesting habits and nocturnal behaviour.

A number of penguins and other birds occasionally are found within the station area; however significant breeding colonies of each species are located some distance from the station. The nearest colony is a population of Adélie penguin on Bechervaise Island, 2 km to the north-west of Mawson station.

Where appropriate, the only permitted approaches to the station would be those detailed in the Antarctic Flight Information Manual and the Environmental Requirements for Aircraft Operations (Appendix 3), which are designed to avoid bird breeding sites and other sensitive areas.

5.4.3.2 Seals - Weddell seals (*Leptonychotes weddelli*) are common in the vicinity of the station and at coastal islands and tide cracks during the late spring and early summer. Crabeater seals (*Lobodon carcinophagus*) are present in small numbers off-shore, but none has been observed breeding near Mawson. Occasional sightings of Leopard seals (*Hydrurga leptonyx*) and rare observations of other species have been recorded.

5.4.3.3 Terrestrial invertebrates - There are no known concentrations of terrestrial invertebrates in the vicinity of the skiways. While a small number of invertebrates have been found within the station area they are generally more likely to be found in areas of moraine and where bryophyte colonies exist.

5.4.3.4 Terrestrial flora - The vegetation of Mawson Rock is depauperate, consisting of generally microscopic non-marine algae, lichen and mosses. Of the 21 species of lichen recorded, the two most common are *Buellia frigida* and *Xanthoria elegans*. The lichens form open colonies on exposed rock, and closed patches on sheltered rock. Bryophytes are limited to three species (*Bryum pseudotriquetrum, Grimmia lawiana* and *Grimmia antarctica*) and confined chiefly to gravel on northerly aspects receiving snowbank melt waters.

Human presence at Mawson since 1954 and associated activities have resulted in the degradation of vegetation within the station area. The most significant area of relatively undisturbed vegetation on Mawson Rock is to the west of the Cosmic Ray Observatory.

5.4.4 Current land use

5.4.4.1 History - Mawson Station was established in 1954 and has been continuously operated by Australia since then. A brief history of human exploration of the coast of Mac. Robertson Land prior to establishment of Mawson Station is provided in the Mawson Station Management Plan.

5.4.4.2 Buildings - In its original form Mawson consisted of some 30 buildings located within a radius of 100m. Current station buildings are sited immediately to the north and east of the original buildings and consist of approximately 20 buildings, covering an area of 0.3km².

5.4.4.3 Population - Mawson station's over-winter population is 15-25 persons for the winter. Over the summer period Mawson station may support up to about 40 expeditioners (including field program scientists).

5.4.4.4 Communications - Data and voice links are provided via leased satellite circuits. These circuits provide for instantaneous monitoring of scientific projects and 24 hour communications by telephone, fax and email to Australia and international networks. Communication within Antarctica is also possible via HF radio. Local communications links are provided by VHF radio. The communication facilities utilise aerial arrays and a satellite ground station within the station area (an additional small ground station has been installed for back-up purposes).

5.4.4.5 Logistic support - Logistic support to the station is presently ship based, with small craft, amphibious vehicles and helicopters being used from ship to shore.

5.4.4.6 Roads - Mawson station area has approximately two kilometres of roadways and three heavy vehicle bridges.

5.4.4.7 Power supply - Power at the station is supplied by four 125 kW generators in the Main Power House and one 350 kW generator in the Emergency Power House. In total some 540 kL of fuel is used annually, however, with the introduction of wind turbines at Mawson station, fuel usage is expected to decrease over the coming years. The fuel is stored in existing bulk storage tanks within the station area with a total capacity of 1150 kL.

5.4.4.8 Water supply - Water for the station is produced during the summer melt, and collected in caverns where it is maintained in liquid form by utilising heat from a boiler in the pump building. The caverns are situated on the edge of the ice plateau some 500 m south of the helipads.

5.4.4.9 Waste management - Solid waste generated at the station is separated on the basis of whether it can be reused, recycled, incinerated or whether the waste is to be returned to Australia for disposal. A portion of the waste that can be incinerated (specifically untreated wood, cardboard and paper) is stacked into a two stage, high temperature incinerator and burnt with kitchen waste. Incineration is acknowledged as an acceptable waste disposal option under the Madrid Protocol (Annex III, Article 3). Waste that can not be recycled or incinerated is returned to Australia.

Buildings are serviced by a reticulated sewage system. All human waste and waste water from the station complex passes through the Waste Treatment building, where it receives primary and secondary treatment in a two-stage rotating biological contactor (RBC). The average number of personnel on station following introduction of the air transport system is expected to be below current maximum station population levels. The proposed activity would therefore not increase the demands on the waste treatment facilities.

5.4.5 Special values of the area

5.4.5.1 Scientific research - Mawson is a key location in the network of Australian Antarctic research stations. Station science includes meteorology, upper atmosphere and cosmic ray physics, magnetics, tidal/sea level monitoring, wildlife monitoring, and medical science. Mawson also serves as a staging and support base for geological, glaciological and biological studies in Mac. Robertson Land. Details of the scientific programs conducted at Mawson are provided in the Mawson Station Management Plan.

5.4.5.2 Scenic and recreational importance of the general area - Most areas of the AAT exhibit very high wilderness values. Field camps, fuel caches, weather stations and scientific installations are additional signs of human activity, but very large areas remain free from even transitory evidence of activity. The region outside Mawson station limits is relatively undisturbed and offers a number of picturesque glaciological features such as moraines, melt lakes and windscours which offer excellent photographic opportunities.

5.4.5.3 Historic importance - Mawson is the oldest continually operated Antarctic continental station south of the Antarctic Circle. A number of features have been identified in the Mawson Station Management Plan as having potential heritage significance. In 1995, a heritage plan for Mawson station was prepared. Some of the buildings at the station are listed on the Register of National Estate.

5.4.5.4 Existing protected areas - There are two Antarctic Specially Protected Areas (ASPA's) in the Mawson region:

- ASPA No. 101, Taylor Rookery on the east side of Taylor Glacier, Mac. Robertson Land some 90 km from the station;
- ASPA No. 102, Rookery Islands, Holme Bay about 10 km to the west of Mawson.

ASPA No. 101 was designated to protect the breeding grounds of a colony of Emperor penguins. Taylor Rookery is one of the few, and probably the largest, known colony of this species located wholly on land. ASPA No. 102 was designated on the grounds that the Rookery Islands contain breeding colonies of all six bird species resident in the local Mawson area. It was considered to be of scientific importance to safeguard this unusual association of six species and to preserve a sample of their habitat.

There are no protected areas near the Mawson station.

5.4.6 Passenger links between skiways and station

Access to and from skiway locations will be over snow/ice and/or existing station roads.

5.5 Other locations

On an as needed basis, the air transport system will be used for other scientific applications (ie. aerial surveys, access to remote scientific field camps), to assist with the transportation of personnel to remote bases, and to assist other national Antarctic programs. These activities will be subject to their own environmental assessment process.

5.6 Prediction of future environmental state in the absence of the proposed activity

In the absence of the proposed introduction of the air transport system, the immediate environment at the Casey runway (where trial construction of the ice surface has been carried out) will eventually return to its pre-disturbed state. Impacts associated with the transportation of passengers to stations will remain as current ship and aircraft (fixed wing and helicopter) operations will continue. It is likely that AAD’s greenhouse gas emissions will continue at current levels.

6. METHODS AND DATA

6.1 Sources of Information

6.1.1 Design

Following many years of research and development, AAD went to tender for an air service provider. The design of the proposed system was based on the proposal of the successful tenderer, Skytraders. One of the deciding factors behind the successful tenderer was the environmental benefits of their proposed system. The inter-continental aircraft capable of a return Antarctic flight without refuelling, removes the need for an alternative runway and the storage of large amounts of fuel for inter-continental operations. Careful consideration of all environment aspects of the air transport system has been incorporated in to its design and discussed throughout this document.

6.1.2 Timing

It is planned to commence intra-continental flights in the season of 2004/05, and the inter-continental flights in 2004/05-2005/06 (dependent on budgetary outcomes).

6.1.3 Existing environment

Descriptions of the existing environment (Chapter 5) were based on information from scientific publications and from individuals from appropriate disciplines within and outside the Australia Antarctic Division. These are listed in Chapter 11 of this report.

6.1.4 Potential impacts on scientific programs

Information on the potential impacts on scientific program was obtain through discussions with relevant program managers and senior scientific personnel listed in Chapter 11 and is discussed in detail in Section 7.2.7.

6.1.5 Potential impacts on environment, logistics and station operations

Although the air transport system will change the way in which scientific and operational personnel are transported to and around Antarctica, the potential impacts on station operations will need to be further explored. A number of working groups within AAD are examining the potential issues and appropriate ways to address them. The results from these working groups were not finalised in time for this report.

The logistical support and coordination of passenger induction and processing will be different to current methods and these changes are currently being investigated. Addressing and mitigating these changes is the objective of many working groups throughout the AAD. Many of these working groups will continue to monitor the associated impacts on stations and logistical operations to ensure continual improvement.

Potential impacts on the environment have greatly been alleviated due to the design of the air transport system. Details on the potential impacts on the environment have been gathered over the previous seasons, previous reports and through individual personnel. This is discussed throughout the IEE and particularly in Chapter 7.

6.2 Gaps in knowledge and uncertainties

Given that the establishment of the new air transport system is a dramatic change in the way AAD transport personnel, it is expected that there will be a number of uncertainties and gaps in current knowledge.

Fuel requirements are being based on the assumption of 100 hours per month for each C212 and initially 25 flights per season for the Falcon 900EX. This is a proposed figure and actual fuel usage will not be known until the system is fully operational. The type of fuel storage is unknown at this stage of the project. Options for fuel storage include but are not limited to 205L drums, 25kL IOS tanks and/or commercial bulk fuel installations. Further investigation into appropriate storage solutions will be undertaken and finalised prior to the commencement of the system.

Accurate accommodation requirements and associated impacts on station resources/infrastructure are also difficult to predict at this stage, however it is the intention of the AAD to maintain station and infrastructure capacities at the present level for the foreseeable future. The program, while responsive to demand from the scientific community, will not diverge from the present practice of managing access and providing support to a number of personnel and scientific projects commensurate with ability of facilities to support them.

Exactly how the new air transport system will alter the AAD's science program is unknown at this stage, as the system provides new opportunities, such as aerial science activities, better access to some remote locations and more effective use of time. Specific science programs, access to remote or new field locations, and airborne science programs will be subject to individual environmental assessment under the AT(EP) Act.

Little research has been conducted on the noise impact on wildlife and there are still a number of uncertainties surrounding appropriate separation distances and associated noise levels. Based on the noise modelling data (Appendix 6), C212 noise levels are approximately 70 dBA at a 750m vertical distance. The noise emissions exercise that was undertaken used a model to predict the noise footprint associated with the Falcon 900EX and C212. A number of assumptions were applied to this model. Ground-truthing of the noise footprints, especially for the C212 will confirm noise levels received along the flight paths and skiways. A number of other Antarctic nations are also interested in the impacts on wildlife by aircraft operations. As further research into this area is undertaken and published, reconsideration of the 750m separation distance may be required.

The risk of foreign organisms entering the Antarctic environment through the new air transport system is not fully understood. The AAD has existing protocols that deal with measures to mitigate the risk of introduction of foreign organisms by sea based transport. In order to gauge a better understanding of risks involved, a risk assessment will be undertaken, and appropriate measures taken to minimise risks.

7 ANALYSIS OF POTENTIAL IMPACTS

It is expected that the introduction of an air transport system may result in a number of environmental impacts. Appendix 5 lists the likely impacts associated with the activity. Through the identified mitigation measures (Chapter 8) and the Environmental Management Plan for the system, all responsible steps will be taken to reduce these impacts during the construction and operational phases.

7.1 Direct impacts

Further to the tabled potential impacts in Appendix 5, Table 11 summarises the severity of impacts on Antarctic values for each potential impact area. Impacts are assessed according to the severity (which takes account of consequence and likelihood - *Use Table 11 in combination with Table 11A).*

Table 11: Summary of impacts for each aspect of the system

Potential impact areas	**Direct impacts**							
	Atmos/ emissions	Water/ snow/ ice	Birds/ seals	Flora/ vegetation	Significant areas	Surface disturb-ance	Wilderness/ visual	Heritage
Potential Impact Section	*7.1.1*	*7.1.2*	*7.1.3*	*7.1.4*	*7.1.5*	*7.1.6*	*7.1.7*	*7.1.8*
Hobart-Casey link	L	L	L	L	n/a	n/a	L	n/a
Casey runway	L	L-M	L/nil	L	L	L	L	n/a
Casey link	L	L	L-M	L	L	n/a	L	n/a
Casey skiway./ station	L	L-M	L-M	L	L	L	L	L
Davis-Casey link	L	L	L-M	L	L	n/a	L	n/a
Davis skiways/ station	L	L-M	L-M	L	L	L	L	L
Davis Plateau skiway	L	L-M	L	L	L	L	L	n/a
Plateau-Davis link	L	L	L-M	L	L	n/a	L	n/a
Mawson-Davis Link	L	L	L-M	L	L	n/a	L	n/a
Mawson skiways/ station	L	L-M	L-M	L	L	L	L	L
Legend – L- low, M-medium								

Table 11A: Consequence/likelihood impacts table

Likelihood	**Consequence**				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Certain	Medium	Medium	High	High	Extreme
Likely	Medium	Medium	Medium	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

<u>Consequence</u>

Insignificant – recoverable damage or impact
Minor – small fuel spill (20L or less), loss of individual plants
Moderate – Moderate fuel spill (approximately 100L), injury or behavioural disturbance to an animal
Major –Large fuel spill (greater than 100L), loss of localised plant communities
Catastrophic – local extinction of a species, establishment of exotic invasive species, loss of human life or permanent injury.

<u>Likelihood</u>

Certain – the impact will be the outcome of the activity.
Likely – there is a good chance that the impact will occur as a result of this activity, however it will not always be the case.
Possible – the impact may occur, but it is not expected to be the outcome of the activity. (e.g. person dependent – human error)
Unlikely – minor chance that the activity will result in the impact.
Rare – extremely unlikely

7.1.1 Atmosphere/air quality

The air transport system has the potential to affect the quality of the air in Antarctica as a result of exhaust emissions from the aircraft and construction/maintenance vehicles. Aircraft and vehicles will produce atmospheric pollutants (gaseous and particulate) such as sulphur oxides, nitrogen oxides, carbon monoxide, carbon dioxide, hydrocarbons and heavy metals in the vicinity of their operations. The emission of these pollutants into the Antarctic environment is difficult to avoid when fossil fuels are utilised in support activities (Elsom, 1989). Their presence has already been noticed through the sampling of snow and ice throughout the Antarctic continent, and found to be attributable to sources both within and external to Antarctica. In addition to impacting on air quality, these exhaust products can have an impact on the pollutant content of water, snow and ice. They can also have an effect on the micro-organisms and plant life of the impacted area. It is believed that the impacts of exhaust emissions from Antarctic station activities are usually localised (Boutron and Wolff, 1989).

Australian operations in Antarctica currently use significant quantities of fossil fuel for station electrical power generation, oversnow traverse vehicles, helicopters, occasional fixed wing aircraft and research/resupply ships. While station generator fuel consumption would be mostly unaffected by introduction and ongoing use of fixed wing aircraft, there are expected to be some significant changes in fuel usage by the major transport components of the program. Current and expected major transport fuel usage figures (in kilolitres) with their associated greenhouse gas emissions are given below (Table 12 and 13).

Table 12: Greenhouse gas emissions for current and forecasted fuel consumption used in air and sea transportation

	Fuel	Current consumption	Emission	Forecast consumption[2]	Emission	+/- (%)	
Units:		kL	Gg CO_2-e	kL	Gg CO_2-e	Fuel kL	emission
Helicopter	Avtur	166	0.43	100	0.26	-66	-39.8%
C212	Avtur	0	0	263	0.68	+263	-
Falcon 900EX	Avtur	0	0	300[3]	0.77	+300	-
Ships	Fuel Oil	7200[4]	21.61	4800[5]	14.40	-2400	-33.3%
Total		7366	22.04	5463	16.11	-1903	-26.9%

Table 13: Emissions summary for each fuel type

	Units	CO_2	CH_4	N_2O	Specific Energy		Fraction Oxidised
Avtur	g/MJ	69.7	0.0094	0.002	36.8	MJ/L	0.99
Fuel Oil	g/MJ	73.6	0.003	0.002	40.8	MJ/L	0.99
GWP		1	21	310			

Source: NGGIC (1996) Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks. National Greenhouse Gas Inventory Committee, Canberra.

From the above figures it can be seen that the introduction of the air transport system will lead to an overall reduction in fuel consumption of approximately 1900kL. These figures are purely based on the estimates for the transportation of personnel and cargo (not additional science expeditions); is therefore a very simplistic estimate of the predicted changes in fuel usage.

This overall reduction in fuel usage (and therefore greenhouse gas emissions) results from two main factors. Firstly, the use of the long range jet providing transportation for AAD/science personnel from Australia to the AAT is predicted to reduce the number of ship voyages (cargo will still be required to be transported by ship). Secondly, the ability of fixed wing turbo-prop aircraft to transfer personnel within the AAT is predicted to reduce the number of voyages to stations. The net effect is that regional air quality in Antarctica would not be adversely affected by the proposed air transport; however there will be an increase in fuel usage and emissions at some localities.

At the more regularly used locations, such as Davis, Casey and Mawson, aircraft use and associated emissions in the local area of the stations are not expected to increase significantly over current levels. However, by their nature, the emissions from these intra-continental operations (either between stations or to remote research locations)

[2] Expected fuel usage resulting from the introduction of the air transport system is only an estimate - actual fuel usage will can not be accurately predicted at this stage
[3] Based on 25 flights per season
[4] Based on the average of 300 ship days using approximately 24kL of fuel per day
[5] Based on an assumption of 200 total ship days per season (Potter, S. pers. comm..)

are likely to be dispersed over a very wide area and therefore be undetectable against background concentrations in the atmosphere.

Construction of the ice runway surface at Casey will involve some vehicle usage but the amount of fuel used and the emissions produced are considered insignificant in terms of local air quality. Ongoing maintenance required at the Casey runway will add particulates and nitrogenous compounds to the atmosphere but these will be quickly dispersed with the exception of very low levels of particulate fallout to the snow or ice surface.

Dispersal of gaseous and particulate emission products is likely to be rapid. Particulate fallout on snow surfaces will occur in the local area. The impacts associated with this are considered to be negligible.

Emissions from aircraft and construction vehicles would include chemical pollutants such as sulphur oxides, nitrogen oxides, carbon monoxide, carbon dioxide, hydrocarbons and heavy metals. These unavoidable exhaust products could have an effect on any plant life and micro-organisms in the immediate vicinity of the proposed operations, although deposition and accumulation of these pollutants is likely to be extremely low due to dilution and dispersal by wind. The greatest effects, if detectable, are likely to be found immediately downwind of the skiway areas. However, none of the proposed landing sites have any known biota in their immediate downwind vicinities that cannot be found in their more general areas. Skiways have been or will be positioned to ensure minimal impact on the surrounding environment, taking special consideration of wildlife concentrations, ASPA areas and melt lakes.

Adjacent to Casey station, ASPA No.135 protects the diverse assemblage of vegetation, including the extremely rich lichen and moss communities found there, and the fact that it is the main continental site for a liverwort, as well as being close to the station to facilitate research. Some of this research involves the environmental impact of station operations. Deposition and accumulation of any pollutants in ASPA No.135 from aircraft overflights should be extremely low because the prevailing wind would tend to blow any pollutants away from the ASPA and back in the direction of the current proposed skiway locations. Any changes in these locations will take into consideration the associated impacts on ASPAs.

En route between Casey and Hobart, Tasmania, the Falcon 900EX may leave contrails in the upper atmosphere. Contrails are line-shaped clouds or ‘condensation trails’, comprised of ice particles, that are visible behind jet aircraft engines, typically at cruise altitudes. Aircraft engines emit water vapour, carbon dioxide (CO_2), small amounts of nitrogen oxides, hydrocarbons, carbon monoxide, sulphur gases and soot and metal particles formed by the high temperature combustion of jet fuel during flight (US EPA – Aircraft Contrails Factsheet, 2000). Of these emissions, only water vapour and small particles are necessary for contrail formation. It is unlikely that the formation of contrails would pose any environmental impact or hazard to the Antarctic environment. As contrails fall, ice particles evaporate in the lower atmosphere and are readily dispersed.

7.1.2 Water, snow and ice quality/processes

The construction of the Casey runway and support facilities placement will modify the physical surface of the ice and snow. The areas disturbed represent an extremely small proportion of similar areas in the region. The modifications are not permanent and natural processes will return the location to an unmodified state over time if use ceases.

At times, areas of the snow-cap surface on the Casey runway will need to be removed and replaced with fresh snow. In areas of high use, such as take-off and landing zones, refueling locations and around buildings and maintenance, contaminants may spill or drip onto the snow surface. Nearly all contaminants will be hydrocarbon related. Some tyre rubber dust (zinc) (remnants from "real world" runway operation) will also end up in the landing zone.

The volume of snow-cap contaminant is very small volumetrically. Some contaminants, primarily exhaust soot, are distributed widely and will deposit on the snow and ice surface. Other contaminants will mainly be associated with refuelling and machinery maintenance.

Skiways and access routes to stations will entail minimal modifications to ice and snow surfaces and will not be of a permanent nature.

There is some potential for lake chemistry to be altered by aircraft exhaust emissions if low level overflights result in the deposition and accumulation of chemical pollutants. There may be some lakes or tarns in the immediate vicinity of proposed skiway landing areas in the Davis region that may be adversely affected. Overall, aircraft operations are unlikely to have any detectable impact on water quality, however, a monitoring program has commenced in order to confirm this assumption.

Expected station population numbers will be approximately the same as current levels, except in the event of flight delays. The introduction of an air transport system will not therefore put additional demands on the waste treatment facilities at the permanent stations and there will be no increase in discharge of treated wastes and nutrients into the sea.

There could be some chance that spilt fuel or other contaminants could affect water quality within station boundaries or in coastal areas where melt occurs. Care will be taken during refuelling, transportation and storage of fuel, so as not to contaminate snow or ice surfaces (or ground surfaces in station areas where fuel is stored or handled). It is likely that only fuel required in remote locations will be delivered and stored in 205 litre drums for ease of handling and to minimise the potential for any large accidental spills of fuel.

Aviation fuel testing may lead to minor spillage. Fuel contamination is usually water related. The removing of a fuel drum lid may cause a small amount of fuel to fall to the ground. To test fuel, often pilots will use a torch to sight any water bodies in the bottom of fuel drums. Approximately half a litre of fuel may be removed from the drum or aircraft tank to further test for contaminants. Aviation requirements prevent this test sample to be returned to the aircraft fuel tank. This creates the need for a safe disposal technique to be made available.

Other contaminants may be sourced from engine coolants, oils, and other maintenance lubricants. These will most likely be concentrated in maintenance areas.

The intra-continental component of the air transport system requires the transportation, storage and transfer of large quantities of fuel. Although unlikely, dealing with fuel on this scale could result in a large fuel spill leading to a direct impact on the environment. The exact nature of that impact would greatly depend on the location and scale of the spill.

In time of emergencies, such as sudden bad weather at Davis Station preventing landing, alternative skiways will be required. Once landed, additional fuel may be required in order to enable the aircraft to return to a station. Alternatives could be at the Russian Base, Mirny, PRC base at Zhongshan on the sea ice, or at the Bunger Hills. Delivery of fuel and refuelling operations has the potential to contaminant snow/ice surfaces.

7.1.3 Antarctic birds, seals and other wildlife (including ASPAs)

There is a low risk of impacts on wildlife occurring at the Casey runway as there is no wildlife present in the area or on the access routes. There is a very low risk of bird strike on aircraft, runway camp facilities or associated objects, if flying birds visit the location.

7.1.3.1 Historic noise data – Disturbance of wildlife by aircraft can be caused by visual and/or noise related impacts. Studies have indicated that the noise of aircraft flying overhead can have a disturbing effect on birds and seals. In particular, it has been concluded that behavioural and physiological reactions to stimuli such as helicopter operations can lead to reduced hatching or fledging success in a disturbed Adélie penguin colony, followed by an overall decline in the breeding population, if the stimuli are not controlled (Culik *et al*, 1988). Culik *et al* (1990) reported observations of panic runs and escape reactions in walking Adélie penguins as far as 1500 metres horizontally from a large military helicopter (Culik *et al*, 1990). Disturbance was also noted with the behaviour of creching Emperor penguins (*Atenodytes forsteri*) with the overflight of a twin engined helicopter (Sikorsky S.76) at 1000m (Giese & Riddle 1999)

Other studies have indicated that the level of disturbance depends on the height of the helicopter and that Adélie penguins are moderately to greatly disturbed by overflights by helicopters at heights of less than 600 metres. At heights above 600 metres, slight disturbance has been observed (Sladen *et al*, 1970). Experimental flights conducted by the New Zealand Antarctic Research Program in 1990 similarly found that no significant disturbance occurs to Adélie penguins when the helicopters are more than 600 metres above ground level (Wilson *et al*, 1990).

Limited information is available on disturbance to seals from aircraft operations. Agitated behaviour in Weddell Seals was observed in response to larger helicopters used by the United States and New Zealand Antarctic operations. This response was observed at some distance (order of kilometres) particularly during low level flights (less than 300 m). Anecdotal evident suggests that elephant seals are not significantly disturbed by aircraft, especially in areas of regular use.

7.1.3.2 Noise modelling and associated noise footprints - Currently, for Squirrel helicopter operations in the AAT, a separation distance of 750m from wildlife concentrations is required. Research undertaken by Giese and Riddle helped form the basis for this separation distance (Appendix 3). At a vertical height of 750m, Squirrel and C212 aircraft noise levels are approximately the same at 65-70db (Appendix 6).

Despite intra-continental skiways being located on ice and snow surfaces, ice free areas that contain wildlife habitat may be affected by noise emissions from aircraft and support machinery. To assist in determining noise related impacts, a noise modelling study was commissioned (Appendix 6). It is evident from the noise modelling data and knowledge of the surrounding environment that the Casey runway site does not present any noise related impacts on wildlife. Noise related impacts are more directly related to the C212 operations in coastal areas, near stations. Conclusions relating to C212 operations reached are summarised in Table14.

Table 14: Summary of noise exposure scenarios

Location	Airstrip proximity to wildlife concentration	Direction /heading from	VFR approach	Non precision GPS approach	Departure
Casey runway	30km NW	West	*Given the distance to wildlife concentrations, aircraft activities in this area will not cause any noise related impacts on wildlife*		
Casey – south of station	1500m NW	West	Minor noise encroachment into wildlife separation zone, however aircraft will be outside this area.	No wildlife concentrations at threshold. Minor noise near Shirley Island (aircraft is outside 750m zone)	No restriction provided aircraft does not turn to fly over Casey.
		East	No restrictions	No restrictions	Aircraft should maintain runway heading until beyond Shirley and Beall Islands
Casey – east of station	4.5km W	West	Approach should be from the south or between Shirley and Beall Islands	Threshold should be access from the south to avoid wildlife	No restrictions
		East	No restrictions	No restrictions	Aircraft to avoid flying over identified wildlife

					concentration areas below 750m
Davis sea ice	2.75 km NW	South west	Aircraft should fly between Gardner and Warriner Islands during approach	Threshold should be approached from the north to avoid Warriner Island area	Departure path to follow NNE heading until over 750m
		North east	Approach from SE to avoid wildlife	Threshold should be approached from the SE	Maintain skiway heading to fly between Gardner and Warriner Islands
Davis Plateau	15km NW	South west	No restrictions	No restrictions	No restrictions
		North east	No restrictions	No restrictions	No restrictions
Mawson sea ice	1.5km W or E	South east	No restrictions	No restrictions	Aircraft should maintain runway heading to avoid wildlife and ensure NE turns avoid Klung Islands below 750m
		North west	No restrictions	No restrictions	Departures should not pass over Jocelyn and Flat Islands below 750m
Mawson plateau (Gwamm)	3.7km NNW	North west	Aircraft to avoid flying over Flat Islands at low altitudes (below 750m)	Aircraft below 750m over wildlife concentration noted directly above Flat Islands-further investigation into the ability to move the orientation of Gwamm to fit approach path between Jocelyn and Flat Islands	No restrictions
		South east	No restrictions	No restrictions	Departure path to be restricted to area between Jocelyn and Flat Islands.

Noise modelling/emission conclusions will be incorporated into the Environmental Requirements for Aircraft Operations prior to the C212 commencing operation in 2004/05. However, to be certain that the 750m separation distance is adequate, additional studies will need to be undertaken (such as ground-truthing of noise emission levels in the field. A number of other Antarctic nations are also interested in the impacts on wildlife by aircraft operations. As further research into this area is undertaken and published, reconsideration of the 750m separation distance may be required.

It is anticipated that the proposed activity will not significantly disturb any breeding colonies of birds or seals as all known colonies are at least 750 metres from proposed landing areas. Approach and departure paths to and from the runway (inter-continental) and skiway (intra-continental) areas do not require overflights of any colonies below 750m. In addition, as occurs at present, all future Australian aircraft operations would continue to be planned to avoid overflights of any concentrations of birds and seals, unless specifically required as part of an approved scientific program - in which case a separate environmental impact assessment would be undertaken.

The helicopter link between the Davis Plateau and station will not result in significant noise impacts on wildlife concentrations as flight routes to the plateau skiway avoid these areas (Map 6).

Noise and other disturbance factors associated with any construction activities required for the project, such as skiway/runway preparation will be isolated and for a limited duration. Management of these impacts will be addressed in the EMP.

7.1.3.3 Other impacts - Given the close proximity of most intra-continental skiways to the coastline and therefore close to flying birdlife, there is the possibility of bird strike by aircraft or where a bird may fly into a structure. Currently bird strike reporting for AAD stations and ships is sporadic and limited accurate information is available. An additional hazard for aircraft and birds is the gathering of birdlife on the skiways. Birdlife will need to be encouraged away from the skiway prior to landing to avoid bird strike.

Sudden and unexpected weather changes may require Davis-Casey bound flights to utilise an alternate skiway if the PNR has been reached. Depending on the location of the alternate skiway, approaches, departures and landings may effect nearby wildlife or other values.

Oceanic species of the Southern Ocean (from Australia to Antarctica), including listed species will be exposed only to overflight at high altitude (46,000 feet). As such, adverse impacts are considered unlikely. Bird species restricted to coastal areas of Australia have not been listed, as aviation operations in the vicinity of departure airfields are common at present and the proposed activity represents a negligible increase in aircraft movements. Flight routes will not pass close to subantarctic islands.

7.1.4 Flora/vegetation

Vegetation can be impacted upon through surface disturbance, emissions or water quality and is discussed throughout this chapter.

7.1.5 Areas of geological significance

No area of geological significance will be disturbed by the proposed activity.

7.1.6 Surface disturbance

Construction of the runway and skiways will result in minimal impact to the immediate environment as only surface preparations are required. No major earthworks, excavation or blasting will be required for the project. Some minor works may be required if larger fuel storage tanks are to be utilised

Physical disturbance of the surface by construction activity at or near stations has the potential to effect vegetation and soil biota. However, as noted in earlier sections, the majority of construction (ie skiway/runway preparation or fuel storage construction) would either be limited to already disturbed sites within station boundaries or at runway/skiway sites. While it is assumed that any vegetation and the soil community in the directly impacted areas would be totally destroyed by the construction activity, these sites have no known vegetation or other biota that cannot be found more generally in the station areas. The scale of impacts on station based vegetation and other biota is expected to be small and localised. Runway or skiway activities will not be occurring on ice free areas and do not have any vegetation or other biota in the immediate area.

Spills of aviation fuel would severely damage or kill any organisms covered by the fuel. Furthermore, sufficient accumulation at the surface would inhibit recolonisation by soil organisms. While great care would be taken during refuelling operations to ensure that even very small spills of fuel do not occur, spills of this scale would not affect the surrounding undisturbed environment. Dealing with large quantities of fuel, there is always the possibility of a large spill occurring. Depending of the scale and location of the spill, associated impacts on the environment will vary. The greatest risk to any fuel management system is during the transfer process (either from ship to shore or from storage to aircraft). This potential risk will be addressed through the establishment of a Fuel Management Plan as well as in the Air Operations Manual.

7.1.7 Wilderness values and visual impact

The area of operations exhibits wilderness and aesthetic values. Very large areas of east Antarctica exhibit similar characteristics. While these values will be locally affected by the activity, no permanent impact on wilderness and aesthetic values will persist if the area ceases to be used after this activity.

There would be negligible and very transitory visual and noise impacts on the wilderness and aesthetic values of the snow, ice and rock areas used for fuel drum storage and refuelling. However, these impacts would largely be limited to actual operational periods. All fuel drums and other equipment will be removed from remote sites at the conclusion of operations to those locations.

Runway construction and infrastructure will not result in a lasting impact on the environment. Most supporting infrastructure at the Casey runway will be removed at the end of each flying season and transported back to Casey for winter storage. Intra-continental operations will also have a temporary impact on the surrounding environment, enabling all sites to return to a pre-operation state except for minor wintering infrastructure).

7.1.8 Heritage values

There are no known heritage values affected by the introduction of an air transport system.

7.2 Indirect impacts

A summary of indirect impacts associated with the air transport system is presented in Table 15.

Table 15: Summary of indirect impacts on each aspect of the system

Potential impact areas	**Indirect impacts**							
	Facilities / Comms.	Water/ power	Accommo -dation	Station ops	Waste	Quaran-tine	Science/ research	Cumulative impacts
Potential Impact Section	*7.2.1*	*7.2.2*	*7.2.3*	*7.2.4*	*7.2.5*	*7.2.6*	*7.2.7*	*7.2.8*
Hobart-Casey link	n/a	n/a	n/a	n/a	n/a	L-M	L	L
Casey runway	L	L	L-M	L	L	L-M	L	L
Casey link	L-M	n/a	n/a	n/a	n/a	n/a	L	L
Casey skiway./ station	L	L	L-M	L-M	L	L-M	L	L
Davis-Casey link	L	n/a	n/a	n/a	n/a	n/a	L	L
Davis skiways/ station	L-M	L	L-M	L-M	L	L	L	L
Davis Plateau skiway	L	L	L	n/a	L	L	L	L
Plateau-Davis link	L	L	n/a	n/a	n/a	n/a	L	L
Mawson-Davis Link	L	n/a	n/a	n/a	n/a	n/a	L	L
Mawson skiways/ station	L	L	L	L	L	L	L	L

See Table 11A: Consequence/likelihood impacts table

7.2.1 Associated facilities and communications

During the summer/flying season, facilities associated with aircraft operations will be required at runway/skiways and within stations. The majority of the remote equipment will be removed and stored at nearby stations at the end of the flying season. The minor equipment left in the field during the winter months will not adversely effect the surrounding environment. No new permanent buildings would be required.

7.2.2 Water and power supply

Power supply at the three stations will be adequate to cater for any minor changes that may occur due to the introduction of the air transport system. Additional power supply will be required at the Casey runway and at remote skiways. The operation and maintenance associated with these additional power units will be within the operational procedures currently applied within the AAT.

Water supply will be adequate to cater for the expected numbers associated with the accommodation or transiting of passengers. If an expansion to current water storage infrastructure is required, it will undergo an environmental assessment.

7.2.3 Accommodation

Initially, no additional permanent accommodation will be required at any of the stations to support the proposed construction or operational activity. On the basis of projected station population levels, there may be peak times when existing accommodation facilities are exceeded necessitating accommodation of transit personnel delayed by bad weather. If existing accommodation is found to be inadequate for safe and effective operations, alternatives will be investigated and any works undertaken will be subject to environmental assessment.

Sufficient emergency accommodation will be provided at each station, the Davis Plateau skiway, and at the Casey runway. Impacts associated with this style of accommodation will be dealt with through current operational procedures and outlined in the EMP.

7.2.4 Station operations

The proposed construction and operational activity is not expected to adversely affect any existing activities at stations or field locations. It is envisaged that current facilities at the stations will be adequate to cater for the changed usage patterns. Any additional facilities will require their own environment assessment to be undertaken.

The Antarctic Division Chief Engineer does not consider that the proposed construction or operational activity would have any adverse effect on existing engineering support facilities including sewage, water supply, power supply, fire protection and communications.

7.2.5 Waste management

Waste will be managed to minimise impact upon the Antarctic environment and to minimise interference with the natural values of Antarctica, with scientific research and with other uses.

In recognition of probable waste impacts Annex III to the Protocol on Environmental Protection to the Antarctic Treaty requires waste storage, disposal and removal as well as recycling and source reduction to be essential considerations in the planning and conduct of activities in the Antarctic Treaty area.

The management of waste is also regulated by the *Antarctic Treaty (Environmental Protection) Act* and the *Antarctic Treaty (Environment Protection) (Waste Management) Regulations 1994*. In addition, wastes will be managed in accordance with the AAD environmental policy and code of conduct (see http://www.aad.gov.au/environment/ConductCode/default.asp).

Waste produced by any additional personnel based at or transiting through the stations will be treated by the existing station facilities. However, as the expected station population numbers would be the same as current levels there should be no additional net demand on the waste treatment facilities. All wastes produced at remote landing sites will be returned to Davis, Casey or Mawson for processing or return to Australia in accordance with established waste disposal practices. If modifications to the Casey waste treatment plant are necessary as a result of waste generated at the Casey runway, AAD will investigate methods to modify existing infrastructure to meet the demand.

7.2.6 Quarantine issues

The ships and aircraft which support modern expeditions provide a path for organisms to enter the Antarctic environment, for example in food products, or in luggage or cargo. There is a risk that introduced organisms may spread and become established within Antarctica more easily as a result of air transport.

An air transport system has the potential to quickly disperse introduced organisms to Antarctica and between stations. Organisms can be introduced in the clothing, shoes and gear of expeditioners and on aircraft and cargo or equipment, and in the past have been found in clothing (Bergstrom D. pers comm.). AAD has a number of effective quarantine measures currently in place to prevent the transfer of foreign organisms to Antarctica.

The intra-continental component of the system will allow expeditioners and equipment to move quickly between stations. In the absence of effective internal quarantine procedures, this may permit the translocation of organisms between stations or field locations.

Existing quarantine measures are discussed in section 8.5. These measures will be reviewed and modified to take into account additional risks identified with the introduction of the air transport system.

7.2.7 Effect on Antarctic science/research

The introduction of an air transport system to Antarctica is expected to change research in the Australian Antarctic program. The system will provide the ability for scientists to quickly get to and from Antarctica without the need for long sea voyages.

The intra-continental component will also enable aerial research to be undertaken and provide easier access to remote field locations.

All research programs that operate on the Antarctic continent are expected to benefit from the advantages of short transit times to and from Antarctica. Australia is the last of the major Antarctic nations not to utilise the benefits of air transportation and, correspondingly, has fallen behind in many areas of research. The Antarctic Science Advisory Committee (the committee that advises the Government on the future directions for Australia's Antarctic scientific research program) has recently endorsed the proposed air transport system and stated that it will do more than any other initiative to open the scientific research program to a wider number of scientists, including many from overseas. Increased collaboration, both nationally and internationally, is a cornerstone of the Government's National Research Priorities.

Intra-continental air travel will provide an opportunity for the conduct of aerial research, using geophysical or other sensors attached to aircraft. The AAT is characterised by a paucity of knowledge about gravity and magnetism – basic scientific information that other nations active in the Antarctic have been collecting for many years. The widespread use of ice-penetrating radar will greatly advantage research leading to better predictions about the balance of the ice mass on the Antarctic plateau. Use of intra-continental aircraft for the collection of such data is planned and would be subject to a separate environmental assessment.

Intra-continental air transport will make the support of deep-field projects possible and economically justifiable, and provide the opportunity for research to be conducted in hitherto inaccessible locations. Researchers require access to the western part of the AAT for biological and geoscience research. Such research is currently not possible. Inland studies, such as in the southern Prince Charles Mountains – an area of great scientific relevance – will be able to be conducted as a matter of routine, and at low cost.

The science program will benefit from the introduction of air transport in another, very valuable manner. The opportunity arises for failed equipment, or replacement parts for items of scientific equipment, to be transported from and to Antarctica within the season of failure. This will enable planned studies to continue with minimal disruption and with far higher efficiency that is possible at present.

7.2.8 Cumulative impacts

Components of the activity that may have a cumulative impact include:

- fuel consumption, emissions and surface contamination from emissions;
- surface contamination from accidental spills;
- impacts associated with treatment and disposal of waste from remote field locations;
- impacts on birdlife, other fauna, and flora
- impacts on wilderness and aesthetic values of activity in the area.

Areas susceptible to cumulative impacts will be around stations and where regular aircraft operations are undertaken, particularly refuelling. Other cumulative impacts will be associated with frequency of flights and disturbance of wildlife through noise or visual disturbance. The exact consequences of the cumulative impacts of the air transport system are unknown at this stage. The proposed monitoring program and other additional research will assist in future years in determining the significance of cumulative impacts.

7.3 Environmental impact of aircraft crashes

Safety considerations in the new air transport system have been paramount in the planning and design of the operation. Historically, the majority of Antarctic aviation accidents occur while the aircraft is grounded. Extreme winds and blizzard conditions are usually the cause of aircraft damage. As discussed in Chapter 3, C212 aircraft will either overnight at Casey station, Casey runway or Davis skiway. No hangers are proposed at this stage. Overnight locations have been selected for their weather conditions. Extreme winds at Casey and Davis in summer are uncommon. The aircraft will be anchored to the ice or snow in the event of high winds. The Falcon 900EX will overnight at Hobart Airport.

No air transport system is entirely safe. Human or mechanical error or unforeseen environmental hazards, such as extreme weather conditions can play a part in an aircraft incident. Despite there being a very low probability of a serious incident, the associated environmental impacts have been identified. These would include:

- localised zone of environmental impacts
- localised and intensive spill of fuel and other liquid contaminants
- potential for localised physical damage to wildlife and landscape
- atmospheric emissions through the burning of fuel and other products

8 MITIGATION MEASURES

All works undertaken will follow the environmental protection policies and procedures required under the *Antarctic Treaty (Environment Protection) Act 1980* and Regulations and the requirements set out in specific manuals/guidelines including:

- Environmental Requirements for Aircraft Operations (2003)
- A Waste Management Strategy for Australia's Antarctic Stations (1994)
- Air Operations Manual and Fuel Management Plan (in preparation)
- The AAD Operations manual
- Station Management Plans
- Emergency Response Plan

Table 16: Mitigation measures addressing impacts on key values summary

Key Value	Impact	Impact Level	Mitigation measures	Impact level after mitigation
Air quality	Exhaust emissions	L-M	8.3	L
Vegetation	Emissions	L	8.3 8.4	L
	Contaminants	L	8.4	L
Surface	Disturbance	L	8.2 8.3	L
Snow/ice quality	Contaminants	L-M	8.3 8.7	L-M
	Fuel spill	L-M	8.3 8.6	L-M
Birds/Seals	Disturbance	L-M	8.1 8.4	L-M
	Bird strike	L-M	8.4	L
Quarantine issues	Introduced organisms	L-M	8.2 8.5	L

See table 11A (page 73) Consequence/likelihood impacts table

8.1 General

- The Environmental Requirements for Aircraft Operations (2003) has been revised in preparation for the introduction of the new air transport system. Separation distances have been developed taking aircraft noise footprints into account in an attempt to minimise impacts on wildlife concentrations. A distance of 750m for both twin-engined fixed wing aircraft and single engined helicopters forms the basis of these new requirements. (Sub-section 7.1.3.2 explains the reasoning behind the 750m separation distance).

- All personnel involved in construction or operational activities will be educated on environmental protection practices and requirements.

8.2 Construction

- Pre-existing facilities and previously used fuel storage sites will be used wherever possible to minimise the potential for creating additional long-term impacts.
- To the maximum extent possible, all construction vehicles will keep to established roads and access routes.
- Construction equipment will be cleaned of dirt and other contaminants prior to being transported to and from Antarctica.
- Further investigation into the use of renewable energy sources for the construction camp will be undertaken.

8.3 Aircraft operations

- Aircraft engines and maintenance equipment will be maintained in good condition at all times to minimise emission levels.
- Protocols for assessing additional temporary or long term airfield sites will be developed to ensure minimal impact on the surrounding environment. Temporary runway/skiway markers will be adequately secured during use and removed when decommissioned.
- Only non-permanent buildings will be used in field locations.
- Contingency response plans for environmental incidents will include response to aircraft accidents and consequent environmental contamination.
- The management protocols for the Casey runway will ensure that all reasonable steps will be taken to minimise contamination. However, high use areas are likely to develop some degree of contamination. The surface will be treated by periodic removal of the contaminated snow surface followed by treatment in an oil/water separator at Casey station. Waste water will be treated in the waste treatment plant, while the remaining contaminants will be returned to Australia for safe disposal.
- Alternative energy sources will be investigated for the provision of power to field locations.
- Any surface liquid contaminant will be mopped up with absorbent pads followed by removal of contaminated snow.
- The pads will be placed in solid hazardous waste bins for RTA, and the dirty snow treated as above.
- Occasionally, there may be a need to remove contaminants from a large area. In this case, the affected area would be removed and processed through the oil/water separator at the nearest station.
- Wintering infrastructure will be properly secured to endure severe weather during the winter months

8.4 Protection of biota

- All requirements of the AT(EP) Act will be applied to the activity. These requirements include not using an aircraft in such a manner as to disturb a concentration of birds or seals unless a permit has been obtained for the proposed air operations. There is also a requirement that, with the exception of the establishment, supply or operation of a station, an environmental impact assessment must be undertaken for all proposed scientific and non-scientific programs (including those requiring aircraft support).
- Preferred flight paths have been or will be established for all regular landing sites to minimise disturbance to bird and seal breeding colonies and other sensitive areas (Appendix 3). Flight paths to and from each Antarctic station have been or will be designed to avoid overflights wildlife sites, areas of important flora, station water supplies and ASPAs. Flight operational protocols and requirements will be reviewed taking into account the results of the monitoring program on an annual basis, for the first five years of operation, and thereafter on a five yearly basis.
- As a minimum all flights will, unless specifically exempted (such as for safety or resupply of a station), be required to be conducted within the following limitations detailed in the Environmental Requirements for Aircraft Operations (Appendix 3):
    - Scientific or non-scientific flights are not to land or take off within a 750 metre horizontal separation, or overfly less than a 750 metre vertical separation, from concentrations of birds or seals.

  - Scientific or non-scientific flights are not to:

    ◊ operate a helicopter at an altitude lower than 3000 feet within a horizontal radius of 1000m, of a whale (or other cetacean) or

    ◊ operate a fixed wing aircraft at an altitude lower than 1000 feet with a horizontal radius of 300m, of a whale (or other cetacean) or

    ◊ approach cetaceans head on, or hover over a cetacean, at any altitude.

- Due to the sensitivity of the Southern giant petrel, overflights of known breeding areas will not be made.
- When wildlife is situated on a skiway prior to an aircraft arrival, ground staff will be required to move wildlife by approaching the species and gently encouraging them to relocate a safe distance from the skiway.
- All bird strikes will be reported to Environment Advisor, Operations Branch for consideration through the incident reporting system and/or as a State of the Environment indicator and, where relevant, mitigation measures develop according to the location and frequency of incidents.
- A monitoring program for biological and chemical impacts will be developed and maintained.
- Procedures for choosing alternative skiways at times of emergencies will be covered in the Air Operations Manual.
- If unacceptable wildlife disturbance is detected, the air transport system will be modified to reduce impacts.

8.5 Quarantine issues

8.5.1 Current quarantine measures

Quarantine procedures are an integral part of the AAD shipping operations. When travelling south, cargo and expeditioners are subject to quarantine controls to reduce the risk of alien introductions to Antarctic and subantarctic environments. Southbound AAD voyages are outside the application of AQIS (Commonwealth) administered legislation, however the AAD has established a Memorandum of Understanding (MOU) with Quarantine Tasmania to ensure that high quarantine standards are maintained to protect the Antarctic environment.

Current quarantine measures apply also to passengers and cargo leaving Antarctica for Australia or other destinations.

To assist in preventing foreign organisms entering Antarctica, expeditioners MUST:

- clean and disinfect all clothing, footwear, camera gear, tripods, bushwalking, camping gear and other equipment before departure;
- pack and seal personal gear in one go, rather than leaving containers open for insects and spiders over several days;
- not send plants, fruit and seeds by mail, and ensure that insects and plant material are not accidentally included in parcels.

Prior to all vessel departures Quarantine Officers make regular inspections of the wharf area, cargo facility, and shipping containers. This can involve the use of Quarantine detector dogs. The cargo facility is a Quarantine Approved Premise and the Macquarie Wharf 4 (M4) staff are accredited to maintain high quarantine standards.

Quarantine Tasmania officers and M4 staff conduct checks of all containers and cargo. All containers and machinery are washed down, cleaned and fumigated if necessary prior to despatch. Of particular concern is the accidental movement of insects, plant material, or animal material including feathers and soil on cargo.

On their return to Australia, AAD vessels are governed by both Commonwealth and State legislation, administered through AQIS and Quarantine Tasmania. When returning from Antarctica a number of quarantine issues need to be considered. All items, cargo and personal effects, imported into Australia must be clean and free of soil and other contaminants that could carry pests and disease. Declarations to Customs and Quarantine must be completed for personal effects, and all cabin baggage is subject to examination, or may even be x-rayed, upon arrival.

Most of the current quarantine measures will be applied to the air transport system. However, some aircraft operation specific measures will need to be developed.

8.5.2 Air transport quarantine measures

- Quarantine measures will be developed to prevent the transfer of organisms, including a quarantine procedure that will be implemented at Hobart Airport and within the aircraft to reduce the opportunity for foreign organisms to enter Antarctica. Expeditioners will continue to be trained to ensure that they have cleaned boots, clothing and gear of soils and seeds. A risk assessment will be undertaken and high risk passengers will require a more thorough screening.
- Aircraft and other equipment will be cleaned of dirt and other contaminants prior to being transported to Antarctica. Pre-departure training will address this issue.
- Dependent on the outcome of a risk assessment, preventative measures may be developed to minimise the opportunity for organism transfer between stations and field locations to protect the integrity of localized Antarctic biodiversity processes.

8.6 Fuel management

- A fuel management plan for the transport, transfer and storage of fuel will be developed ensuring that all necessary environmental measures are undertaken to reduce/minimize and where possible eliminate impacts on the environment;
- A fuel and contaminant spill contingency plan (including specification and provision of equipment) (currently in draft) will be developed to promptly respond to fuel/contaminant spills;
- Fuel handling protocols will be developed by the service provider, SkyTraders in accordance with Australian standards and with Civil Aviation Safety Authority requirements.
- In cases where fuel is stored in other than 205 litre drums, secondary containment will be provided in order to prevent a large spill incident. Risks associated with larger fuel storage options will be addressed through the establishment of the fuel handling system, with additional mitigation measures incorporated into the Fuel Management Plan. Expired aviation fuel will be re-mixed and used in diesel fuelled vehicles based at the stations.
- Refueling will utilise equipment and procedures designed to minimise the risk of fuel loss to the environment.
- All sites where refueling will occur will be fitted with spills kits and correct procedures as described in the fuel management plan will be followed. Personnel training will cover the environmental aspects of fuel handling and storage. Refueling will be undertaken in approximately the same location each time in order to minimise the area of snow/ice that could become contaminated. All spills will be reported as an incident though the AAD incident reporting system;
- The AAD is responsible for the removal of empty fuel drums from all sites (either to a station or directly to Australia if retrieval is by ship).
- Where possible, fuel storage or handling will not be within a lake or stream catchments.

- Where fuel testing is undertaken in remote/field locations, an empty drum will be provided to collect fuel samples taken. This fuel will be returned to a station or to Australia for use or safe disposal.
- Care will be taken when opening fuel drums to prevent any accidental spillage.

8.7 Waste management

AAD waste management policies and regulations dictate that wastes from airfield support camps and general air transport operations will be returned to a station for treatment, or returned to continental Australia. Human waste and grey water will be treated at the nearby station using current practices. Food scraps and perishable wastes may be incinerated on station or returned to a waste disposal facility outside Antarctica. Non-perishable garbage, other liquid waste, and general waste materials will be returned to a waste disposal facility outside Antarctica for landfill or other appropriate disposal.

- If any new waste types or handling processes are identified, additional waste management protocols will be developed in accordance with the requirements of the Madrid Protocol, Australian law and AAD policies and procedures.
- Waste produced by any additional personnel based at or transiting through the stations will be treated by the existing station facilities.
- All wastes produced at remote landing sites, including the Casey runway, will be returned to a nearby station for processing or return to Australia in accordance with established waste disposal practices.
- Human waste from aircraft toilets will be treated within station facilities or returned to Australia for treatment.

8.8 Environmental Management Plan

An Environmental Management Plan (EMP) will be prepared for the construction and operational phase of the project to ensure all personnel are aware of their environmental responsibilities specifically in relation to air transport operations. The document will be provided to all relevant personnel and used for induction processes, as well as an environmental management tool for AAD. The EMP will address:

1. Roles and responsibilities in environmental management - listing individuals, contact details and their responsibilities.
2. Statutory requirements - summary of statutory requirements for the operation and relevant approval conditions.
3. Project scope – establishing the limits and scope of the project, particularly to show items of environmental sensitivity (eg ASPAs).
4. Staff induction – documenting how personnel are to be briefed about environmental management and recording who has and who is required to do the briefing.
5. Environmental mitigation strategies (such as waste management, flight guidelines/requirements, fuel management) which would outline in detail what is to happen specifically on the site.

6. Environmental incident process – establishing guidelines if things go wrong.
7. Reporting and monitoring - what environmental monitoring and reporting is to happen on the site and who is to undertake it.

8.9 EPBC Act specified manner requirements

As discussed in Chapter 2, following the EPBC Act referral to the Department of the Environment and Heritage, the Minister determined that the action was deemed to be a non-controlled action on the proviso that it is undertaken in a specified manner. Table 17 outlines how AAD is meeting the specified manner requirements:

Table 17: Addressing EPBC specified manner requirements

EPBC Specified Manner	AAD Action
• Operational flight paths and flight guidelines will be developed and implemented to minimize the potential for wildlife disturbance or impacts on sensitive marine and Antarctic environments.	• Environmental Requirements for Aircraft Operations have been upgraded to incorporate twin-engined fixed wing aircraft for the intra-continental flights. Noise modelling and past research assisted in their development.
• Modelling of noise footprints for aircraft, to aid in assessing noise related impacts and planning of operations, will be undertaken to assist in development and implementation of flight operational protocols and guidelines to minimize disturbance to fauna.	• Noise modelling has been undertaken and has confirmed that 750m will be adequate until further research is presented. Environmental Requirements for Aircraft Operations will be modified to reflect the recommendations made in the Noise Modelling report.
• The requirements for interacting with cetaceans within the Australian Whale Sanctuary (Part 8, Division 8.1, Clause 8.05 of the *Environment Protection and Biodiversity Conservation Regulations 2000*) will be incorporated into flight operational protocols and guidelines, as appropriate.	• Environmental Requirements for Aircraft Operations includes the EPBC Regulation requirements for interacting with cetaceans.

• Monitoring programs to verify impact predictions, identify unexpected impacts, and to ensure impacts remain within any required limits will be developed and implemented.	• Baseline studies have been undertaken and a further two years of preparation is scheduled in order to develop a monitoring program that will verify impact predictions and identify unexpected impacts. Data collected will also assist with ensuring that impacts remain within required limits.
• The monitoring program will also specifically address the potential for noise disturbance to the Southern giant petrel and the Wilson's storm petrel and any measures needed to avoid impacts.	• Some baseline data has been collected. Further data collection is scheduled for next season. From this a monitoring program will be developed.
• The flight operational protocols and guidelines will be reviewed and updated against the results of the monitoring programs on an annual basis, for the first five years of operation, and thereafter on a five yearly basis.	• Environmental Requirements for Aircraft Operations and operational protocols will be reviewed and updated against the results of the monitoring programs and other information on an annual basis, for the first five years of operation, and thereafter on a five yearly basis.
• Flight operational protocols and guidelines, and monitoring programs relevant to identification and minimization of environmental impacts, will be developed in consultation with relevant expert agencies, including Environment Australia.	• Environmental Requirements for Aircraft Operations and operational protocols and monitoring programs relevant to identification and minimization of environmental impacts, have been and will be developed in consultation with relevant expert agencies, including the Department of the Environment and Heritage.

9 MONITORING OF IMPACTS

9.1 General Introduction

As operators of the air transport system, AAD is required by both the EPBC and AT(EP) Acts to conduct environmental monitoring. AAD has developed a plan of action that meets the requirements of the project and takes advantage of available expert personnel and logistic support. Importantly, the 2002-03 season established an environmental baseline, which will provide a reference point for future evaluation.

The following tasks were undertaken during the 2002/03 season:

1. Desktop study and documentation of the impact assessment process
2. Risk-analysis and reporting of the potential disturbance to wildlife by the proposed air transport system. Specifically, the risks to Southern giant petrels (*Macronectes giganteus*) and Wilson's storm petrels (*Oceanites oceanicus*) were examined.
3. Quantification archival material relating to Adélie and Emperor penguin populations in the Windmill Islands to establish baselines on regional distribution and abundance.
4. Establishment and documentation of a monitoring system to assess the cumulative impacts of the air transport system using Adélie penguin colonies at Casey.
5. Establishment of a baseline reference collection for potentially impacted media (moss, water, ice, snow).
6. Analysis of key parameters in potentially impacted media (ongoing)

The air transport system monitoring program centred on the Windmill Islands as an example of a future key high use area. Davis station and the Vestfold Hills and to a lesser extent Mawson will also be affected by the air transport system, however given the amount of historic data on wildlife numbers in the Windmill Islands, Casey station region was chosen to be more appropriate.

Biological data collected from the monitoring program will be entered into AAD's Antarctic Data Centre database for future reference. All data collected will be made available to assist with other scientific programs.

9.2 Impact assessment monitoring

9.2.1 Biological monitoring

The biological component of the environmental monitoring for the air transport system will take advantage of existing long term data sets and initiate the collection of novel, complementary population data to maximise the potential for detecting direct, indirect or cumulative impacts arising from the project.

Several existing long term data sets are available from a number of species in the Windmill Islands region, in some cases extending for more than 40 years. These long term data sets, and the analyses that have been undertaken to date, establish baselines on the distribution, abundance and trends in breeding populations of seabirds throughout the Windmill Islands. Two of these data sets (Adélie penguins and Southern giant petrels) are currently components of the AAD's State of the Environment Reporting system (see http://www-aadc.aad.gov.au/soe/ for further details). The Adélie penguin population data set commenced in 1959/60 and in 1955/56 for Southern giant petrels.

The collection of novel seabird population data will further enhance the potential to detect impacts arising from the air transport project. The approach proposed will involve collecting annual data from a suite of seabird species that breed at several localities within the Windmill Islands. By comparing trends in population size and rates of breeding success among localities close to Casey station with more distant breeding sites, and comparing future trends in population size and breeding success against established trends, this integrated approach aims to detect any impacts from the air transport system itself or from the expected increased human presence at Casey.

The risk analysis of the proposed air transport system identifies three likely sources of potential impact to seabirds in the Windmill Islands (see Section 9.3). These are disturbance from noise and visual presence of operations, bird strikes and disturbance at breeding colonies from human visitation. Disturbance at breeding colonies is likely to have the greatest potential for impacting on wildlife in the Windmill Islands. The biological monitoring component will thus focus on this potential source of disturbance and make full use of existing long term data sets as baselines (see Section 9.5).

9.2.2 Chemical monitoring

It was decided that several pollutants should be monitored for changes associated with the introduction of the air transport system, and that a whole system approach should be considered. Casey was chosen as the main monitoring site as there are a number of scientific studies relating to global pollution being conducted in the Casey region, and the bulk of aircraft activity and associated services were to be concentrated in and around the Casey site.

The highest priority for monitoring was to establish a pre-disturbance baseline for a range of media. The monitoring work was to include water, moss, ice, and snow. Analysis focused on Pb isotopes, heavy metals, N oxides and organics, as these have been currently studied for scientific purposes in the region. Another goal of the baseline monitoring was to provide an archive of material in case future generations wanted access to pre-disturbance material.

9.3 Risk analysis of the potential impact to wildlife in the Windmill Islands

9.3.1 Overview

There are a number of potential impacts to wildlife in the Windmill Islands arising from the air transport project. A complete list of all impacts identified for the project is tabulated in Appendix 5. This section examines the potential impacts to the wildlife of the Windmill Islands, the site of the inter-continental link with Australia and intra-continental link with Davis.

The fauna of the Windmill Islands comprises of nine breeding species of seabirds and two breeding species of seals. The current estimated breeding populations are listed in Table 18. A detailed inventory of the distribution of penguin colonies is listed in Section 9.5.

Table 18 Estimated regional breeding populations of seabirds (pairs) and seals (pups) in the Windmill Islands. *Dates are given of the most recent population estimates where appropriate.*

Species	Estimate	Year	Source(s)
Adélie penguin	105,000 pairs	1991	Woehler et al. (1991), EJ Woehler unpubl. data
Emperor penguin	2000 pairs	2000	Mellick & Bremmers (1995), EJ Woehler unpubl. data
Southern giant petrel	248 pairs	2001	Woehler et al. (2003)
Antarctic petrel	300 pairs		van Franeker et al. (1990)
Snow petrel*	2000 pairs		van Franeker et al. (1990)
Cape petrel	2000 pairs		Orton (1963), van Franeker et al. (1990)
Southern fulmar	5500 pairs		van Franeker et al. (1990)
Wilson's storm petrel	2000 pairs		van Franeker et al. (1990)
South polar skua**	100 pairs		
Weddell seal	100 to150 pups		Murray & Luders (1990)
Southern elephant seal***			McMahon & Campbell (2000)

** Preliminary analyses of survey data collected in 2001/02 & 2002/03 indicate the breeding population of skuas may exceed 12,000 pairs (Olivier et al. submitted ms).*

*** Results of surveys in 2001/02 and 2002/03 suggest the total breeding population of skuas is likely to exceed 200 pairs (E Woehler, F Olivier and D Lee, unpubl. data)*

**** Southern Elephant Seals occasionally pup in the Windmill Islands but numbers are very low (4 pups reported in period 1972 – 1981 and in 1997)*

Appendix 5 lists a number of potential impacts to the wildlife of the AAT arising from the proposed air transport project. This section will focus on the Windmill Islands, deal with the impacts relevant to the wildlife of the region, and provide additional assessment of the risks to Adélie penguins, Southern giant petrels, Snow petrels, Wilson's storm petrels and South polar skuas.

The potential risks to wildlife in the Windmill Islands are a subset of risks identified elsewhere (see Appendix 5). The three impacts likely to have the greatest potential for impacting wildlife are disturbance from noise and visual presence of operations, bird strikes and disturbance at breeding colonies arising from increased human visitation. Of these three, both disturbance from noise and visual presence and bird strikes are unlikely to occur, with a low to very low frequency of occurrence.

9.3.2 Noise and visual impacts

There is a potential for disturbance to the wildlife in the Windmill Islands from noise originating from the operation of the proposed air transport link. There are limited data available on the hearing abilities of Antarctic seabirds, and very few studies have investigated the reaction(s) of seabirds to aircraft operations. A study by Giese and Riddle (1999) investigated the response by Emperor penguin adults and chicks to overflights by helicopters, and found behavioural responses to the overflights of twin-engine helicopters (Figure 8.3.1). Noise levels were measured using a Cesva SC-2 sound level meter mounted on a tripod approximately 50m to the side of the aircraft flight line. The meter calculated a frequency weighting incorporating signal frequency and amplitude [db(A)]. Significant changes in the behaviours of the penguin chicks in response to the overflights were reported (Giese & Riddle 1999).

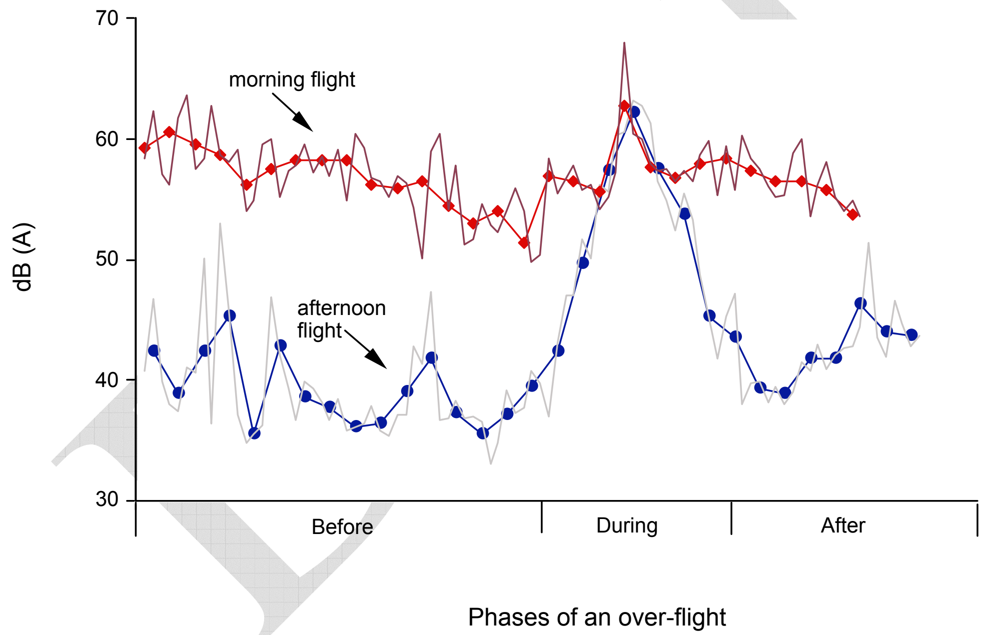


Figure 1 - Results from a study of the impacts of helicopter overflights on Emperor penguin chicks that recorded noise levels [db(A)] from helicopter overflights with 10kn katabatic wind (morning data) and in the absence of wind (afternoon flight). The helicopter was a Sikorsky S76, twin engine aircraft that flew at 1000m altitude at 60kn air speed. The heavy lines are running means (3 * 5–sec intervals). From Giese & Riddle (1999), used with permission of the authors.

Preliminary investigations have been conducted on the response by seals to human activities (M Giese pers. comm.) and are currently the subject of a PhD. Data from these studies could contribute to the annual revision of the Environmental Requirements for Aircraft Operations.

There are no data available on the impacts or responses by birds or seals to visual stimuli that can be used to assess the potential impact of aircraft operations to wildlife in the Windmill Islands.

9.3.3 Bird strikes

The risks of bird strikes with any aspect of the air transport project are low (Appendix 5).

A database for all bird strike incidents arising from AAD station and ship operations was established in 2002 to assess the extent, species involved, and frequency of incidents, and to determine if specific factors (locations, sites, buildings, weather conditions, species) were significant. At present there are approximately 100 records in the database, but this is insufficient to undertake any detailed analyses. Contemporary records for bird strikes are currently being entered into the database managed by AAD.

9.3.4 Human presence

The introduction of air transport system may lead to increased human visitation to seabird colonies in the Casey region, leading to a potential increase in human – seabird interactions and associated disturbance. Given that there are breeding colonies of Adélie penguins and nesting sites of Snow petrels, Wilson's storm petrels and South polar skuas within Casey station limits, there is a potential for greater levels of visitation to these sites arising from higher turn-over of personnel at Casey.

9.3.4.1 Adélie penguin - There is a large Adélie penguin population on Shirley Island, <1km from Casey and within the Casey station recreational area. The breeding population is approximately 10,000 pairs (2002/03, EJ Woehler unpubl. data). In contrast to all other Adélie penguin populations in the Windmill Islands, the breeding population on Shirley Island has not increased since 1968, the population has a lower breeding success than nearby monitored populations in ASPA No.136, and a westward shift away from areas used by station and ship visitors in the breeding population on the island has occurred (Woehler et al. 1991, Woehler et al. 1994, EJ Woehler unpubl. data). Shirley Island is a popular destination for station and ship-based personnel to visit penguin colonies, and a higher turn-over of personnel Casey resulting from the air transport system may see an increase in human visitation to Shirley Island. The impact of this likely increase cannot be predicted, but is likely to result in a greater level of disturbance to breeding penguins. On-going monitoring of the breeding penguin population will be used to assess the population trends and identify potential impacts associated with increased human presence at Casey.

9.3.4.2 Snow petrel - There is a breeding colony of approximately 75 nests on Reeve Hill, within Casey station limits. Most visitors to Casey visit Reeve Hill for photography of the station and Newcomb Bay, the cross on Reeve Hill and the resident Snow petrels. The breeding population was originally mapped in 1968 and has been the subject of irregular monitoring during the 1980s and 1990s. A detailed study of the available historical data and of contemporary data commenced in 2001/02 and is the subject for a PhD study currently underway under the supervision of EJ Woehler. At present, there are no data to indicate that the past and current levels of visitation to Reeve Hill have impacted on breeding success or population trends of this snow petrel population. Construction activities associated with the establishment of the new Casey station would have removed suitable habitat for Snow petrels. An increase in human visitation to Reeve Hill may result in an impact on the snow petrel population, and the results of the PhD would contribute to the required analyses and assessments.

There are approximately another 30 pairs of Snow petrels distributed throughout the Casey station and recreational areas (EJ Woehler & F Olivier unpubl. data). Some of these nests are in close proximity to station infrastructure and it appears that the birds have habituated to the presence and operations of the station. It is unknown what potential impact an increase in the human population or station operations may have on these breeding petrels.

9.3.4.3 Southern giant petrel - The largest breeding population of Southern giant petrels in continental Antarctica is present on the Frazier Islands, approximately 16nm NW of Casey. The population was discovered in the mid 1950s (250 pairs), and has decreased following its discovery. Guidelines on the types of activities, frequency of visitation and approach distances were implemented in the early 1980s, and the population has subsequently recovered (248 pairs in 2001/02), Woehler et al. (2003).

In recognition of the conservation status of this species (Vulnerable under IUCN criteria), the Frazier Islands were nominated as an ASPA in 2003. The management plan for the Frazier Islands restricts visits to one census every three to five years, with close approaches to colonies and nesting birds prohibited, so the potential impact of human disturbance to this population is very low.

9.3.4.4 Wilson's storm petrel - Wilson's storm petrels nest throughout the Casey station and recreational areas. There is no accurate estimate of the regional breeding population, but it is likely to be in the 1000s; there are likely to be several hundred breeding pairs within the station and recreational areas. Many of these nests are in close proximity to station infrastructure (roads, buildings and service trays), and it appears that the birds have habituated to the presence and operations of the station. At present, there are no data to indicate that the past and current levels of human activities (excluding construction activities that would have removed suitable habitat) have impacted on the breeding success or population trends of this population. It is unknown what potential impact a higher turn-over of personnel may have on these breeding petrels.

9.3.4.5 South polar skua - South polar skuas nest on Shirley Island, within the Casey recreational area. There were 13 nests present in 2002/03 (EJ Woehler unpubl. data), a population similar to that reported from 1968. Given the lack of data from the intervening period, little can be inferred from these two data points 35 years apart; further, there are no data available on breeding success. At present, there are no data to indicate that the past and current levels of human activities on Shirley Island have impacted on the breeding success or population trends of this population. It is unknown what potential impact an increase in the human population or station operations may have on these breeding skuas.

9.4 Archival material relating to penguin populations in the Windmill Islands

There are two species of penguins breeding in the Windmill Islands: Adélie *Pygoscelis adeliae* and Emperor penguins *Aptenodytes forsteri*.

9.4.1 Adélie penguins

The current estimated total population of Adélie penguins in the Windmill Islands is approximately 105,000 breeding pairs (as of 1991). There are no more recent estimates currently available.

9.4.1.1 Overview – Regional surveys - The distribution of Adélie penguins in the Windmill Islands has been studied since the earliest United States Antarctic Research Program (USARP) and ANARE expeditions. The most complete surveys and census were conducted in 1989/90 when all breeding localities were visited in the one season. This survey clearly showed the total breeding population had increased by approximately three-fold since the late 1950s from approximately 30,000 pairs to approximately 90,000 pairs (Woehler et al. 1991, Woehler 1993). An inventory of all population data to 1991 is shown in Table 18. Appendix 8.1 summarises the estimates rates of increase in the breeding populations at each of the 14 nesting localities.

9.4.1.2 Ground counts and colony visits – population monitoring - In addition to regional surveys, the breeding populations of Adélie penguins have been monitored at Whitney Pt (ASPA No 136) since 1989/90, and on Shirley Island, within Casey station limits, since 1989/90. Detailed historical census data are available for Whitney Pt since 1959/60, and for Shirley Island since 1968/69. Data for these two sites to 1990 have been published (Woehler et al. 1991) and differences in population trends (500%+ increase at Whitney Pt over 30 years compared to no change at Shirley Island) have been interpreted as evidence of human disturbance from ship and station visitors to the breeding population on Shirley Island since 1968 (Woehler et al. 1994).

9.4.1.3 Aerial photographs - Two sets of aerial photographs of Adélie penguin colonies are known for the Windmill Islands. These were taken in December 1990 and December 1994. Counts have been made from the 1990 images, but not all colonies on all islands were photographed, so the counts are incomplete. Where entire islands were photographed in 1990, the census data clearly show that the breeding population of Adélie penguins in the Windmill Islands continues to increase.

The 1994 photographs have been returned to the Division following their use for mapping the Windmill Islands. It is believed that all Adélie penguin colonies except those on Odbert Island (ASPA No.103) were photographed at low altitude (750m) and that counts will be possible from these images once scanned. These images have not yet been used to collect census data, and it is intended that this will be done during 2003/04.

In addition to the 1990 and 1994 images, there are several series of aerial photographs for Casey and the immediate surrounds that include some of the penguin colonies at Whitney Pt and on Shirley Island. Typically however, colonies are not completely photographed or only colonies adjacent to coasts were photographed. Many of these images are of little use for population surveys. Aerial photographs with incomplete coverage of Shirley Island are known from the mid 1980s, and some early oblique images of most colonies are known from the 1970s. Where counts have been made from these images, these data have been tabulated (Appendix 8.2), otherwise the images do not allow accurate counts to be made.

Some late season (February) low-altitude (750m) aerial photography of Whitney Pt and of Shirley Island was made in 2002/03. These images will allow the accurate mapping of the extent of Adélie penguin colonies, but will not provide any census data, as the colonies were empty following the end of the 2002/03 breeding season. The intention is to undertake a complete aerial photographic survey of all Adélie penguin colonies in the Windmill Islands in 2003/04. All islands and mainland breeding localities listed in Table 18 will be overflown at 750m to allow high-resolution photography to be undertaken. Contemporary census data will be obtained from these images.

9.4.2 Emperor penguins

There is only one known Emperor penguin colony in the Windmill Islands region. The colony is located on the sea ice over Peterson Bank (a sub-sea feature), approximately 40km NNW of Casey. The colony was discovered on 3 November 1994 at 65° 56'S 110° 12'E (Mellick & Bremmers 1995). At the time of the brief visit, there were approximately 2000 chicks present in a single large crèche. The nearest Emperor penguin colonies are located at Bowman I (1500 pairs) and at Dumont d'Urville (3000 pairs), Woehler (1993).

There have been no further landings or known visits to this colony. The colony was briefly overflown at 750m in October 2001, with numerous 35mm images taken at near-vertical perspectives. The October 2001 images were taken specifically to facilitate a more accurate estimate of the breeding population of this colony. These images have not yet been used to collect census data, and it is intended that this will be done during 2003/04.

9.5 Monitoring system to assess the cumulative impacts at Casey

A preliminary assessment of the potential cumulative impacts of the air transport project will make use of existing census data and ongoing monitoring of Adélie penguins. Adélie penguin breeding populations on two localities close to Casey have been studied for more than 30 years and provide valuable baseline data on population trends and impacts of human activities at Casey before the commencement of air transport operations.

The breeding population at Whitney Pt (ASPA No.136) was first counted and mapped in 1958/59. At the time there were 1100 pairs in 14 colonies (Penney 1968). Irregular counts of the total breeding population were conducted between the mid 1960s and the late 1980s (Martin et al. 1990). Annual counts of breeding pairs commenced in 1989/90 and have been conducted each season since then (EJ Woehler unpubl. data). Additional data on breeding success (chicks per breeding pair) have been collected in most seasons, although some data gaps exist due to logistical constraints on survey personnel. The population has increased to more than 7000 breeding pairs in more than 40 colonies in 2002/03 (EJ Woehler unpubl. data).

The breeding population on Shirley Island, just offshore from Casey and within Casey recreational area, was first counted and mapped in 1968/69 when there were 7300 pairs in 45 colonies (Woehler et al. 1991). Irregular counts of the breeding population were conducted between the early 1970s and the late 1980s. Annual counts of breeding pairs commenced in 1989/90 and have been conducted each season since then (EJ Woehler unpubl. data). Additional data on breeding success (chicks per breeding pair) have been collected in most seasons, although some data gaps exist due to logistical constraints on survey personnel. The population has increased to approximately 10000 breeding pairs in more than 50 colonies in 2002/03 (EJ Woehler unpubl. data).

All Adélie penguin breeding populations in the Windmill Islands, with the exception of Shirley Island, have increased substantially since the 1960s (Woehler et al. 1991, Woehler et al. 1994, Tables 8.5.1 & 8.5.2). The regional population increased from approximately 30,000 pairs in the early 1960s to more than 90,000 pairs in 1989/90, and has since increased to approximately 105,000 pairs by the mid 1990s (EJ Woehler unpubl. data).

The trend of the breeding population of Adélie penguins on Shirley Island contrasts with this regional increase. The breeding population has increased only slightly (Figure 8.6.1) but the increase is not significantly different from zero – implying a constant population. Further, the breeding success (chicks fledged per pair per year) at Shirley Island is 20% lower than at Whitney Point (Fig 8.6.2).

The breeding population on Shirley Island has changed its relative distribution. Colonies at the eastern end of the island (closest to Casey) have decreased by 33% from more than 1700 pairs in 1968/69 to fewer than 900 pairs in 1999/00, while the colonies at the western end of the island have increased by 50% from approximately 5000 pairs in 1968/69 to 7500 pairs in 1999/00. In 1968/69, 65% of the total population on Shirley I was in the western colonies; by 1999/00 the proportion had increased to 80%. The eastern end of Shirley Island attracts the highest numbers of station and ship-based visitors, as it is closest to Casey station. Human visitation occurs each summer until the sea-ice breakout sometime in late December or early January.

The results obtained over the past 30+ years are consistent with the hypothesis that human disturbance is responsible for some or all of the observed population trends at Shirley Island. Originally proposed in 1994 (Woehler et al. 1994), the results obtained from annual surveys at both localities in the last decade continue to support the proposition that human disturbance is involved in the observed disparity between Whitney Point (ASPA 136) and Shirley Island, just 3km from Whitney Point.

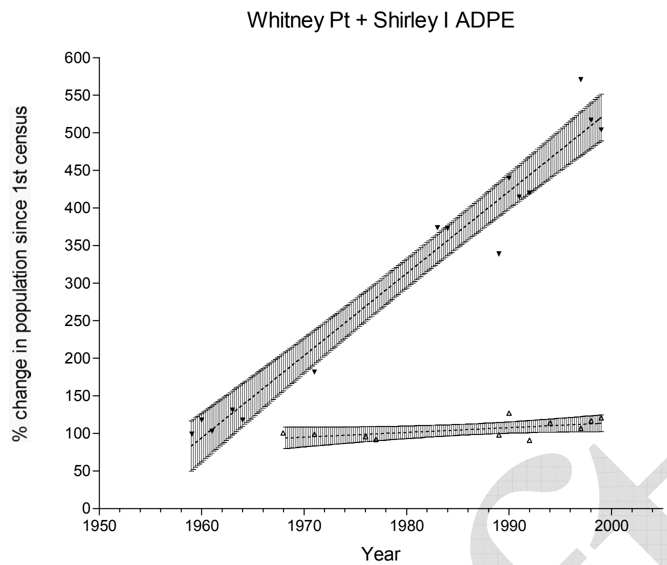


Figure 2 - Trends in Adélie penguin breeding populations at Whitney Pt (upper line) and Shirley Island (lower line). Population data have been converted to percentages relative to initial surveys (1968/69 for Shirley Island, 1958/59 for Whitney Point). The two trends are significantly different from each other.

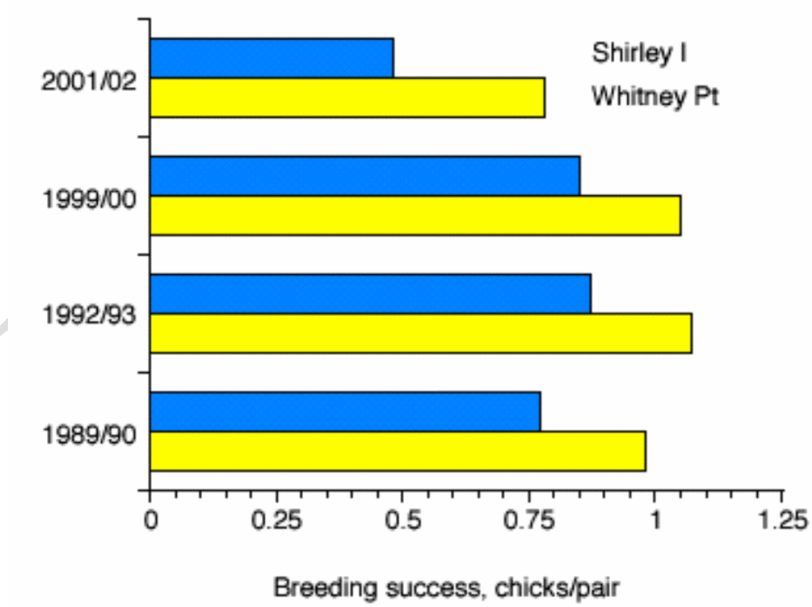


Figure 3 - Breeding success (chicks/pair) for Adélie penguins at Shirley Island (upper bars) and Whitney Point (lower bars). The difference is approximately 20% per annum.

An increased human presence at Casey resulting from the air transport project is likely to indirectly be manifested in increased human visitation to seabird colonies in the Casey region, and in particular to Shirley Island as this is the sole locality within Casey Station limits with Adélie penguins. The impact(s) of this likely increase cannot be assessed, but it is reasonable to predict a level of disturbance to breeding penguins equal to or greater than currently present.

To assess the potential cumulative impacts of the air transport project, the data obtained by the annual monitoring of the breeding penguin population will be used to assess the population trends and identify potential impacts associated with increased human presence at Casey. Any changes from the long-term trends previously identified (for example, a further decrease in breeding success of penguins on Shirley Island relative to Whitney Point) could be interpreted as indications of cumulative impact.

In addition to the collection of ongoing monitoring data on breeding populations and breeding success in Adélie penguins, additional data will be collected to assist in the interpretation of long term data sets. The following novel data will be collected in conjunction with the ongoing monitoring of the Adélie penguin population:

a) accurate data on the distribution, intensity and extent of human visitation to Shirley Island. This would collect data on group size, area(s) visited, colonies approached, duration of visit etc. Earlier efforts to collect such data in the 1989/90 season were successful, and could be readily implemented into the formal requirements for visits to Shirley Island.

b) annual census data on the breeding population of south polar skuas on Shirley Island. Only limited historical data are available (1968/69, limited data from the 1970s, complete census inn 2002/03). Annual census data could be collected during annual visits to census the penguin colonies in November each season.

9.6 Baseline reference collection for potentially impacted media

9.6.1 Snow and ice sampling

During the 2002/03 baseline data collection project, a total of 72 surface snow samples, 37 snow pit samples and 11m of firn core were obtained from selected sites of the Budd coast -East Antarctica during summer 2002/03. These samples, collected using ultra-clean procedures will be analysed for lead and lead isotopes by Thermal Ionisation Mass Spectrometry. The data will provide an assessment of the baseline conditions of the local environment prior to commissioning of the air transport system.

Snow samples were taken in selected sites: the Casey area, Haupt Nunataks, Law Dome and the proposed Casey runway site. Collections were completed during the field summer season at Casey (mid December 2002- mid March 2003) and kept frozen in the AAD repository in Kingston. Some of these samples are now being analysed at Curtin University (Perth, WA).

The First Site: Law Dome
Although remote from the Casey runway and east of the proposed flight path, the strategic importance of Law Dome to several ongoing glaciology programs (trace

chemicals and long range pollution studies) qualifies this site for monitoring purposes.

Sampling was conducted between 12 - 22 January 2002. An 11m deep firn core was obtained with an 82mm PICO drill. Although the drill could not be cleaned using classical procedures it was roughly cleaned with ethanol and rinsed with MQ water in Casey Science laboratory. However limited the preparation of the drill, the decontamination procedures should produce genuine sub-samples from the augered cores. The core samples were doubled-bagged onsite. The core is likely to encompass the accumulation over the last decade, likely up to 13 years. To complement this decadal record, a continuous set of highly resolved seasonal samples was collected from a 2m deep snow pit dug in a virgin location ~1km upwind from the core drilling site. The series is expected to cover the last 2 years of site accumulation. Detailed dating will be provided by ancillary Del measurements. Altogether, six surface samples, 37 pit samples and 11m of firn core have been retrieved from Law Dome.

The second site: Casey area.
The main wind influencing Bailey Peninsula will tend to disperse Casey atmospheric emissions towards the sea. Given the right conditions, it cannot be precluded that aerosols from the incinerator, vehicle exhaust and dust generated by using heavy machinery within the station limits could be transported inland. These activities are maximal in summer, and will be ongoing during the flying season. It will be an advantage to give a qualitative evaluation of this expectedly minor contribution. Evaluating the halo of influence of an Antarctic station is an interesting exercise in itself.

Surface snow from four sites along the cane line linking Casey to S1 was sampled in triplicate according to nested site sampling concept. The first two sites were spread 250m either side of the cane line 2.5 km above S1.The last two sites were closer to Casey, also 250m either side of the cane line, approximately 1km below S1. It is not possible to determine the age of the snow, however its appearance, especially on the lower of the sites, presented characteristics of aging effects. Apparent frost/melt features indicated the snow could have been exposed to the summer sun for an extended period. In total, 18 samples were collected at these locations.

The third site: Casey runway location
The Casey runway site was sampled initially in early February roughly a week after its location was finalized and again, a fortnight later. The sampling strategy was conceived according to local wind observations made by G. Blaisdell, the engineer in charge of the trial runway project. The local environment is made out of glacial ice partially covered by patches of firmly compacted snow of unknown age. Snow was preferred to ice as a sampling medium. From the two visits 36 samples were obtained.

The Fourth site: Haupt Nunataks
Haupt Nunataks (S 66 34.910 E 110 41.560, 81 m above sea level, 9.3 km from sea shore) is approximately as remote from the Casey runway as from Casey station and in all respects outside the station influence. The site could thus provide a suitable alternative for assessing the background, though it may show a stronger oceanic influence as being closer to the sea and lower in altitude. It was sampled on the last

day of February 2003 as the weather conditions and melt streams had prevented access earlier. The location was covered by a 10-12cm thick coat of light fresh snow which still generously sprinkled the outcropping rocks. On these, the snow appearance, consistency and also the lack of melt traces indicated a very recent fall.

Surface snow samples were taken in triplicate according to nested sampling site concept in 4 locations of the area, for a total of 12 samples.

Appendix 7 provides details of the baseline reference collection for the 2002-03 season.

9.6.2 Rock, sediment, snow, lake and moss sampling

Seven sites at various locations around the Windmill Islands were sampled for rock, sediment, snow, water and moss. Generally samples were taken with several replicates at several sites at each location. The locations were North-east Bailey Peninsula (ASPA No.135), Clark Peninsula (ASPA No.136), Robinsons Ridge, Mitchell Peninsula, Clarke Peninsula, Odbert Island (ASPA No.103), and Peterson Island. In total there are 70 lake samples, 49 moss/lichen samples, 42 sediment samples, 14 rock and 29 snow samples.

Appendix 7 provides details of the baseline reference collection for the 2002-03 season.

9.7 Analysis of key parameters in potentially impacted media

The follow analysis was undertaken in the 2002/03 financial year:

- Sediment analysis - 37 grab sediments. 5 sediment cores, total of 25 samples. Grand total 62 samples. Core description and grain size analysis (Malvern for <500 um);

- Sediment analysis - total 62 samples. Total, organic, and inorganic carbon analysis and loss on ignition

- Sediment analysis - total 62 samples. ICP-OES analysis of leachates - quantitative for ions >50ppb and screening for ICP-MS analysis;

- Preliminary water analysis - major cations and screening for ICP-MS. 90 water plus 40 snow samples - total 130 samples;

- Rock analysis - including Major and 10 trace elements by ICP-OES, Loss on ignition, thin sections and basic petrographic description, crushing. Total 26 samples.

9.8 Ongoing monitoring program

The monitoring program for the 2003/04 season is planned to cover the following areas:

- Present interim report on baseline chemical concentrations from moss, water and ice.
- Feasibility study into aerosol sampling
- Present interim report on bird monitoring

Phase 3 of the establishment of an air transport monitoring program (2004/05) can not be fully developed until the results of 2002/03 and 2003/04 can be analysed. However it is likely that aerosol sampling may be undertaken early in 2004-2005 season (dependent on the outcome of the feasibility study).

10 REPORTING AND AUDITTING ARRANGEMENTS

10.1 Environmental Management System

The AAD has brought together and strengthened its environmental management processes by implementing an environmental management system (EMS), which has been certified to meet the requirements of the Australian / New Zealand Standard AS/NZS ISO 14001:1996 *Environmental Management Systems - Specification with guidance for use.*

The AAD environmental management system (EMS) is a systematic means of managing the AAD's interaction with the environment.

The EMS addresses all of the environmentally significant issues over which the AAD has direct control, or is reasonably able to have an influence, and encompasses all locations in which the AAD operates - continental Australia, the AAT, and the sub Antarctic region (Heard and Macquarie Islands and the Southern Ocean).

The EMS will be amended to include systematic processes to ensure:

- the environment is being protected by the system; and
- the air transport system is continually improving its environmental performance.

Parts of the EMS that will be reviewed in light of the introduction of the air transport system include:

- reviewing the AAD Environmental Policy to ensure air transport is sufficiently addressed in the Environmental Policy;
- setting Environmental Objectives and Targets for the air transport system;
- developing an Environmental Management Plan for the construction and ongoing operation of the air transport system; and
- ensuring the Environmental Incident Process adequately responds to the air transport system.

10.2 Other reporting and auditing arrangements

The Antarctic Division Environment Committee shall evaluate the effectiveness of this environmental assessment and the EMP two years after the commencement of the operation of the proposed air transport system or part thereof on the basis of the reports referred to in Chapter 9 and other information it might request.

A report on the effectiveness of the Environmental Requirements for Aircraft Operations will be prepared annually for the first five years and submitted to the Antarctic Division Environment Committee. After the first five years, reporting on this aspect of the system will be on a five yearly basis, as a minimum.

The Antarctic Division's General Manager, Operations Branch shall ensure that reports are prepared on each of the items called for in Chapter 9 and considered through the Antarctic Division Environment Committee or acted upon as necessary. Where investigations indicate that impacts of the activity considerably exceed those originally predicted, a report will be forwarded to the Minister in fulfilment of the *Antarctic Treaty (Environment Protection) (Environmental Impact Assessment) Regulations 1993*.

The Antarctic Division maintains a register of all mitigation measures and monitoring requirements outlined in environmental impact assessments prepared by the Division. This ensures that reviews or future monitoring requirements are undertaken at the nominated time. This register is maintained by the Policy Section Environment Officer. The Policy Section is responsible for compiling and reporting to the Antarctic Division Environment Committee on conditions which apply to each environmental impact assessment.

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11.2 Personal Communications

In addition the following persons provided oral and/or written advice:

Dr Jo Jacka	Senior Glaciologist, AAD
Rob Sheers	Operations Branch, AAD
Charlton Clark	Project Manager, Air Transport, AAD
Stuart McFadzean	Senior Project Officer, Air Transport, AAD
Shaun Walsh	Environmental Advisor, Operations Branch, AAD
Simon Smalley	Manager, Environmental Management and Audit, AAD
Susan Ingram	Environmental Management and Audit Unit, AAD
Adrian Pate	Senior Logistics Officer - Aviation, Operations Branch, AAD
Dr Phillip Tracey	Project Pool Officer, AAD
Dr Eric Woehler	Antarctic Bird Specialist, Consultant, AAD
Geoff Dannock	Logistics Manager, Operations Branch, AAD
Sandra Potter	Senior Logistics Officer - Shipping, Operations Branch, AAD
Terry Vickers	Director, Flying Operations, Skytraders
Melissa Giese	Marine Species Unit, Department of the Environment and Heritage
Ivor Harris	2003 Station Leader, Casey station
Jeremy Smith	2003 Station Leader, Davis station
Bob Orchard	2003 Communication Officer, Mawson station
Peter Magill	Operations Branch, AAD
Chris Paterson	Chief Engineer, Operations Branch, AAD
Dr Ian Snape	Contaminants Geo-chemist Human Impacts Research, AAD
Dr Martin Riddle	Program Leader, Human Impacts, AAD
Dr Dana Bergstrom	Human Impacts, AAD
David Miles	Director, Ambidji Group, Melbourne
Matthew Dudley	Australian Greenhouse Office

11.3 Website addresses

Scoping Study http://www.aad.gov.au/goingsouth/airlink/scoping_9900/default.asp.
Air Transport Report (2000)
http://www.aad.gov.au/goingsouth/airlink/report_00/default.asp
State of the Environment indicator http://aadc-maps.aad.gov.au/aadc/soe/list_of_indicators.cfm
Australian Antarctic Program http://www.aad.gov.au/default.asp?casid=1167
Environmental characteristic/general information http://www.aad.gov.au/airtransport

Environmental Code of Conduct for Australian Field Activities in Antarctica
http://www-new.aad.gov.au/default.asp?casid=1344
Casey Station Management Plan http://www.aad.gov.au/default.asp?casid=3578
Casey station general information http://www.aad.gov.au/default.asp?casid=405
Davis Station Management Plan http://www.aad.gov.au/default.asp?casid=7329
Mawson Station Management Plan (http://www.aad.gov.au/default.asp?casid=7044

11.4 Maps

A number of maps are available online at http://www-aadc.aad.gov.au/mapping/. This web address also provides a catalogue of hard copy AAD map holdings including satellite image maps.

Maps referred to within the text of the IEE are:

Map 1: Air transport system - Operating locations
Map 2: Casey runway location
Map 3: Potential travel times and routes
Map 4: Casey station skiways and flight paths
Map 5: Davis station skiways and flight paths
Map 6: Davis Plateau skiway and flight paths
Map 7: Mawson station skiways and flight paths
Map 8: Casey station/Windmill Islands wildlife concentration areas
Map 9: Davis station wildlife concentration areas
Map 10: Mawson station wildlife concentration areas

11.5 Appendices

1. EPBC non-controlled action decision instrument
2. Design layout for Casey runway
3. Environmental Requirements for Aircraft Operations (Draft)
4. Species List
5. Likely impacts table
6. Noise emissions for C212 and Falcon 900EX
7. Monitoring Project – Outcomes for 2002-03
8. Historic Adélie penguin data in the Windmill Islands

11.6 Photographs credits

Front page photo - C212 aircraft (courtesy EADS CASA)
Photo 1 – Falcon 900EX (courtesy Dassault Falcon Jet Corporation, EADS CASA)
Photo 2 – C212 aircraft (courtesy EADS CASA)
Photo 3 – Trial runway construction 2002/03 (Blaisdell, G.)
Photo 4 – Proposed runway site: flat ice plain with minor sastrugi (Blaisdell, G.)
Photo 5 – Ridge as seen looking due east from proposed runway (Blaisdell, G.)
Photo 6 – Casey station (Grant Dixon, 1998)
Photo 7 – Davis station (Neil Smith, 1998)
Photo 8 - Mawson station (Wayne Papps, 1999)

Photographs of typical intra-continental skiways are available online at http://www.aad.gov.au/airtransport.

12 CONCLUSION

The assessed impacts of the proposed activity are summarised in the following table:

Key Values	Assessed Impact
Atmosphere	Overall Australian fuel use and therefore emissions in Antarctica will significantly decrease through the reduction in voyages. Atmospheric emissions from aircraft will be quickly dispersed. Effects at rarely visited locations expected to be negligible and transitory. Monitoring will be conducted to measure potential impacts.
Vegetation and wildlife	Minor disturbance to breeding colonies of birds or seals is possible. All landing areas are a sufficient distance from nearest breeding colonies and outside AAD's minimum separation distances of 750m. Some landing and departure paths will be modified to ensure 750m separation distance is not breached. These are discussed in Appendix 6. A monitoring program will be undertaken to monitor the adequacy of the system's environmental controls aimed at minimising impacts on wildlife concentrations, areas of special scientific interest, and protected areas.
Areas of geological or other significance	Negligible.
Ice and water quality, volume and movement	Construction activity will have a very minor effect on snow drift accumulation and melting. Mitigation measures have been developed to reduce the likelihood of fuel spills.
Wilderness value and visual impacts	Snow and ice construction activities will not have a lasting visual impact due to the nature of construction methods. Noise and visual impacts associated with the system will be transitory and restricted to operational periods.
Effects on associated facilities	No negative effects. Station population numbers will be similar to present figures, except during unexpected delays.
Effects on Antarctic research	The air transport system will provide a net benefit to the Antarctic science and research program. It will benefit many aspects of Antarctic research by allowing easier access, shorter travel times, improvements to marine science opportunities and new opportunities for airborne research.

As indicated in the above summary, the proposed activity is assessed as likely to have no more than a "minor or transitory" impact on the Antarctic environment and is considered consistent with the principles set out in Article 3 of the Madrid Protocol.

The mitigation measures and the EMP will ensure that impacts are minimised or eliminated.

13 CONTACT DETAILS

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14 OVERVIEW

This Initial Environmental Evaluation (IEE) has been prepared in compliance with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty (the 'Madrid Protocol'), particularly Annex I on Environmental Impact Assessment. Preparation of an environmental impact assessment is a legal requirement under the *Antarctic Treaty (Environment Protection) Act 1980*.

As part of the legal requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Australian Antarctic Division (AAD) submitted a referral to the Department of the Environment and Heritage to determine if assessment under the EPBC Act was required. The resulting decision by the Minister for the Environment and Heritage was that the action would not require assessment providing that it is undertaken in a specified manner (ie. Non-controlled action-specified manner). This IEE report addresses those specified manner requirements.

This IEE adopts a format for environmental impact assessment developed by the Council of Managers of National Antarctic Programs (COMNAP), to satisfy the requirements of the Madrid Protocol and has been adapted to suit relevant Australian legislation.

14.1 Description of proposed activity

To assist the Australian Government in meeting its goals for the Australian Antarctic Program, the AAD proposes to develop and operate an ongoing air transport system including inter-continental flights between the Australian and Antarctic continents and intra-continental flights between Antarctic stations (Table i). The system will transport scientists and support personnel as part of the Australian Antarctic Program during the Austral summer (September to March), moving between 400 to 600 passengers per season. The upper limits of the number of passengers are self regulating through the station infrastructure limitations and the cost of field based science. The system will also provide a year round capability to respond to emergencies. There will be approximately 25 inter-continental flights in a season, initially, with the potential to increase to 40 flights per season. The chosen aircraft for this system are the Falcon 900EX for inter-continental operations and CASA 212/400 (C212) for intra-continental operations. Up to 12 staff will be required to assist in the operation of the system.

The system will operate between the Antarctic and Australian continents over the Southern Ocean, and between Casey, Davis and Mawson stations, and field locations throughout Antarctica (Map 1) as required. It is envisaged that the system will be used for conducting Antarctic science, and by other Antarctic nations.

Situated 65km south-east of Casey station, the inter-continental runway will be a four kilometre long, snow-capped glacial blue ice runway, known as the Casey runway.

Table i - Summary of air transport system

Location:	**Tasmania**	**Casey**		**Davis**		**Mawson**	
Runway/ skiways:	Hobart	Runway	Plateau skiway/s (varying sites)	Sea Ice Skiway (varying sites)	Plateau Skiway (site may vary)	Sea Ice Skiway (varying sites)	Plateau Skiway (site may vary)
Role:	Hobart International airport	Receive wheeled inter-continental aircraft, C212 operations	Service Casey station	Service Davis station in early season	Service Davis station in mid/ late season	Service Mawson station in early season	Service Mawson station in mid/late season
Surface:	Pavement	Glacial (blue) ice runway with a protective compressed snow cap	Snow, groomed when necessary	Sea ice, groomed when necessary	Snow, groomed when necessary	Sea ice, groomed when necessary	Snow, groomed when necessary
Aircraft:	Falcon 900EX C212 – start and end of season	Falcon 900 EX C212 Helicopter (Casey link)	C212	C212	C212 Helicopter (link to Davis station)	C212	C212
Maintenance:	n/a	- grading required at the start of season with grader/dozer and laser leveller - further grading on an as-required basis	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season	-grade at start of season and as-required during season
Distance to station:	n/a	65 km	1-15 km	750m-8km	Approx 30km	1 - 6 km	1-5 km
Travelling time:	4.3 hours (to Casey runway)	20 mins by air (to Casey station) 4.3 hrs to Hobart 5.1 hr to Davis	5.1 hours (to Davis station)	2.4 hours (to Mawson station) 5.1 hours (to Casey runway/station)		2.4 hours (to Davis station)	
Transport to station:	n/a	Oversnow vehicle (2 hrs) or aircraft (20 min)	Oversnow vehicle (10min)	Oversnow vehicle (10min – 1 hour)	Helicopter (10-15min)	Oversnow vehicle (15 mins)	Oversnow vehicle (10min)
Frequency (average):	Once to twice weekly	Weekly to Davis		Weekly to Casey 1-2 per month to Mawson		1-2 per month to Davis	

The area footprint will be approximately 104 ha. This will include the runway, aprons and support services areas. Infrastructure at the runway will consist of approximately 10 removable buildings (including staff and emergency accommodation) and storage for approximately 100kL of aviation fuel. Equipment will be stored at Casey station over winter, with minimal infrastructure remaining at the runway site. Passenger links with Casey station will either be by over snow vehicle or by air (helicopter or C212).

Intra-continental operations will use both groomed and unprepared snow and ice skiway surfaces. Existing skiways will be utilised at stations for intra-continental flights, in areas where they are currently available and suitable for the aircraft, such as Davis and Mawson sea ice . The most isolated skiway is on the inland ice plateau approximately 30km from Davis station. One to two flights a week will be provided to the Davis region from Casey, and flights to Mawson will occur approximately once a month.

Excluding the Davis Plateau skiway, support infrastructure at intra-continental skiways will be minimal as the majority of required services will be available from nearby stations. With the exception of some fuel and an AWS at the Davis Plateau skiway, no other infrastructure will remain through winter at skiway sites. During a normal flying season it is envisaged that the Davis Plateau skiway will require approximately 50kL aviation fuel for Casey and Mawson bound flights (dependent on the number of scheduled flights for the season). Additional fuel for flights directly in support of science will be required. Davis Plateau will be linked to Davis station by helicopter. All other skiway locations will be linked to nearby stations by foot or using over snow vehicles. As all runway/skiway surfaces are either snow or ice, surface grading will be required for construction and maintenance. In addition to this the Casey runway requires a 5-10cm snow-cap over the surface of the glacial blue ice to protect the subsurface from melt and to increase surface friction.

It is planned that the air transport system will be introduced over the next three Antarctic summers. In the 2003/04 summer, construction equipment and other associated infrastructure will be shipped down to Casey in preparation for the introduction of the C212 operations in 2004/05. Subject to the necessary approvals, the Antarctic air transport system should be fully operational in 2005/06, with the introduction of the Falcon 900EX.

There are many benefits that an air transport system will bring to the Australian Antarctic Program, including:

- Increased flexibility and responsiveness in deploying scientific and support personnel
- Increased frequency of access
- Increased capacity to support remote area research
- Increased capacity to support airborne research
- Decreased unproductive travel times
- Improved marine science opportunities
- Increased ability to respond to emergency situation
- Increased ability to collaborate with other national Antarctic programs
- Increased flexibility in logistic support of the entire program

The new air transport system will provide Antarctic science with new opportunities by providing better access to remote areas and airborne research. All science based activities will continue to require individual assessments of environmental impacts and have not been assessed as part of this report.

14.2 Alternatives

It has been recognised for many years that ship based transportation to Antarctica is time consuming and costly, especially when ships become beset by sea ice. Over the past three decades, a number of aircraft and runway alternatives have been considered for the establishment of an air transport system between Australia and Antarctica and within Antarctica. Some of these options included a rock runway at Davis, a compressed snow runway at Casey with an alternative runway at Bunger Hills, and a glacial blue ice runway similar to the Pegasus runway operated at McMurdo. Following years of research and field investigations, the rock runway at Davis suitable for inter-continental flights was ruled out on economic and environmental grounds. Other alternatives were still being considered up until the aircraft supplier tendering process was finalised. The successful tenderer, Skytraders, propose to use a long range jet for the inter-continental flights (ie. Falcon 900EX). This option eliminated the need for an alternative runway at Bunger Hills as the Falcon 900EX is capable of returning to Australia without refuelling. This aircraft is capable of landing on either blue ice or compressed snow runways. Runway construction trials in 2002/03 confirmed a suitable blue ice runway in the outer Casey region.

To support the intra-continental component of the system, skiways are required at each station (ie. Casey, Davis and Mawson). A number of locations were investigated, including a short rock runway at Davis. At this stage of the development of the system, it was decided to recommend previously used skiway locations at each station. This decision took wildlife impacts into consideration as well as the infrastructure support that would be required.

Links from runway/skiways to stations also required careful consideration of the alternatives. The recommended method of transportation depends greatly on the location of the runway/skiway. Skiways close to stations would be best linked either by foot or oversnow vehicle. During the mid to late operating season, the Davis Plateau site can only be linked to the station by helicopter due to the terrain of the Vestfold Hills. The Casey runway can be access from Casey station by oversnow vehicle, helicopter or C212.

14.3 Description of the existing environment

14.3.1 Casey runway

Situated 65km south-east of Casey station, the Casey runway is located at an elevation of approximately 750m, on a vast area of glacial blue ice with some snow cover and minor sastrugi. The runway is approximately 30km from the nearest area recognised for wildlife presence. Current infrastructure at the site consists of a 4m Automatic Weather Station (AWS).

14.3.2 Casey station

Casey station covers an area of approximately 0.5km² on Bailey Peninsula, west of Law Dome. Many large wildlife colonies exist within the broader Casey region. The area is also well known for its extensive moss and lichen communities. The importance of these communities has been reflected through the declaration of two Antarctic Specially Protected Areas (ASPA No.135 North-east Bailey Peninsula and 136 Clark Peninsula). Casey station can accommodate up to 60 expeditioners and generally has a wintering population of 15-25. Shirley Island, situated adjacent to the station, is a known Adélie penguin breeding area as well as a popular recreation/sight-seeing destination for expeditioners.

14.3.3 Davis station

Davis station is situated on the Ingrid Christensen Coast, Princess Elizabeth Land, on the edge of the ice-free Vestfold Hills. Beyond the Vestfold Hills is the Davis Plateau. The station covers approximately 0.5km² and can accommodate up to 80 expeditioners (wintering population ranges from 15-25 people). The Davis region hosts a wide variety of flora and fauna. Most wildlife concentrations are situated between north east and south east from the station.

14.3.4 Mawson station

Mawson station, located on the south-eastern shore of Horseshoe Harbour, on the Mawson Coast of Mac. Robertson Land, covers 0.3km² and can accommodate up to 40 expeditioners (15-25 people during winter). Main wildlife concentrations are generally distant from the station to the NW-NE. A wide variety of penguins and flying birds occupy these areas.

14.3.5 Other locations

The air transport system will be used to access other locations within Antarctica in support of science programs, or in assisting other Antarctic nations. These activities will undergo their own environmental assessments, and will include assessment of the impacts of using air support in each location.

14.4 Analysis of potential impacts

It is expected that the introduction of an air transport system to Antarctica will result in a number of environmental impacts. The most obvious direct impacts will affect the following key values: air quality, snow/ice surfaces and wildlife. Other factors may be indirectly impacted upon, such as station operations, quarantine, and Antarctic research.

Air Quality - Air quality is affected by exhaust from aircraft and other machinery. These exhaust emissions usually contain such atmospheric pollutants as sulphur oxides, nitrogen oxides, carbon monoxide, carbon dioxide, hydrocarbons and heavy metals. At altitudes, these emissions are readily dispersed over a vast area. In areas downwind of runways or skiways, emissions may be detectable. The overall greenhouse gas emissions from AAD activities in Antarctica will be reduced due to a reduction in the number of shipping voyages required.

Surface contaminants - Contaminants on the snow/ice surfaces will impact on surface quality. Contaminants can be derived from tyre residues from aircraft at Casey runway, other aircraft operations, maintenance by-products, engine emissions, and fuel transfer, storage and refuelling.

Wildlife – The air transport system has the potential to affect wildlife. There are no direct concerns involving disturbance to wildlife associated with the Falcon 900EX operations at the Casey runway site as known wildlife concentrations are up to 30km from the site. Given the proximity of skiways and frequency of flights, intra-continental operations have the potential to disturb wildlife. Impacts on wildlife can be through noise/visual disturbance, pollution, or bird strike. There has been a small amount of research that has been undertaken into the effects of aircraft noise on wildlife. Some of this work helped form the basis of the current 750m separation distance from wildlife (Appendix 3 – Environmental Requirements for Aircraft Operations).

To assist in determining noise related impacts, noise modelling was undertaken (Appendix 6). It was evident from the noise modelling data and knowledge of the surrounding environment that the Casey runway site does not present any noise related impacts on wildlife due to their absence from the site. Noise related impacts predicted by the modelling are possible with C212 operations in coastal areas, near stations. The model provided a good indicator for the level of noise received at different skiway locations.

Wilderness - Impacts associated with aircraft activities on wilderness qualities are predicted to be transitory and minor.

Waste management - The air transport system will not add significantly to the amount of waste presently generated by AAD operations. Existing waste management measures are predicted to be sufficient (ie removal of waste from field locations to station for processing and/or return to Australia).

Station operations - Additional station infrastructure is not likely to be needed however, if in the course of time, facilities are not adequate, any additional infrastructure will be subject to its own environmental assessment.

Quarantine - An air transport system has the potential to quickly disperse introduced organisms to Antarctica and between stations. Organisms can be introduced in the clothing/shoes and gear of expeditioners and on aircraft and cargo/equipment. AAD has a number of effective quarantine measures currently in place to prevent the transfer of foreign organisms to Antarctica.

Antarctic research - The introduction of air transport to Antarctica is expected to change the way in which some Antarctic research is conducted. The system will provide the ability for scientists to quickly get to and from Antarctica without the need for long sea voyages. The intra-continental component will provide easier access to remote field locations. Intra-continental aircraft will provide an opportunity for the conduct of aerial research, using geophysical or other sensors attached to aircraft as well as reducing the need for oversnow traversing.

Cumulative impacts - Cumulative impacts can have a detrimental effect on Antarctic values. Areas with potential for cumulative impacts will mostly be around stations and where regular refuelling and aircraft activities are undertaken. Other cumulative impacts will be associated with frequency of flights and noise/visual disturbance of wildlife. The exact consequences of the cumulative impacts of the air transport system are unknown at this stage.

Aircraft incidents - Safety considerations in the new air transport system have been paramount in the planning and design of the operation. Historically, the majority of Antarctic aviation accidents occur while the aircraft is grounded. Despite a very low probability of a serious incident, the associated environmental impacts have been identified and are discussed in section 7.3.

14.5 Mitigation measures

A wide variety of mitigation measures have been developed to address the impacts identified. These include measures to address construction activities, aircraft operations, protection of biota, quarantine measures, fuel and waste management and the development of an Environmental Management Plan (EMP) to ensure all personnel are aware of the environmental obligations. Details of the proposed mitigation measures can be found in Chapter 8.

14.6 Monitoring of impacts

There is a requirement under both the EPBC and AT(EP) Acts to conduct environmental monitoring of the air transport system. The AAD has developed a plan of action to meet the requirements of the project and took advantage of available expert personnel and logistic support during the 2002-03 season. Importantly, the 2002-03 season established an environmental baseline, which will provide a reference point for future evaluation.

The following tasks were undertaken during the 2002/03 season:

1. Desktop study and documentation of the impact assessment process
2. Risk-analysis and reporting of the potential disturbance to wildlife as a result of the proposed air transport system. Specifically, the risks to Southern giant petrels (*Macronectes giganteus*) and Wilson’s storm petrels (*Oceanites oceanicus*) were investigated.
3. Quantification archival material relating to Adélie and Emperor penguin populations in the Windmill Islands to establish baselines on regional distribution and abundance.
4. Establishment and documentation of a monitoring system to assess the cumulative impacts of the air transport system using Adélie penguin colonies at Casey as an environmental indicator.

5. Establishment of a baseline reference collection for potentially impacted media (moss, water, ice, snow).
6. Analysis of key parameters in potentially impacted media (ongoing)

Further baseline data collection is scheduled for 2003/04. A number of other studies are to be undertaken as funds become available: quarantine risk assessment, ground-truthing of noise model.

14.7 Reporting and auditing arrangements

Through the AAD's Environmental Management System (EMS) and implementation of the EMP, the air transport system will operate to achieve a system that is continually improving its environmental management in the Antarctic environment. Based on related research, further data or incident reporting, relevant documents will be updated and additional mitigation measures developed, where appropriate.

14.8 Conclusion

The proposed activity has the potential to cause adverse environmental impacts. However, these impacts are assessed as "minor or transitory" and are controlled by mitigation measures incorporated into the system design. The assessment of the environmental impacts of the air transport system on the Antarctic environment is considered consistent with the principles set out in Article 3 of the Madrid Protocol.

Key Values	Assessed Impact
Atmosphere	Overall Australian fuel use and therefore emissions in Antarctica will significantly decrease through the reduction in voyages. Atmospheric emissions from aircraft and other machinery will be quickly dispersed. Effects at rarely visited locations expected to be negligible and transitory. Monitoring will be conducted to measure potential impacts.
Vegetation and wildlife	Minor disturbance to breeding colonies of birds or seals is possible. All landing areas are a sufficient distance from nearest breeding colonies and outside AAD's minimum separation distances of 750m. Some landing and departure paths will be modified to ensure 750m separation distance is not breached. These are discussed in Appendix 6. A monitoring program will be undertaken to monitor the adequacy of the system's environmental controls aimed at minimising impacts on wildlife concentrations, areas of special scientific interest, and protected areas.
Areas of geological or other significance	Negligible.
Ice and water quality, volume and movement	Construction activity will have a very minor effect on snow drift accumulation and melting. Mitigation measures have been developed to reduce the likelihood of fuel spills.

Wilderness value and visual impacts	Snow and ice construction activities will not have a lasting visual impact due to the nature of construction methods. Noise and visual impacts associated with the system will be transitory and restricted to operational periods.
Effects on associated facilities	No negative effects. Station population numbers will be similar to present figures, except during unexpected delays.
Effects on Antarctic research	The air transport system will provide a net benefit to the Australian Antarctic Program. It will benefit many aspects of Antarctic research by allowing easier access, shorter travel times, improvements to marine science opportunities and new opportunities for airborne research.

Appendix 1

EPBC non-controlled action decision instrument

+61 2 6273 6101

COMMONWEALTH OF AUSTRALIA

ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999
DECISION THAT ACTION IS NOT A CONTROLLED ACTION

Pursuant to section 75 of the *Environment Protection and Biodiversity Conservation Act 1999*, I, DAVID ALASTAIR KEMP, Minister for the Environment and Heritage, decide that the proposed action, set out in the Schedule, is not a controlled action. Provided that the proposed action is taken in the manner described in the Schedule, the provisions of Part 3 of the EPBC Act set out in the Schedule are not controlling provisions.

SCHEDULE

The proposed action by the Australian Antarctic Division to develop and operate an air transport system for inter-continental flights between Australia and Antarctica, and intra-continental flights within Antarctica, and as described in the referral received on 12 September 2002 under the Act (EPBC 2002/801).

Provisions of Part 3

The relevant provisions of Part 3 are:

- sections 18 and 18A (Listed threatened species and communities);
- sections 20 and 20A (Listed migratory species);
- section 28 (Protection of the environment from Commonwealth actions).

Manner in which the proposed action is to be taken:

- Operational flight paths and flight guidelines will be developed and implemented to minimise the potential for wildlife disturbance or impacts on sensitive marine and Antarctic environments.
- Modelling of noise footprints for aircraft, to aid in assessing noise related impacts and planning of operations, will be undertaken to assist in development and implementation of flight operational protocols and guidelines to minimise disturbance to fauna.
- The requirements for interacting with cetaceans within the Australian Whale Sanctuary (Part 8, Division 8.1, Clause 8.05 of the *Environment Protection and Biodiversity Conservation Regulations 2000*) will be incorporated into flight operational protocols and guidelines, as appropriate.
- Monitoring programs to verify impact predictions, identify unexpected impacts, and to ensure impacts remain within any required limits will be developed and implemented.
- The monitoring program will also specifically address the potential for noise disturbance to the Southern Giant Petrel and the Wilson's Storm Petrel and any measures needed to avoid impacts.
- The flight operational protocols and guidelines will be reviewed and updated against the results of the monitoring programs on an annual basis, for the first five years of operation, and thereafter on a five yearly basis.
- Flight operational protocols and guidelines, and monitoring programs relevant to identification and minimisation of environmental impacts, will be developed in consultation with relevant expert agencies, including Environment Australia.

Dated this 14th day of October 2002

David Kemp

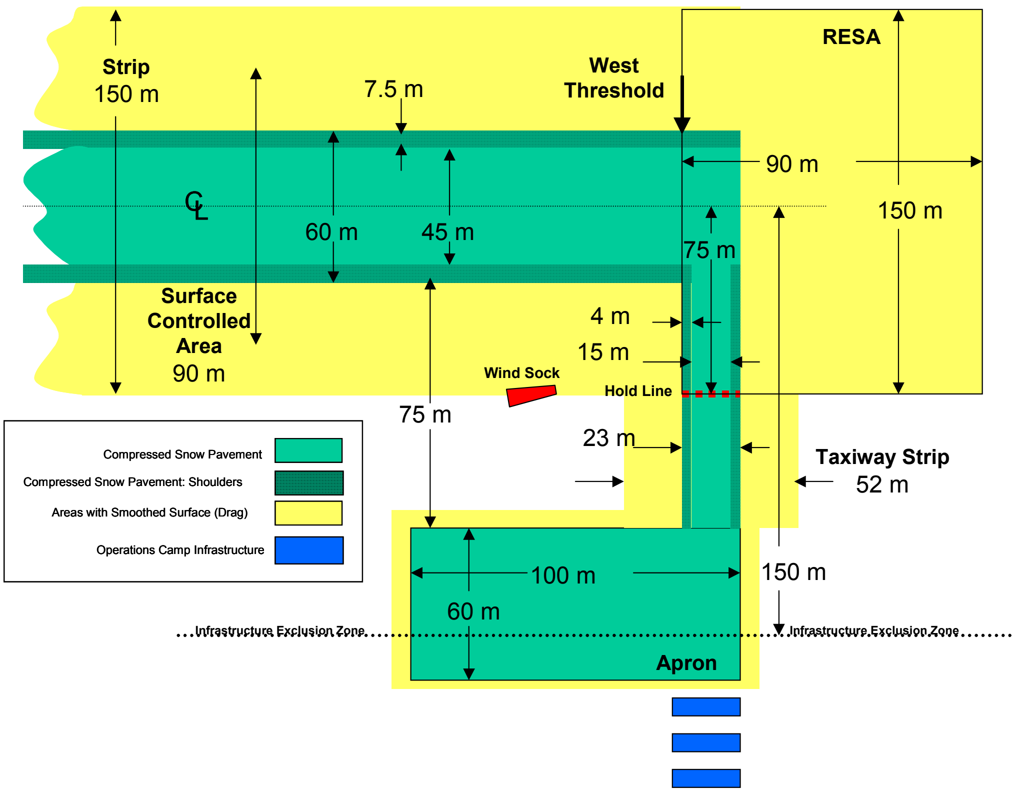
MINISTER FOR THE ENVIRONMENT AND HERITAGE

Appendix 2

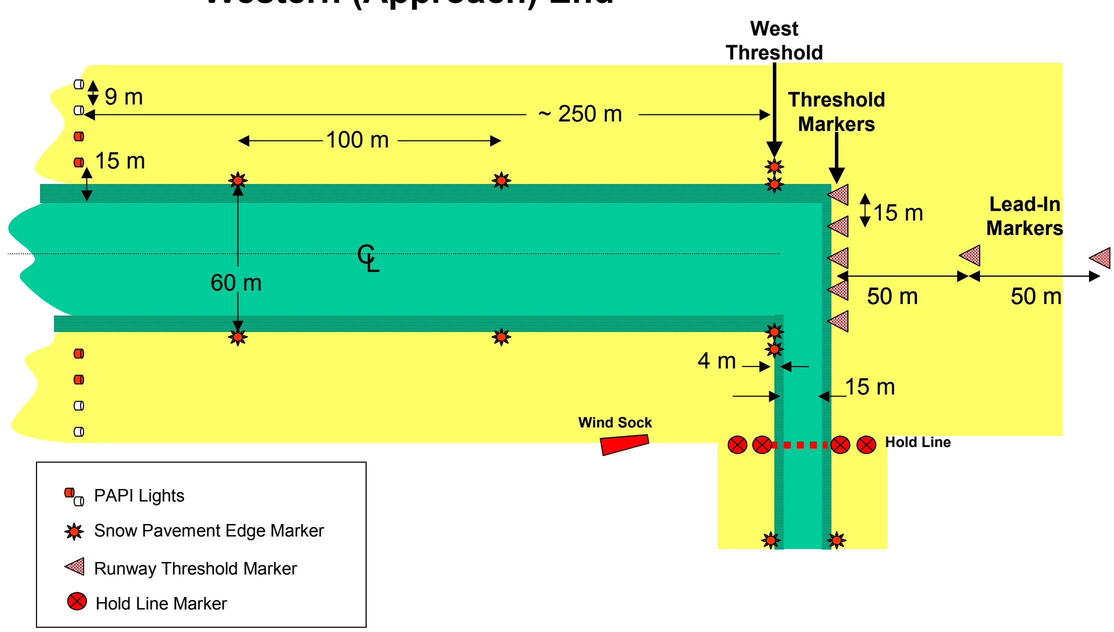
Design layout for Casey Runway

Design layout for inter-continental runway

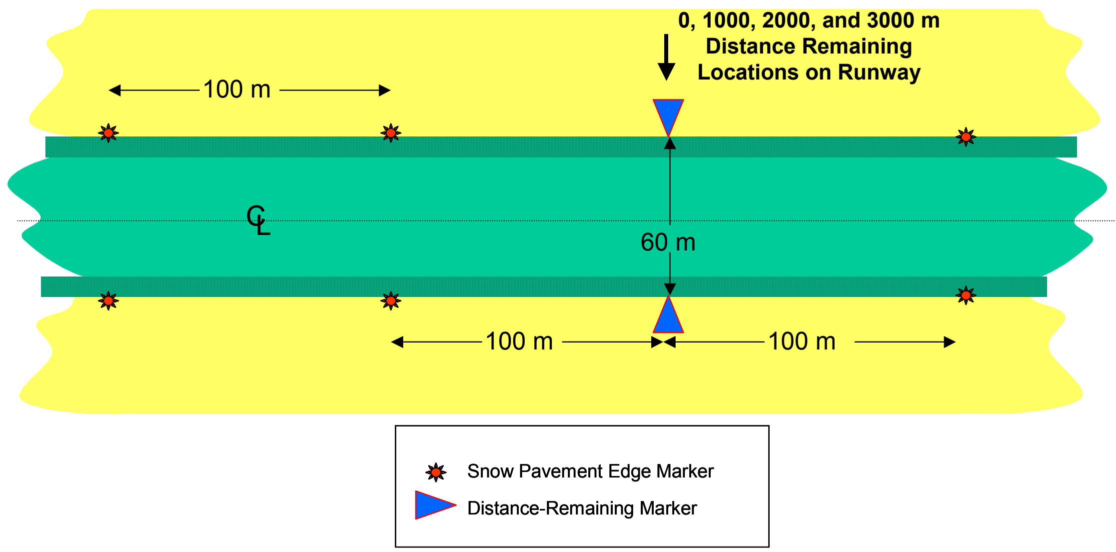
Western (Approach) End



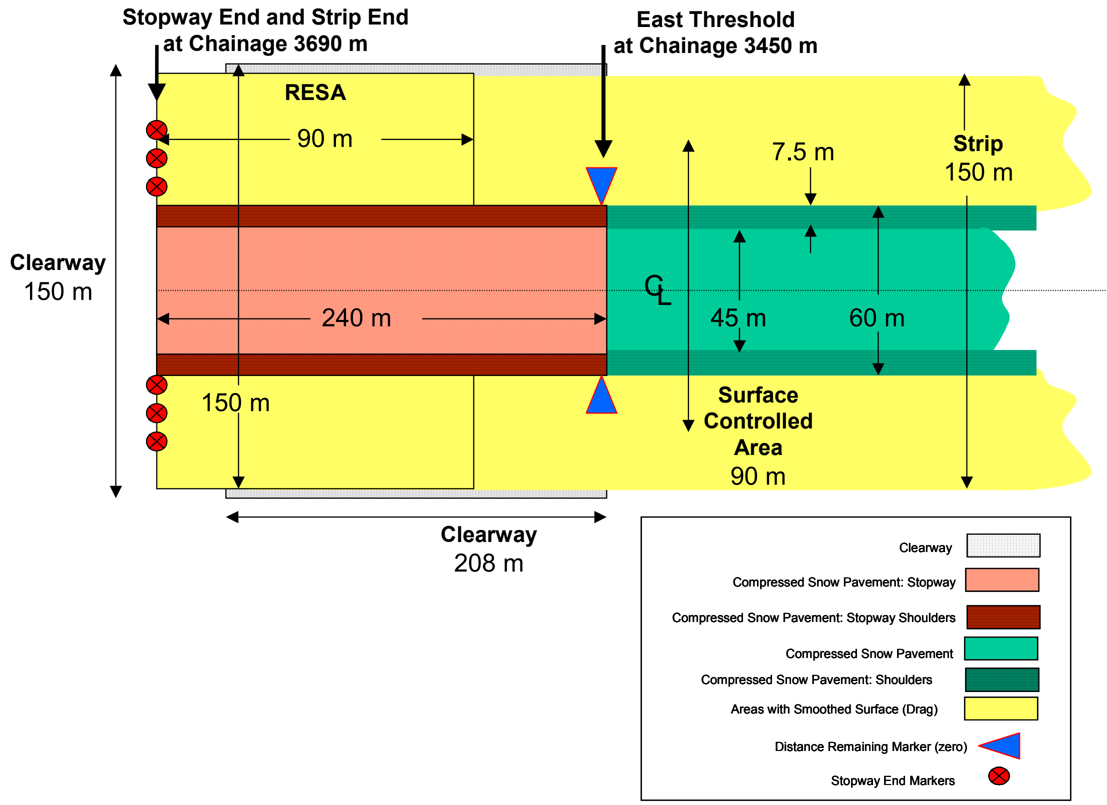
Western (Approach) End



Runway Midsection (Typical)



East (Departure) End



<u>Appendix 3</u>

Environmental Requirements for Aircraft Operations (Draft)

Australian Antarctic Division

ABN 56 428 630 676 GST-registered

Environmental Requirements for aircraft operations

in the Australian Antarctic Territory

Originally published in hard copy September 2000. This most recent version has been substantially modified and new information added to cover DeHavilland Twin Otter(DHC-6) operations in 2003/04. The maps may be accessed from the Australian Antarctic Data Centre's map catalogue via the Australian Antarctic Division website: http://www.aad.gov.au.

Updated and issued August 2003 to include changed distances for flight restrictions due to changes in the type of aircraft being utilised.

Revision due by September 2004

Authorising Officer: Logistics Manager, Australian Antarctic Division.

Document control:
All printed, unnumbered and unsigned copies are 'uncontrolled copies' and need to be checked for currency against the web copy held at http://www-new.aad.gov.au/default.asp?content=dynamic&title=Flight+paths+for+helicopter+operations&casid=2937&docid=2227&type=1&children=

Environment Australia

Department of the Environment and Heritage

Advancing Australia's Antarctic interests

1. User guide

1.1 Purpose

This document has been produced to assist in minimising the potential impacts of aircraft activities on the Antarctic environment. It focuses on the information needs of pilots.

Fixed and rotary wing aircraft operations have the potential to cause disturbance leading to changes in the behaviour, physiology and the breeding success of wildlife. The level of impact will vary according to the intensity, duration and frequency of disturbance, the species involved and the phase in their breeding season. Most species are particularly sensitive to disturbance between late September and early May—the period when Antarctic helicopter and fixed wing operations usually occur. Flying over or landing on or near lakes and vegetation may also result in impacts on the surrounding environments.

Note that these requirements apply to single-engined helicopters and twin-engined fixed wing aircraft. The minimum separation distance for these aircraft from concentrations of wildlife is 750 metres vertically and horizontally. On very rare occasions, AAD may utilise twin-engined helicopters. The separation distances for these aircraft is 1500m from a wildlife concentration. Maps included in these requirements shows the 750m and 1500m zones near known wildlife populations.

1.2 Structure

• Flight restrictions

The 'Flight restrictions' section defines aircraft-related activities that constitute an offence unless an environmental authorisation and/or a permit allowing the activity has been issued, and outlines the process whereby activities may have environmental conditions attached to their conduct.

• Requirements of pilots

Section 3 lists general environment protection measures that all pilots are required to observe.

• Station, Voyage and Field Leader requirements

Station, Voyage and Field Leaders all play an important role in briefing pilots on their environmental responsibilities. This role is outlined in Section 4.

• Wildlife areas—long-range flights

Section 6 outlines known wildlife concentrations that may be encountered on flights between stations. It identifies any detailed maps covering these areas.

• Map index and maps

Grouped according to the closest station, the maps indicate known concentrations of wildlife; designated flight paths; helicopter final approach paths; approved landing and refuelling sites; and Antarctic Specially Protected Areas (ASPAs) and an Antarctic Specially Managed Area (ASMA) (Section 7). The inclusion of wildlife data does not, however, imply that this information is necessarily complete, and locations may vary within or between seasons. Please note that most wildlife concentrations typically occur in ice-free coastal areas, although emperor penguin colonies are typically located on winter sea ice.

Maps should be used for orientation rather than navigation purposes.

1.3 Update and distribution

In line with AAD obligations under the ISO14001 standards, our Environmental Management System is designed to seek continual improvement. This document will be reviewed and updated as required, after the completion of each season's aircraft operations. Updates will be issued to holders of controlled distribution (numbered) copies.

1.4 Environmental documents/information

Information for aspects of aircraft operations in the Australian Antarctic Territory can be found in the following documents:

Operations Manual

Antarctic Flight Instruction Manual (AFIM)

ANARE Field Manual

Helicopter Resources Pty Ltd - Pilot Operations Safety Manual

Kenn Borek Operations Manual

Antarctic Flight Information Manual

AMSA Ship – Helicopter Transfers Australian Code of Safe Practice

The AAD web page www.aad.gov.au/environment also contains additional information in relation to environmental matters.

1.5 Compliance issues/Queries

Difficulties in adhering to these environmental protection measures should be reported to and discussed further with the Station, Voyage or Field Leader, and the Logistics Manager, Australian Antarctic Division (sao@aad.gov.au).

Environmental authorisation queries for aircraft activities should be addressed to ems@aad.gov.au and copied to sao@aad.gov.au.

Aircraft-related permit queries should be addressed to permits@aad.gov.au and copied to sao@aad.gov.au.

Suggested changes to the maps in this document (such as new data on wildlife concentrations) should be referred to sao@aad.gov.au.

2. Flight restrictions

2.1 Environmental authorisations

2.1.1 Operational and scientific activities, and the flying operations necessary to support them, are assessed for their potential for environmental impacts and formally authorised under the *Antarctic Treaty (Environment Protection) Act* [(AT(EP)Act] 1980 (and *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act] as required). Environmental authorisations may also have conditions attached. These may include specific flight paths, refuelling locations, seasonal variations, etc. Aircraft operations are not to be conducted in the Australian Antarctic Territory without an environmental authorisation. However, there are some activities that are exempt from these requirements (i.e. supplying and maintaining a station).

2.1.2 The conduct of certain helicopter and fixed wing aircraft activities (see below) requires a permit under the AT(EP)Act, EPBC Act or Antarctic Seals Conservation Regulations by virtue of their adverse impact on wildlife and the environment. Permits, where issued, are likely to have conditions attached.

2.2 Aircraft-related restrictions

2.2.1 Unless a permit has been obtained, aircraft may not:

- Be used in a way that disturbs a concentration of birds or seals (a concentration is defined in the AT(EP) Act and Regulations as a group of more than 20 animals). In practical terms this means that a single-engine helicopter or twin-engine fixed wing aircraft must operate outside of 2500 ft (about 750 m) horizontally or vertically of a wildlife concentration. If a disturbance is observed at the 750 m boundary, the interfering aircraft must retreat and maintain a greater distance. However, it should be noted that observing disturbance to nesting birds may be difficult to detect at 750 m, except in instances of mass nest abandonment. When in doubt, maintain greater separation distances. A twin-engined helicopter is to ensure that a separation distance of 1500m is not breached.

  **Although it will not always be possible to maintain the prescribed separation distances from southern elephant seals and Adélie penguins when approaching some stations, a permit is not required for this activity so long as controlled flight paths are followed.*

- Land in an Antarctic Specially Protected Area (ASPA). The locations of ASPAs are marked on the maps in this document.
- Do anything in an ASPA that is not permitted in the management plan for the protected area. Copies of management plans for ASPAs are available from the Australian Antarctic Division (AAD) or the AAD's website, and are held onboard AAD-chartered vessels and at Casey, Davis and Mawson Stations. These management plans should be consulted before any flying operations commence.

- Not adhering to the above requirements will constitute an offence under the AT(EP) Act. Exceptions to the above are an emergency situation, or when it is reasonably necessary to do so for the purpose of supplying or maintaining a station.

2.2.2 It is also an offence under Commonwealth law (the EPBC Act) to:

- Operate a helicopter at an altitude lower than 3000 feet within a horizontal radius of 1000m, of a whale (or other cetacean).

- Operate a fixed wing aircraft at an altitude lower than 1000 feet with a horizontal radius of 300m, of a whale (or other cetacean).
- Approach cetaceans head on, or hover over a cetacean, at any altitude.
- Land the aircraft on water and/or sea ice to observe a cetacean, if the aircraft can land on such surfaces.
- Not move away if cetaceans show signs of disturbance, that is, if they undertake immediate or repeated dives or increase their swimming speed.

Aircraft type	Distance from Wildlife Concentration	Distance from Cetaceans
Twin-engined fixed wing aircraft	750m (2500 feet)	300m (1000 feet)
Single-engined helicopter	750m (2500 feet)	1000m (3300 feet)
Twin-engined helicopter	1500m (5000 feet)	1000m

Disclaimer: PILOT COMPLIANCE WITH THE ENVIRONMENTAL REQUIREMENTS LISTED IN THIS DOCUMENT IS SECONDARY TO SAFE AIRCRAFT OPERATION. AIRCREW ARE ASKED TO ADVISE AAD-SHIPPING AND AIR OPERATIONS (SAO) OF ANY CONFLICT AS SOON AS POSSIBLE.

3 . Requirements of pilots

3.1 At all times pilots are expected to:

- Adhere to any environmental authorisation conditions (refer to Section 1.1).
- Adhere to permit conditions; confirm permit status with Station Leader when necessary.
- Observe the flight and approach paths described in this document which describe an area within which disturbance to known concentrations of wildlife will be minimised. Alternative flight paths may be used if listed distances from wildlife are maintained.
- Avoid, where practicable, overflying concentrations of wildlife.
- Where the flight paths are such that a choice exists, approach wildlife concentration sites from down-wind to reduce any disturbance from noise, exhaust fumes and dust.
- Land behind features such as ridge lines, huts and snow banks to help obscure aircraft from wildlife concentrations, where appropriate.
- Fly, land or position cargo in a way that will not result in the significant modification of the habitat or population of any native animal, bird, invertebrate or plant.
- Avoid ‘banking’, particularly in helicopters, as this significantly increases the amount of noise generated.
- Avoid landing on or next to lakes.

- Consider noise impacts if flying under low cloud when near wildlife concentrations.
- Avoid landing or positioning cargo on areas of moss or lichen.
- Restrict refuelling and maintenance activities to designated areas in the field or at the stations.
- Be aware of the location and the application of fuel spill kits and use them whenever necessary.
- Note and avoid the magnetic quiet zones and radio interference zones in the station areas. All sensitive areas are clearly identified in the AFIM.
- Ensure that cargo is secure so items are not inadvertently lost from external loads.
- Make suggestions on, and adopt, any other practical means of minimising the potential environmental impacts of aircraft activities.
- Be aware that flights over Casey station should not be below 750m in single engined helicopters or twin engined fixed wing aircraft or 1500m for twin engined helicopters unless in accordance with an Environmental Authorisation or is required in the course of supplying and maintaining a station.
- Report any incidents. An incident is an occurrence that is not expected in the usual course of events and that has had, or could have had, an adverse effect on human safety or the environment. In the first instance those personnel involved in the incident should report the incident to their Station Leader or Field Leader.

4. Requirements of Station, Voyage and Field Leaders

4.1 Station, Voyage and Field Leaders are responsible for briefing pilots on the environmental impact assessment conditions applicable to each day's flying program associated with the science program or the operational needs of the station or field camp. Briefings must advise on matters specified in any Preliminary Assessment, environmental authorisations, permit conditions, and the requirements specified in this document.

4.2 Station and Field Leaders are required to know the location and appropriate application of fuel spill kits.

4.3 Station, Voyage and Field Leaders are required to know the environmental incident reporting procedure. They must also ensure that any personnel involved in an incident completes the Incident Report Form (kept on the AAD Intranet site) and any other formalities.

5. Wildlife areas—long-range flights

5.1 Known wildlife concentrations between Mawson and Davis

- **Taylor Rookery (ASPA 101)**

Refer to the detailed map in the Mawson map section.

Taylor Rookery is an emperor penguin colony with approximately 3000 pairs. It is one of the few, and is the largest of the two known emperor colonies located wholly on land. The penguins are particularly sensitive to disturbance when they are incubating eggs, from mid-May to mid-July; and from mid-July when feeding chicks to mid-December, when the chicks fledge. However, since penguins are known to be present at the rookery during every month except February (when no recorded expeditions to the rookery have been made) flight restrictions apply year-round.

Helicopters are to approach the area from the east over the sea ice to avoid crossing the path of penguins moving between the colony and the sea. Assuming there is no wildlife on the sea ice, the approach should be made at a low altitude and landings made outside the area (when sea ice conditions permit). When landing outside the area, helicopters should not land, take off or fly within 500 metres of the rookery. If sea ice conditions are not suitable, helicopters are authorised to land in the area, to the north-east, where a headland to the south obscures the colony from view. Helicopters approaching to land in the area must fly as low as possible over the sea ice to avoid disturbing the colony. Overflight of the rookery is prohibited.

- **Auster Rookery**

Auster Rookery is an emperor penguin colony with approximately 10 000 pairs. The colony is on the sea ice and occupies an area of approximately 2 hectares. The most critical period (breeding, moulting) and the period when most birds are present is April to December (inclusive), although some birds may be present throughout the year.

There is a small colony of Adélie penguins at Macey Island.

On approach to Auster Rookery it is important to undertake a visual reconnaissance of the area to ascertain the best flight path and landing site—particularly in later winter/ early summer when the colony breaks up and spreads over a wide area. Approaches should be at a minimum altitude of 750m/2500 feet (1500m/5000feet for twin-engined helicopters) and preferably from the north into the prevailing winds.

- **Scullin and Murray Monoliths**

Refer to the Scullin and Murray Monoliths map in the Mawson map section.

An estimated 50 000 pairs of Adélie penguins occupy the shoreline and lower slopes from October to March (inclusive). All higher slopes are occupied by nesting petrels (Antarctic petrels, southern fulmars, Cape petrels, snow petrels and Wilson’s storm-petrels) from October to April (inclusive). The population of Antarctic petrels, at approximately 150 000 pairs, is the second largest colony of this species known in the Antarctic. South polar skuas also breed at Scullin Monolith. Flying within the amphitheatre or near its rim would constitute disturbance and is therefore not permitted.

Given the high sensitivity of wildlife at Murray Monolith, it is highly unlikely that a permit allowing flying in the area would be granted.

- **Béchervaise and Welch Islands**

In excess of 22 000 pairs of Adélie penguins breed annually on the rocky islands within 10 km radius of Mawson station. The colony on one of these islands, Béchervaise Island, consists of 1800 pairs, located on the north-eastern tip of the island. These sub-colonies range in size from one breeding pair to approximately 250 pairs.

Approximately 16 000 pairs breed on Welch Island, distributed among multiple sub-colonies on the north-western corner of the island. Approaches to Welch Island should be made at low altitude.

- **Cape Darnley**

There is an emperor penguin colony on the sea ice close to Cape Darnley (approximately 5000 pairs).

- **Larsemann Hills**

Refer to the detailed map in the Davis map section.

Snow petrels and Wilson's storm-petrels nest throughout the Larsemann Hills. There are concentrations of snow petrels on Base Ridge, approximately 350 m east of Law Base, and on rocky outcrops beside the Dalk Glacier. Landings at Law Base do not require a permit on the basis that they are actions necessary for the purposes of supplying and operating a station. As elsewhere, helicopter landings should be restricted to the existing landing sites— Law Base (immediately near the drum refuelling site), Zhong Shan and Progress 2 on Broknes Peninsula, and on the north-east of Stornes Peninsula. In particular, the petrel nesting sites marked on the map should not be overflown from November to March (inclusive).

- **Amanda Bay**

There is an emperor penguin colony at Amanda Bay (approximately 10 000 pairs).

- **Rauer Group**

Refer the detailed maps in the Davis map section. The Rauer Group are known to be highly sensitive and contain a large concentration of seabirds (105 000 pairs). Note that a management plan for the islands may be drafted in 2003.

5.2 Known concentrations between Davis and Casey

- **Haswell Island**

Haswell Island is approximately 3 km to the north of Mirny station (Russian Federation) and supports nesting populations of Adélie penguins, Cape petrels, snow petrels, Antarctic petrels, Wilson's storm-petrels, Antarctic fulmars and south polar skuas. Emperor penguins breed on the sea ice approximately 1.3 km to the north-east of the island.

- **Edgeworth David / Bunger Hills**

Low numbers of birds are believed to breed in the area between November and February. During this time flight paths should be over the sea ice rather than over the land.

- **Snyder Rocks and Davis Islands**

There are no known nesting sites at Snyder Rocks. However, snow petrels, Adélie penguins, Wilson's storm-petrels, south polar skuas, Cape petrels and Antarctic fulmars nest on the Davis Islands, 28 km north-east of Snyder Rocks.

- **Petersen Bank**

There is an emperor penguin colony at Petersen Bank (approximately 2000 pairs present from April-December).

- **Ardery and Odbert Islands**

Ardery and Odbert Islands are home to large breeding populations of snow petrels, Cape petrels, Antarctic petrels, southern fulmars, Wilson's storm-petrels and south polar skuas. Odbert Island also supports large populations of Adelie penguins (approximately 10 000 breeding pairs).

- **Frazier Islands**

The Frazier Islands hold the largest known breeding population of southern giant petrels in continental Antarctica (approximately 248 pairs in 2001/02). Breeding pairs are found on all three of the Frazier Islands (Nelly, Dewart and Charlton islands), with the largest population on Dewart Island. The breeding season usually commences between late October and mid-November and extends through to April, when the chicks fledge. Snow petrels, Adélie penguins, Wilson's storm-petrels, south polar skuas, Cape petrels and Antarctic petrels and southern fulmars also breed on the Frazier Islands, with approximately 1000 pairs of Adélie penguins nesting on Nelly Island.

- **Clark Peninsula**

Adélie penguins are abundant on the Clark Peninsula, with at least 7 500 breeding pairs counted at Whitney Point (2002/03) and 4 600 breeding pairs at Blakeney Point (1990/91). Wilson's storm-petrels, snow petrels and south polar skuas also breed within the area.

5.3 Known concentrations west of Mawson

- **Rookery Islands**

The Rookery Islands support the largest Adélie penguin population on the Mac.Robertson Coast. Cape petrels, south polar skuas, snow petrels and Wilson's storm-petrels also breed there. Giganteus Island is one of three southern giant petrel nesting sites in East Antarctica; only two pairs were breeding there in 1999.

- **Gibbney Island**

Adélie penguins occupy the entire island. Overflight should be avoided and landing is prohibited.

- **Low Tongue**

Adélie penguins occupy most of the rocky sites. The only suitable potential landing site is the tip of Low Tongue Prominence.

- **Ufs Island**

There is an Adélie penguin colony on the northern end of Ufs Island. Snow petrels also nest in the area and non-breeding skuas are often present. Approaches should be from the south-south-east.

- **Kidson Island**

No landing should occur on Kidson Island, which is only 0.8 km long. The island is home to nesting Adélie penguins, Antarctic fulmars and Cape petrels. Skuas and Wilson's storm-petrels have also been reported.

6. Map index

The maps are based on a universal transverse meracator (UTM) projection which is conformal and preserves shape for small objects, such as depicted in the maps of individual islands. True direction is not maintained on the maps and they should only be used for orientation rather than navigation purposes.

6.1 Casey

North-eastern Bailey Peninsula

Clark Peninsula

Frazier Islands

6.2 Davis

Vestfold Hills and Davis

Vestfold Hills and Davis—main wildlife concentrations

Vestfold Hills and Davis—separation distances

Davis helicopter approach paths

Davis station— helicopter final approach

Magnetic, Turner and Bluff Islands

Hawker Island area

Long Peninsula, Long Fjord

Tryne and Wyatt Earp Islands

Marine Plain

Rauer Group—wildlife marked

Rauer Group—separation distances

Hop and Filla Islands

Larsemann Hills

6.3 Mawson

Mac.Robertson Land coast and Mawson

Mac.Robertson Land coast and Mawson—main wildlife concentrations

Mac.Robertson Land coast and Mawson—separation distances

Mawson helicopter approach paths

Mawson station— helicopter final approach

Béchervaise and Welch Islands

Taylor Rookery

Rookery Islands

Scullin and Murray Monoliths

6.4 Other areas

Cape Denison

All aircraft operations to Mawson's Huts at Cape Denison, Commonwealth Bay require a permit. Note that Cape Denison itself has been designated an Antarctic Specially Managed Area (ASMA); the helicopter landing site is located within the ASMA and all precautions must apply to operations within this area.

Appendix 4

Species List

Appendix 4: Listed and important species

Birds
Spheniscidae

Common name	Scientific name	EPBC List status (threatened and migratory)	Occurrence in area of operations	Specific locations in area of operations (breeding)
Emperor penguin	*Aptenodytes forsteri*	Not listed	Breeds in Antarctica Southern ocean	All known colonies in AAT are listed. Entries in bold are closest to stations and airfield locations. • Enderby Land, Casey Bay (67º30'S, 48ºE) • Enderby Land, Amundsen Bay (66º55'S, 50ºE) • Enderby Land, Kloa Pt (66º37'58"S, 57º19'E) • Enderby Land, Fold I (67º19'58"S, 59º22'58"E) • **Kemp Land, Taylor Glacier (67º28'1"S, 60º52'58"E) (90km W of Mawson Station)** • **Kemp Land, Auster Rookery (67º22'58"S, 64º1'58"E) (51km ENE of Mawson Station)** • Mac.Robertson Land, Cape Darnley (Flutter Rookery) (67º49'58"S, 69º45'E) • Princess Elizabeth Land, Sandefjord Bay (69º40'1", 73º19'58") • **Princess Elizabeth Land, Amanda Bay (69º16'1"S, 76º49'58"E) (90km W of Davis Station)** • Princess Elizabeth Land, Penguin I, 3 colonies (65º55'1"S, 81º55'1"E) • Princess Elizabeth Land, Karelin Bay (65º30'S, 85º30'E) • Princess Elizabeth Land, Gaussberg (66º13'1"S,89º34'58"E) • Princess Elizabeth Land, Haswell I (66º32'59"S, 92º58'1"E) • Queen Mary Land, Shackleton Ice Shelf (64º40'1"S, 97º30'E) • Queen Mary Land, Bowman I (65º4'58", 102º49'58") • **Wilkes Land, Peterson Bank (65º55'58"S, 110º12'E) (44km NNW of Casey Station)**

				• Wilkes Land, Pte Geologie (66º40'1"S, 140º1'1"E) • Wilkes Land, Ninnis Glacier (68º12', 147º11'59"E) • Oates Land, Wilson Hills (69º40'1"S, 158º30'E)
Adelie penguin	*Pygoscelis adeliae*	Not listed	Breeds in Antarctica Southern ocean	Colonies on ice free areas throughout AAT. • Casey – Islands and peninsulas in Windmill Island Group • Davis – Islands and coast of the Vestfold Hills and Rauer Group • Mawson – coastal islands and ice free areas throughout region
Royal Penguin	*Eudyptes schlegeli*	Not listed	Southern ocean	
Rockhopper Penguin	*Eudyptes chrysocome*	Not listed	Southern ocean	
Macaroni Penguin	*Eudyptes chrysolophus*	Not listed	Southern ocean	
King Penguin	*Aptenodytes patagonicus*	Not listed	Southern ocean	
Gentoo penguin	*Pygoscelis papua*	Not listed	Southern ocean	
Chinstrap Penguin	*Pygoscelis antarctica*	Not listed	Southern ocean	

Hydrobatidae

Common name	**Scientific name**	**List status (threatened and migratory)**	**Occurrence in area of operations**	**Specific locations (breeding, congregating)**
Wilson's storm petrel	*Oceanites oceanicus* *Oceanites oceanicus oceanicus* (subantarctic)	Listed migratory (*Oceanites oceanicus)*	Breeds in Antarctica Southern ocean	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region.
White-faced storm	*Pelagodroma*	Not listed	Southern ocean	

petrel	*marina*			
Black-bellied storm petrel	*Fregetta tropica*	Not listed	Southern ocean	
White-bellied storm petrel	*Fregetta grallaria* *Fregetta grallaria grallaria* (Tasman Sea, Australasian)	Listed Vulnerable (*Fregetta grallaria grallaria*)	Southern ocean	

Laridae

Common name	**Scientific name**	**List status (threatened and migratory)**	**Occurrence in area of operations**
Antarctic tern	*Sterna vittata* *Sterna vittata bethunei* (New Zealand) *Sterna vittata vitatta* (Indian Ocean)	 Listed vulnerable (*S. vittata bethunei*) Listed endangered (*S. vittata vittata*)	Southern ocean
Arctic tern	*Sterna paradisaea*	Listed migratory (Atlantic populations only)	Southern ocean
Kelp gull	*Larus dominicanus*	Not listed	Southern ocean

Stercorariidae

Common name	Scientific name	**List status (threatened and migratory)**	**Occurrence in area of operations**	**Specific locations (breeding, congregating)**
Antarctic skua	*Catharacta maccormicki / Stercorarius maccormicki*	Listed migratory as *Stercorarius maccormicki*	Southern ocean Breeds in Antarctica	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region.
Great Skua / Subantarctic skua	*Catharacta skua*	Not listed	Southern ocean	
Pomarine Jaeger Pomerine Skua	*Stercorarius pomarinus*	Listed migratory	Southern ocean	
Parasitic Jaeger / Arctic Jaeger / Arctic Skua	*Stercorarius parasiticus*	Listed migratory	Southern ocean	
Long-tailed Jaeger / Long-tailed Skua	*Stercorarius longicauda*	Listed migratory	Southern ocean	

Diomedeidae

Common name	**Scientific name**	**List status (threatened and migratory)**	**Occurrence in area of operations**
Amsterdam albatross	*Diomedea amsterdamensis*	Listed migratory Listed endangered	Southern ocean
Wandering albatross	*Diomedea exulans (*prev. *Diomedea exulans exulans)*	Listed migratory Listed vulnerable	Southern ocean
Southern Royal albatross	*Diomedea epomophora (*prev. *Diomedea epomophora epomophora)*	Listed vulnerable Listed migratory	Southern ocean

Light-mantled sooty albatross	*Phoebetria palpebrate*	Listed migratory	Southern ocean
Sooty albatross	*Phoebetria fusca*	Listed migratory Listed vulnerable	Southern ocean
Atlantic yellow-nosed albatross / Yellow-nosed albatross	*Thalassarche chlororhynchos (*prev. *Diomedea chlororhy chlororhynchos)*	Listed migratory (as *Diomedea chlororhynchos*)	Southern ocean
Buller's albatross	*Thalassarche bulleri* *(*prev. *Diomedea bulleri bulleri)*	Listed migratory (as *Diomedea bulleri*) Listed vulnerable	Southern ocean
Grey-headed albatross	*Thalassarche chrysostoma* *(*prev. *Diomedea chrysostoma)*	Listed migratory (as *Diomedea chrysostoma*) Listed vulnerable	Southern ocean
Black-browed albatross / Southern Black-browed albatross	*Thalassarche melanophrys* *(*prev. *Diomedea melanophrys melanophrys)*	Listed migratory (as *Diomedea melanophris*)	Southern ocean
Campbell albatross / Northern Black-browed albatross	*Thalassarche impavida (*prev. *Diomedea melanophrys impavida)*	Listed vulnerable	Southern ocean
Shy albatross	*Thalassarche cauta* *(*prev. *Diomedea cauta cauta)*	Listed migratory (as *Diomedea cauta*) Listed vulnerable	Southern ocean
Salvin's albatross	*Thalassarche salvini* *(*prev. *Diomedea cauta salvina)*	Listed vulnerable	Southern ocean
White-capped albatross	*Thalassarche steadi (*prev. *Diomedea cauta cauta)*	Listed vulnerable Listed migratory (as *Diomedea cauta*)	Southern ocean
Chatham albatross	*Thalassarche eremita* *(*prev. *Diomedea cauta eremita)*	Listed endangered	Southern ocean

Procellariidae

Common name	Scientific name	List status (threatened and migratory)	Occurrence in area of operations	Specific locations (breeding, congregating)

Southern giant petrel	*Macronectes giganteus*	Listed migratory species Listed endangered species	Breeds in Antarctica. Southern ocean	Windmill Islands: Frazier Islands, breeding Davis area: Hawker Island (breeding), Long Peninsula (non-breeding) Hop Island, Rauer Group (non-breeding) Mawson Area: Rookery Islands – Giganteus Island (breeding)
Southern fulmar	*Fulmarus glacialoides*	Not listed	Breeds in Antarctica Southern ocean	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region
Antarctic petrel	*Thalassoica antarctica*	Not listed	Breeds in Antarctica Southern ocean	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region
Cape petrel	*Daption capense* *Daption capense capense* (southern)	Not listed	Breeds in Antarctica Southern ocean	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region
Snow petrel	*Pagodroma nivea* *Pagodroma nivea confusa*	Not listed	Breeds in Antarctica in ice free areas Sea ice zone Southern ocean	Coastal ice free areas throughout AAT including Vestfold Hills, Windmill Islands, Mawson region
Northern giant petrel	*Macronectes halli*	Listed migratory species Listed vulnerable species	Southern ocean	
Sooty shearwater	*Puffinus griseus*	Listed migratory	Southern ocean	
Short-tailed shearwater	*Puffinus tenuirostris*	Listed migratory	Southern ocean	
Fluttering shearwater	*Puffinus gavia*	Not listed	Southern ocean	
Little shearwater	*Puffinus assimilis*	Not listed	Southern ocean	
Great-winged petrel	*Pterodroma macroptera* *Pterodroma*	Not listed	Southern ocean	

	macroptera gouldii			
White-headed petrel	*Pterodroma lessonii*	Not listed	Southern ocean	
Mottled petrel	*Pterodroma inexpectata*	Not Listed	Southern ocean	
Kerguelen petrel	*Lugensa brevirostris*	Not listed	Southern ocean	
Soft-plumaged petrel	*Pterodroma mollis* *Pterodroma mollis deceptornis* (northern)	Listed vulnerable	Southern ocean	
Gould's petrel	*Pterodroma leucoptera* *Pterodroma leucoptera leucoptera*	Listed migratory (*leucoptera*) Listed endangered (*leucoptera*)	Southern ocean	
Blue petrel	*Halobaena caerulea*	Listed vulnerable	Southern ocean	
Grey petrel	*Procellaria cineria*	Listed migratory	Southern ocean	
Great shearwater	*Puffinus gravis*	Not listed	Southern ocean	
Cory's shearwater	*Calonectris diomedea*	Not listed	Southern ocean	
Pink-footed shearwater	*Puffinus creatopus*	Not listed	Southern ocean	
Flesh-footed shearwater	*Puffinus carneipes*	Listed migratory	Southern ocean	
Parkinson's petrel	*Procellaria parkinsoni*	Listed migratory	Southern ocean	
Westland petrel	*Procellaria westlandica*	Listed migratory	Southern ocean	
White-chinned petrel	*Procellaria aequinoctialis*	Listed migratory	Southern ocean	
Spectacled petrel	*Procellaria conspicillata*	Listed migratory	Southern ocean	
Common diving-petrel	*Pelecanoides urinatrix*	Not listed	Southern ocean	

South Georgia diving-petrel	*Pelecanoides georgicus*	Not listed	Southern ocean	
Antarctic prion	*Pachyptila desolata*	Not listed	Southern ocean	
Broad-billed Prion	*Pachyptila vittata*	Not listed	Southern ocean	
Narrow-billed Prion / Slender-billed Prion	*Pachyptila belcheri*	Not listed	Southern ocean	
Fulmar Prion	*Pachyptila crassirostris* *Pachyptila crassirostris eaton* (southern)	Not listed	Southern ocean	
Fairy Prion	*Pachyptila turtur* *Pachyptila turtur subantarctica* (southern)	Not listed	Southern ocean	
Salvin's Prion	*Pachyptila salvini*	Not listed	Southern ocean	

Seals

Common name	**Family**	**Scientific name**	**List status (threatened and migratory)**	**Locations in area of operation**
Southern elephant seal	Phocidae	*Mirounga leonina*	Listed vulnerable	Hauled out for moulting on ice free land at Casey and Davis. Southern ocean.
Crabeater seal	Phocidae	*Lobodon carcinophagus*	Not listed	Rest, breed and moult on sea ice, haul out on land throughout AAT. Southern ocean.
Antarctic fur seal	Otariidae	*Arctocephalus gazella*	Not listed	Southern ocean.

Hooker's sea lion	Otariidae	*Phocarctos hookeri*	Not listed	Southern ocean.
Leopard seal	Phocidae	*Hydrurga leptonyx*	Not listed	Hauled out on sea ice, land throughout AAT. Southern ocean.
Weddel seal	Phocidae	*Leptonychotes weddelli*	Not listed	Fast ice zone, hauled out on sea ice to rest, moult and pup throughout AAT. Southern ocean
Ross seal	Phocidae	*Ommatophoca rossi*	Not listed	Pack ice and coastal ice throughout AAT. Southern ocean.
Sub-antarctic fur seal	Otariidae	*Arctocephalus tropicalis*	Listed vulnerable	Southern ocean.
Australian fur seal	Otariidae	*Arctocephalus pusillus*	Not listed	Southern ocean.
New Zealand fur seal	Otariidae	*Arctocephalus forsteri*	Not listed	Southern ocean.

Cetaceans

Common name	Family	Scientific name	List status (threatened and migratory)
Southern right whale	Balaenidae	*Eubalaena australis*	Listed endangered Listed migratory (as *Balaena glacialis australis*)
Pygmy right whale	Neobalaenidae	*Caperea marginata*	Not listed
Minke whale	Balaenopteridae	*Balaenoptera acutorostrat*	Not listed
Sei whale	Balaenopteridae	*Balaenoptera borealis*	Listed vulnerable
Blue whale	Balaenopteridae	*Balaenoptera musculus*	Listed migratory Listed endangered
Fin whale	Balaenopteridae	*Balaenoptera physalus*	Listed vulnerable
Humpback whale	Balaenopteridae	*Megaptera novaeangliae*	Listed migratory Listed vulnerable

Sperm whale	Physeteridae	*Physeter macrocephalus*	Not listed
Pygmy sperm whale	Kogiidae	*Kogia breviceps*	Not listed
Gray's beaked whale	Ziphiidae	*Mesoplodon grayi*	Not listed
Andrews' beaked whale	Ziphiidae	*Mesoplodon bowdoini*	Not listed
True's beaked whale	Ziphiidae	*Mesoplodon mirus*	Not listed
Cuvier's beaked whale	Ziphiidae	*Ziphius cavirostris*	Not listed
Hector's beaked whale	Ziphiidae	*Mesoplodon hectori*	Not listed
Shepherd's beaked whale	Ziphiidae	*Tasmacetus shepherdi*	Not listed
Arnoux's beaked whale	Ziphiidae	*Berardius arnuxii*	Not listed
Blainville's beaked whale	Ziphiidae	*Mesoplodon densirostris*	Not listed
Strap-toothed beaked whale	Ziphiidae	*Mesoplodon layardii*	Not listed
Southern bottlenose whale	Ziphiidae	*Hyperoodon planifrons*	Not listed
Killer whale	Delphinidae	*Orcinus orca*	Not listed
False killer whale	Delphinidae	*Pseudorca crassidens*	Not listed
Long-finned pilot whale	Delphinidae	*Globicephala melas*	Not listed
Short-finned pilot whale	Delphinidae	*Globicephala macrorhynch*	Not listed
Dusky dolphin	Delphinidae	*Lagenorhynchus obscurus*	Listed migratory
Hourglass dolphin	Delphinidae	*Lagenorhynchus cruciger*	Not listed
Risso's dolphin	Delphinidae	*Grampus griseus*	Not listed
Bottlenose dolphin	Delphinidae	*Tursiops truncatus*	Not listed
Common dolphin	Delphinidae	*Delphinus delphis*	Not listed
Southern right whale dolphin	Delphinidae	*Lissodelphis peronii*	Not listed
Spectacled porpoise	Phocoenidae	*Australophocoena dioptric*	Listed migratory as *Phocoena dioptrica*

Listed fishes

Common name	**Scientific name**	**List status (threatened and migratory)**
White shark	*Carcharodon carcharius*	Listed vulnerable
Grey Nurse shark	*Carcharius taurus*	Listed vulnerable

Appendix 5

Likely Impacts Table

Appendix 5: Potential impacts

Notes on Table:

'Duration of impact' refers to individual impact events.

'Frequency of impact' indicates how regularly an individual impact event is likely to occur. This provides an indication of whether a particular impact is likely to have a cumulative dimension, where the impact event may in itself have only a short duration.

'Likelihood of impact' is likelihood after any measures that will be used to minimise or remove risk of impact are taken into account (as noted in 'Comments').

Source of impact	**Type of impact**	**Likelihood of impact** L- low, unlikely to occur M - medium, impact may occur H - high, impact is likely to occur C - certain, impact is unavoidable	**Frequency** VI - very infrequent I - infrequent, occur only occasionally R - regularly, will occur with operations O - ongoing, will occur continuously	**Duration of impact** T - transitory, evidence of impact does not persist S - short , evidence of impact may persist up to a few months M - medium, evidence of impact persists one or two years L - long, evidence of impact persists more than a few years	**Comments**
Flight operations – inter-continental, intra-continental, Davis helicopter link	Disturbance of wildlife (noise and visual presence)	L	I	T	Operations can be planned to minimise or eliminate impact. Noise footprint modelling will be used to develop flight guidelines and routes that do not disturb wildlife. Monitoring for impacts will be conducted according to any requirements identified in further assessments.
	Emissions (gases, aerosols, particulates, trace metals - atmospheric and surface	C	R	L	Fuel consumed will be minimised by efficient operations. Monitoring of impacts of contaminants

	effects)				will be carried out according to any requirements identified in further assessments.
	Contamination of surfaces and runoff (unburnt hydrocarbons, particulates, rubber, lubricants)	C	R	L	Low levels of contamination of snow and ice will occur from air operations. Further assessment will examine methods of managing and recovering surface contamination.
	Species introductions to Antarctica or transfers between Antarctic locations	L	Not predictable	L	Quarantine management procedures will be implemented. Contingency response plans and equipment will be maintained.
	Bird strike	L	VI	T	Operational locations and flight paths will be in areas remote from flying birds.
	Enhanced ability to monitor and respond to environmental emergencies (positive impact)	N/A	N/A	N/A	The air transport system will provide a capability to provide more rapid response for environmental emergencies.
All operations	Reduction in wilderness and aesthetic values (previously visited field deployment areas)	C	R	T	Non-permanent facilities will be used in field locations.
	Reduction in wilderness and aesthetic values of presently used locations (regular use of airfield locations)	C	R	M	Non-permanent facilities will be used.
	Reduction in wilderness and aesthetic values of presently unused locations (occasional use	C	I	T	Non-permanent facilities will be used in field locations. Access to pristine sites will be managed.

	of field locations)				Records of all areas used will be maintained.
Vehicle use at airfields and service routes, airfield power generation	Disturbance of wildlife (noise)	L	VI	T	Airfields and service routes are remote from wildlife.
	Emissions (gases, aerosols, particulates, trace metals - atmospheric and surface effects)	C	R	L	Fuel consumption will be minimised. Alternative energy sources will be used where possible. Monitoring of impacts of contaminants will be carried out according to any requirements identified in further assessments.
	Surface contamination of access routes (soil, fuel, lubricants, transfer of soil).	M	R	L	Vehicle and equipment cleaning protocols will be applied as part of quarantine management.
Site modification - airfield surfaces and routes	Compaction and disturbance of snow and ice on airfield surfaces and access routes	C	R	S (sea ice) M (plateau locations)	The extent of the areas to be used will be minimised.
	Compaction, disturbance of rock and soil, and dust creation on presently used roads in and around stations	C	R	L	Existing routes in and around stations, including existing station roads, will be used. This use will represent a small proportion of total use. No new routes on ice free areas are required.
Equipment installations (navigation, lighting, markers, communications, weather stations)	Compaction and disturbance of snow and ice	C	R	S (sea ice) M (plateau locations)	The extent of the areas to be used will be minimised.
	Bird strike (injury / mortality)	L	VI	T	Bird concentrations and flight paths will be considered when designing and placing facilities.

Site modification: facilities in areas of ice and snow	Compaction and disturbance of snow and ice	C	O	S (sea ice) M (plateau locations)	The extent of the areas to be used will be minimised.
Minor site modification: facilities in ice free areas	Modification of small areas of rock or soil surfaces, impact on biotic communities	C	O	L	Use of locations free of and distant from vegetation will prevent impact. Previously disturbed areas are available and will be used. Minor rock and soil surface modification will occur.
	Dust generation (construction, access and placement)	C	I	L	Previously modified areas will be used. Activities will be managed to minimise dust generation.
Davis plateau camp facility	Compaction and disturbance of snow and ice	C	O	M	The extent of the areas to be used will be minimised.
	Bird strike (injury / mortality) (structures and installations)	L	VI	S	Facility is distant from wildlife concentrations. Bird concentrations and flight paths will be considered when designing and placing facilities.
	Disturbance of wildlife (noise)	L	VI	S	Facility is distant from wildlife concentrations.
	Emissions (gases, aerosols, particulates, trace metals - atmospheric and surface effects)	C	R	L	Fuel consumption will be minimised. Alternative energy sources will be used where possible. Monitoring of impacts of contaminants will be carried out according to any requirements identified in further assessments.
	Waste generation (human, kitchen, greywater, solid rubbish)	C	O	S	All wastes will be removed from operating locations for treatment on station or return to

					Australia.
Fuel, lubricant and other contaminant storage and handling (delivery, transfer, refuelling, storage station/depot, storage airfield, waste fluid management, maintenance activity, aircraft accident)	Contamination of ice or snow from fuel or contaminant spill – eventual additional impacts on ice free, marine or freshwater ecosystems	L (major spill) H (minor spill)	Not predictable (major I (minor spill)	L	Fuel management plans and protocols will be used. Contingency plans and equipment will be developed and maintained.
	Contamination of soil, rock or gravel surfaces and subsurfaces, vegetation or terrestrial fauna, from fuel or contaminant spill on ice free land – eventual impact on marine or freshwater ecosystems	L (major spill) H (minor spill)	Not predictable (major I (minor spill)	L	Fuel management plans and protocols will be used. Contingency plans and equipment will be developed and maintained.
	Direct contamination and ongoing toxicity effects on marine flora and fauna and ecosystems and associated terrestrial ecosystems from coastal marine fuel or contaminant spill	L (major spill) L (minor spill)	Not predictable (major I (minor spill)	L	Fuel management plans and protocols will be used. Contingency plans and equipment will be developed and maintained.
	Direct contamination and ongoing toxicity effects on marine flora and fauna and ecosystems from offshore marine fuel or contaminant spill (transport phase)	L (major spill) L (minor spill)	VI	L	Use appropriate ships for fuel transport. Fuel management plans and protocols will be used. Contingency plans and equipment will be developed and maintained.
	Contamination and ongoing toxicity effects on lake or stream ecosystems from fuel or contaminant spill in catchment	L (major spill) L (minor spill)	VI	L	As far as possible fuel will not be stored or handled in lake or stream catchments - Davis plateau airfield sites may drain to ice free areas, and fuel

					management plans and contingency plans will take this into account. Fuel management plans and protocols will be used. Contingency plans and equipment will be developed and maintained.
Construction and maintenance of airfields	Emissions (gases, aerosols, particulates, trace metals - atmospheric and surface effects) from vehicles and power generation	C	R	L	Fuel consumption will be minimised. Alternative energy sources will be used where possible. Monitoring of impacts of contaminants will be carried out according to any requirements identified in further assessments.
	Disturbance of wildlife - vehicle and camp operations	L	VI	S	Airfields will be distant from wildlife concentrations.
	Contamination of surfaces and runoff (unburnt hydrocarbons, particulates, rubber, lubricants)	C	R	L	Low levels of contamination of snow and ice will occur from construction and maintenance operations. Further assessment will examine methods of managing and recovering surface contamination.
Increased access to remote areas, increase in field science	Species introductions to new areas	L	Not predictable	L	Quarantine management procedures will be implemented. Contingency response plans and equipment will be developed and maintained.
	Reduction or loss of scientific values associated with change to	C	I	L	Access to pristine sites will be managed. Records of all areas used will

	pristine character of previously unused locations				be maintained.
Transition to different logistics system	Reduced effectiveness of science and support capability during development period	M	Single event	M	Phased implementation of the air transport system will reduce problems associated with transition.
Increase in Australian Antarctic Program personnel, periodic or ongoing	Periodic or continued increased emissions, energy consumption, waste volumes, transport requirements. Impacts associated with human presence increased proportional to personnel numbers	C	O	S	Periodic increases are certain. Air transport will make ongoing increases possible, subject to change in present policy. Any change to expand program significantly would require reconsideration of environmental impacts.

Appendix 6

Noise emissions for C212 and Falcon 900EX at Antarctic landing areas

ANTARCTIC AIR SERVICES

NOISE EMISSIONS FOR CN 212 AND FALCON 900EX AT ANTARCTIC LANDING AREAS

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CONTENTS

1. INTRODUCTION

The Australian Antarctic Division of the Department of Environment and Heritage has entered into a contract with Skytraders to provide an inter-continental air service between Antarctica and Australia, and to upgrade air transport services within Antarctica. The inter-continental air service will utilise a Dassault Falcon F900EX tri-jet aircraft, and will travel non-stop between Hobart and a newly prepared blue-ice strip located on the Antarctic inland from Casey Station. The intra-continental services will utilise two Casa CN212-400 twin turboprop aircraft and will also operate out of the intercontinental strip as well a number of other sea-ice and plateau based strips near the coast, in proximity to each of Casey, Davis and Mawson stations. Intra-continental services will also be provided from these sites to many field party locations and a variety of other destinations in Antarctica.

As part of the assessment of the environmental impact of the introduction of these services, and given the proximity of some of the airstrips and skiways to noise sensitive wildlife habitats, the Australian Antarctic Division (AAD) commissioned the preparation of noise emission data for the new air service operations. This work was conduced by the Ambidji Group Pty Ltd, as part of its period contract to AAD for specialist aviation advice. Ambidji was assisted in this through noise modelling services provided by Wilkinson Murray Pty Ltd.

The results of this analysis are presented in the following material, together with a description of the operational environment upon which the model is based, and a description of the noise model and its limitations. Also provided is a brief commentary on the results of the modelling and particularly issues related to the management of noise emissions in environmentally sensitive areas near the airstrips.

2. ASSUMPTIONS - OPERATIONAL CHARACTERISTICS OF AIR SERVICES

2.1 Antarctic Air Strips

For inter-continental services, a 4km long east-west glacial blue-ice runway is being constructed some 65km south east of Casey station, and will be serviced from Casey by both aircraft and surface transport access. It is proposed that the within-Antarctica services will be based on strips somewhat closer to Casey, one just south of the Station, and another slightly inland, both predominantly east-west in orientation.

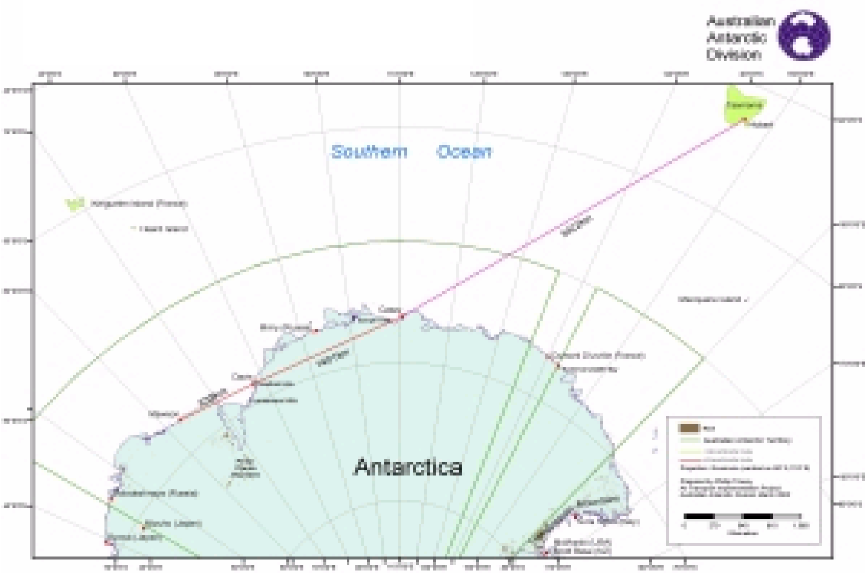


Figure 1 Air Routes and Locations Served
Source: AAD

Fixed wing services at the other two stations will only be provided by the CN 212. At each station there are be two strips proposed for the service. At Davis, one strip is located on the plateau, some 30 km inland, with the other is a seasonal strip located on sea ice just west of the Station. Both have a north-east/south-west orientation. At Mawson there is again an inland strip and a sea ice strip, both adjacent to the station, and both with a north-east/south-west orientation.

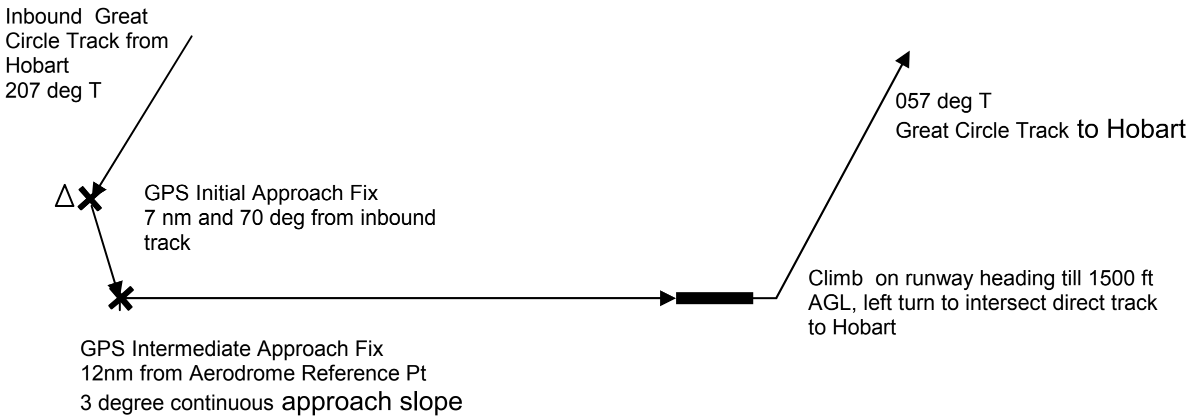
The geographic coordinates and orientations of most of the strips adopted for this analysis are given in Appendix A, as provided by AAD, or as derived from maps. These points are approximate only, in that the locations may vary from season to season depending upon ice strength and winter snow build-up. There are also many other locations where skiways have been constructed in the past for Twin Otter services and have been used for some years. These strips have not been considered in this analysis. Also, there are extensive helicopter operations conducted in the vicinity of the Stations and the proposed airstrips and skiways, and helicopters are expected to be a predominant logistics tool, supporting the fixed wing operations. The analysis here does not extend to helicopter operations.

2.2 International Operations

The operational scenario for international flights arriving at the Casey blue-ice landing area is based upon the Falcon aircraft tracking direct from Hobart to Casey utilising a great circle track. It is assumed that upon arrival at Casey, Falcon flights will operate entirely in accordance with the Instrument Flight rules, and will enter into a non-precision Global Positioning System (GPS) based instrument approach. It is understood that GPS procedure designs have yet to be produced for Antarctica. In the absence of these, a notional approach sequence was modelled, based upon the methodology adopted by the Australian Civil Aviation Safety Authority for the design of GPD non-precision approach procedures[1].

A GPS approach procedure typically allows for aircraft to commence an approach at any one of three Initial Approach Fixes (IAF's). These are at a point around 15 to 17nm from the threshold for a straight in approach, and at points 7nm either side of the approach path, intersecting the approach path at 70 degrees at around 10 to 12 nm from the threshold. For simplicity of modelling, the aircraft is assumed to travel on a direct track from Hobart to the northern-most Initial Approach Fix as shown in Figure 2. In practice aircraft would most likely track direct to the airstrip, and when near the destination, divert from track direct to the IAF, at the same time conforming to track keeping rules and minimum safe altitude criteria. For noise modelling purposes this assumption has no limiting effect since the aircraft is at a considerable altitude until the approach has commenced.

At the IAF the aircraft will be in approach configuration, and when aligned with the final approach path, will descend to the runway at an approach angle of 3 degrees to the plane of the runway. Upon landing the aircraft is assumed to operate with full reverse thrust until reducing to taxi speed.



Location	Approach Slope						
Dist from site (nm)	12	10	8	6	3	2	0
Altitude above Aerodrome Threshold	3,791	3,160	2,528	1,896	948	632	0
Altitude above AMSL	6,087	5,456	4,824	4,192	3,244	2,928	2,296
Approximate altitude AGL (ft)	5,677	4,570	3,676	2,814	1,604	960	0

Figure 2
Modelled Flight Procedures at Casey for Falcon 900EX

[1] ICAO Procedures for Air Navigation – Air Operations DOC 8161-OPS/611 Volume II, Construction of Visual and Instrument Flight Procedures, as modified for Australia in CASA Manual of Standards Part 173 – Standards Applicable to Instrument Flight Procedure Design, February 2003.

Upon departure the aircraft is assumed to take-off along the runway heading until it reaches 1500 ft from the departure end of the runway, and makes a climbing turn to intercept the outbound direct track to Hobart. For determining of takeoff weight and power settings, and hence climb performance, it is assumed (on the advice of AAD) that the aircraft would not be fully refuelled at the Casey runway.

In principle the approach and departure can be from either runway direction. However on advice that there is a prevailing katabatic wind on the plateau, all approaches are assumed to be from the west.

2.3 Within-Antarctica Operations

The domestic fixed wing services will be carried out only in the CN212. The generic flight path model adopted for this aircraft is given in Figure 3. This shows that the operational procedures for the CN212 are a little more diverse than the Falcon, in that aircraft may track to and from many destinations. Further, in Visual Meteorological Conditions (VMC) (expected to prevail for much of the time), aircraft will not necessarily complete full instrument approaches. Rather they can be expected to track to join final approach much closer than the 12 nm instrument approach adopted, typically 3nm. However, some of the time the aircraft will need to make a full instrument approach, and for the purposes of modelling, the same GPS procedure design as used for the Falcon has been adopted at all locations. In practice procedure designs may differ slightly due to differences in local terrain, but since most approaches and departures will be over sea ice, there are unlikely to be significant changes.

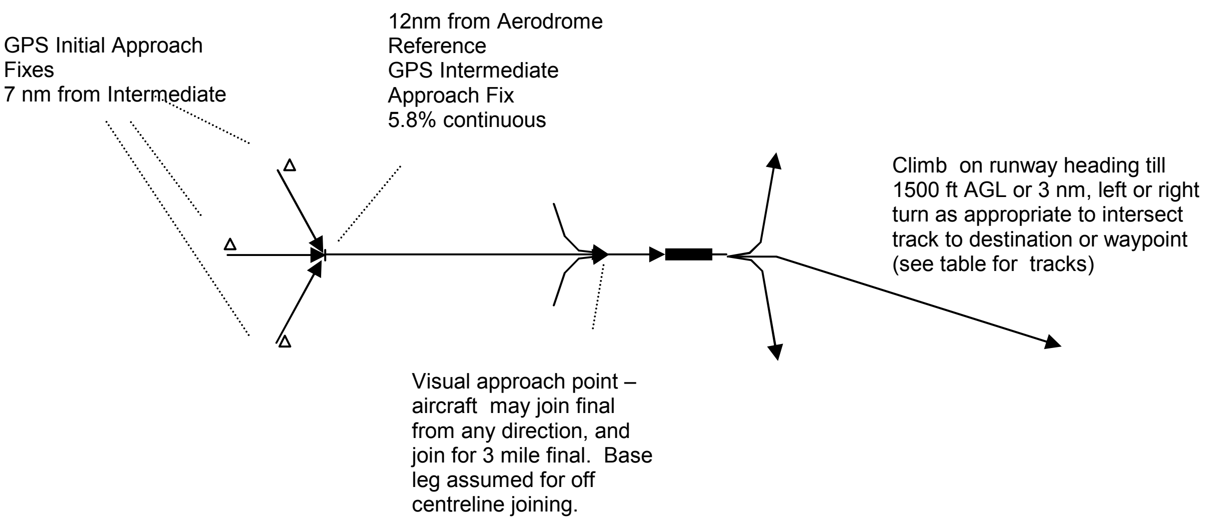


Figure 3
CN 212 Approach and Departure

The model therefore assumes the following scenarios:

i) *Instrument approach procedures* – diversion of the flight from the direct track when within (say) 10nm of the airfield to any one of the three IAF points (see Figure 2), the choice of IAF being based upon the direction of arrival. After the IAF the aircraft descends and joins final approach in accordance with the procedure design.

ii) *Visual approach procedures* – within 5 nm of the airfield and in VMC, the aircraft diverts from the direct track to join final approach at 3 nm. Aircraft joining final approach at a large angle of intercept would probably first join a "base leg" of a circuit[2] as a standard procedure, and commence descent on this leg. Accordingly only three arrival directions are modelled, although in practice aircraft could track to join final approach from any direction.

iii) *Departures* – as per the Falcon, departures are assumed to involve maintaining runway or skiway heading after take-off, then at 3 nm from the departure end, or at 1500 ft, whichever is sooner, the aircraft will turn to intercept the outbound track. The model assumes that this track can be in any direction, including back over the airfield.

Aircraft are assumed to use either direction of runway or skiway, in that whilst operations will favour the direction oriented into the katabatic wind, all strips close the coast are assumed to occasionally experience a sea breeze from the reverse direction. Aircraft are assumed to operate at maximum take-off weight on departure.

[2] A rectangular pattern of flight around an airstrip comprising (from the departure point) upwind leg, crosswind leg, downwind leg, base leg and final approach. This is normally used for traffic sequencing, largely irrelevant in Antarctica, excepting that a base leg would typically be flown if joining at some angle to final approach.

3. NOISE MODELLING

3.1 Description of the Model

The above-described operational scenario has been applied to the Integrated Noise Model, a model developed by the US Federal Aviation Administration for analysis and prediction of aircraft noise emissions in the vicinity of airports. The INM is the de-facto worldwide standard tool for forecasting ground level noise impacts of aircraft. It is one of two methods recommended by the Australian Department of Environment and Heritage and the Department of Transport and Regional Services for use in prediction of aircraft noise impacts in Australia[3].

The INM stores empirical data from a wide variety of aircraft types and models the propagation of noise from the aircraft at all stages of flight. The model takes as input the aircraft type, geographical coordinates of airports airstrips and user defined approach paths, terrain data, and some meteorological data.

The model provides as output a number of alternative measures to describe noise exposure around airports. Each of these is suited to a different purpose, and describes a different aspect of noise exposure. For example, in Australia, to assess the suitability of an area for various types of land use, the Australian Noise Exposure Forecast[4] (ANEF) unit is used. This represents the total noise "dose" received from aircraft during a year. To describe the disturbance caused to various human activities, other measures are used, including the number of noise events per day above 70dBA and number of hours "respite" per day when there are no aircraft movements.

In the AAD case the major possible noise impact is on Antarctic wildlife. The nature of any such impact has not been extensively studied, and little is known about the exact properties of the noise which would cause such impacts. In these circumstances, it is considered that the simplest possible measure of noise impact should be adopted, as this will be most easily understood by relevant observers, and is most easily verified. The simplest possible unit is the maximum sound pressure in dBA experienced on the ground during a typical aircraft overflight. While this unit takes no account of how often aircraft noise will occur, or the actual impact of the noise exposure, it at least gives a good indication of the magnitude of the source of the disturbance from a single event. In the absence of more meaningful measures, this parameter is considered the most pragmatic measure of noise impact for the present application.

The INM aircraft noise prediction model, version 6.1, was used for calculations. The C212 aircraft is included in the INM data set as a "substitution", with noise level modelled as for a DHC6. The F900 EX is not in the INM data set. Based on available data – certification noise levels measured at three points – the F900 was modelled as equivalent to a Canadair Challenger CL601 with a correction of +2dBA to the emitted noise level.

[3] *Guidance Material for Selecting and Providing Aircraft Noise Information*, Aviation and Airports Policy Division, Department of Transport and Regional Services; Approvals and Wildlife Division, Department of the Environment and Heritage, Commonwealth of Australia, 2003,ISBN 0–646–42287–1

[4] Australian Standard ASNZ 2021-1994, *Acoustics Aircraft Noise Intrusion Building Siting and Construction*. Standards Association of Australia

For the intercontinental airstrip, the effect of terrain height was taken into account in calculations. To perform terrain calculations directly, the INM model requires ground height data in a format that is not readily available for Antarctica. For this project, ground height was available only as dxf-format contours. Terrain was taken into account in noise level calculations by first calculating noise levels for flat terrain, over a grid of receiver locations. These noise levels were then corrected at each point, depending on the difference between the slant distance to the aircraft at closest approach for flat terrain and for the actual terrain. Noise level contours were then interpolated from the resulting corrected levels.

For the skiways at all other locations, flat terrain was assumed. This allows the use of a "generic" set of noise contours, which can be oriented to align with any of the strips. Contours showing maximum noise levels of 65, 70, 75, 80 and 85dBA for each of the relevant runways and skiways have been provided.

It should be noted that the INM is an average-value-model, in that it produces a long-term average sound pressure using average annual input conditions. Accordingly differences will exist between predicted and measured results because spot values of certain parameters will be different to those assumed in the model (eg temperature profiles, wind gradients, ground absorption diffraction effects etc.) These effects could cause a variation of 3-4dB between predicted and measured results.

3.2 Interpretation of Noise Levels

Most of the wildlife populations that might be sensitive to aircraft noise are near the coastline, and there are a number of such areas adjacent to the three Australian stations where air services operate. Given the lack of generally accepted criteria for determining the noise level at which aircraft noise levels affect wildlife, AAD have specified restricted areas over which fixed wing aircraft are required to maintain a minimum altitude of 2,500ft (750m).. Other areas have specific "no fly" zones prescribed. It is understood that these limits have been developed on a subjective basis from experience with aircraft types currently used in Antarctica (Twin Otter fixed wing, and various helicopter types, most recently the Squirrel).

Calculations have established that the maximum noise level due to Twin Otter operating at 2,500ft s would be between 70 and 75dBA, depending on the thrust setting used. The lower levels would apply for aircraft in cruise or descent, with the upper end of the range applying on climb. Noise from a single-engine helicopter is more difficult to estimate, because there are more unknown factors related to the operation of the helicopter. A best estimate is a maximum level of approximately 65dBA, ± 5dBA, for a helicopter travelling at a constant velocity and constant altitude. These noise levels will be increased with vertical movement compared with hovering, with downward movement being particularly noisy (compared with hovering at the same altitude) because it can generate blade "slap".

The above values should serve to provide some context for interpreting the contours provided. In the discussion to follow, a threshold of 70dBA has been used to establish a notional noise level at which unacceptable disturbance to wildlife might occur, and this has some correlation with noise levels used to identify significant human exposure. The consequence of this choice is that the present notional height limit of 2500ft or 750m would be valid for overflights and descent, but would be insufficient protection for aircraft on climb or helicopters in climb or descent. The 2,500ft limit would generally remain valid if a threshold of 75dBA were to be set.

4. Output of the Noise Model

The INM was run first as a generic (flat terrain) model for the identified flight paths, for both the Falcon 900EX and the CN212. The results of these plots over the range 65dBA to 80dBA are given in Figure 4 for the Falcon, and Figure 6, 7 and 8 for the CN212. Subsequent to this, the noise contours were overlaid on each airstrip/skiway location identified by AAD, and with the exception of the Casey intercontinental strip, run for both directions of approach. Where information was available, the approach and departure paths terminated and commenced at the approach threshold, otherwise a notional aerodrome reference point was adopted. The results of this superposition are given in Figure 5 and Figures 9 through 20 below.

4.1 Noise Plot for Falcon 900

The results of the generic noise exposure modelling for the Falcon are giving in Figure 4. This shows the noise level exceeds 65 dBA at around 6nm (11km) from threshold and at a 3 degree slope, the aircraft would be around 1800ft (550m) above the runway elevation. The 70 dBA contour would be passed at around 3nm, where the aircraft would be passing about 1,000ft (300m) altitude. The aircraft would descend through 2,500ft (750m) about 7.7nm (14.3km) from the touch down point. On departure the 70 dBA contours extend to 2.5nm (5km), and the aircraft would climb through 2,500ft (750m) at around 3nm (5.6km).

The terrain-modified results are plotted in Figure 5 as an overlay of the Casey Area Map. Comparison of this with the plot of Figure 4 shows a reduction of impact on the approach path reflecting the effect of the terrain sloping away from the runway towards the coast, whilst the departure path impact extends in distance, with the rising terrain as the aircraft tracks inland. It is understood that there are no wildlife sensitive areas near to the inter-continental airstrip, and the data shows that noise emissions at the sensitive coastal areas are well below the assessed 70dBA impact level.

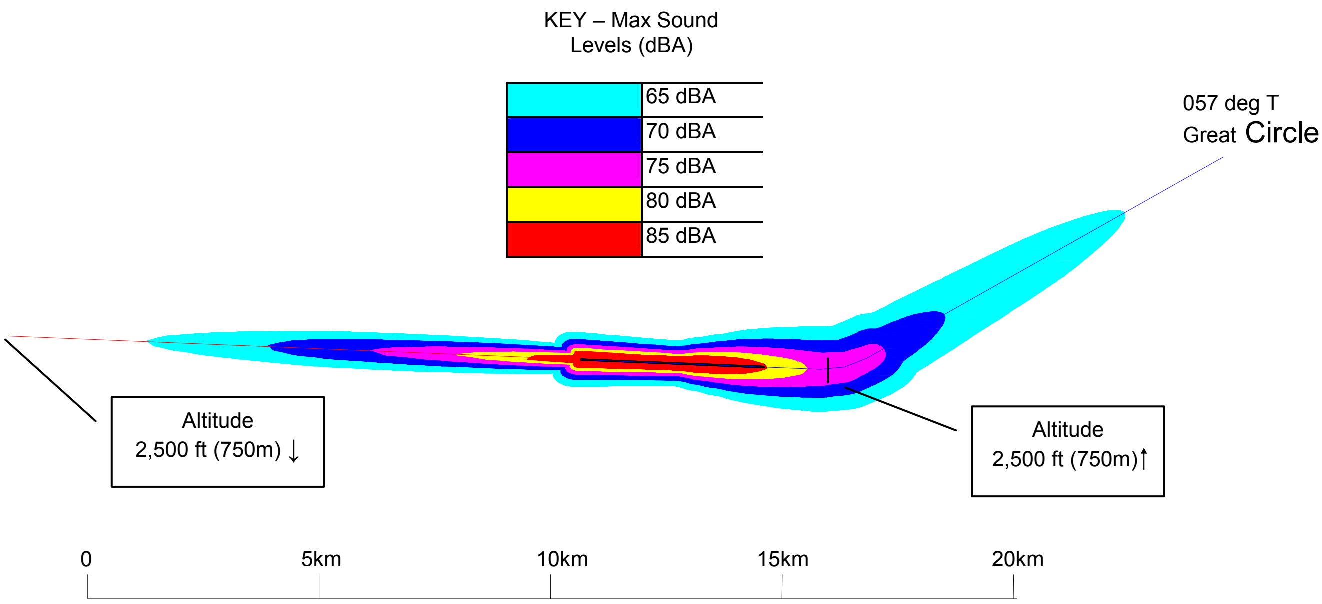


Figure 4.
Generic Single Event Noise Contour Plot for Falcon 900EX (Flat Terrain)

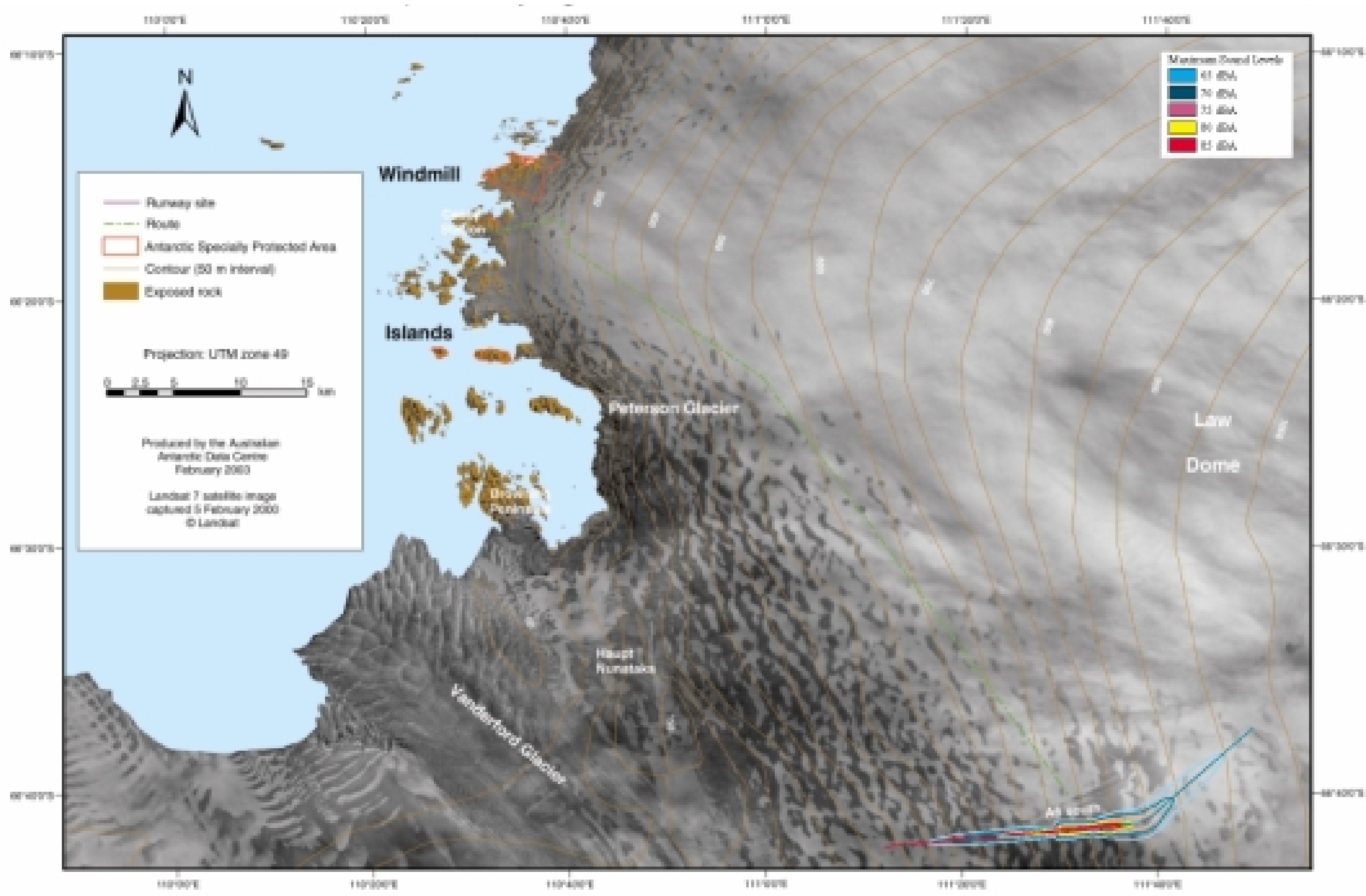


Figure 5.
Noise Contour Overlay
Casey Intercontinental Ice Runway

4.2 Noise Plots for the CASA C212

The generic noise exposure plot for a CN212 over the designated flight paths on flat ground is given in Figure 6. The aircraft descends on a 3-degree approach path which means that it would pass through 2,500ft (750m) at around 7.7nm (14.3km) from touchdown. At this point, the ground level noise exposure is well below 65 dBA. The notional 70 dBA level is generated on approach at about 3nm (6km) from touchdown, where the aircraft is about 1000ft (300m) above the runway or skiway elevation. The effects are similar for flight paths involving a base leg before joining final approach.

On departure the 70dBA contour extends a little over about 3 nm (6km) from the commencement of the take-off roll. The aircraft would climb though an altitude of 2,500ft (750m) at about 1.6nm (3km) from the same point of reference, meaning that the aircraft will travel about for 3 km whilst above the notional protection altitude but whilst still generating noise levels on the ground in excess of the notional harmful level. This suggests that the present 2,500ft (750m) criterion for noise protection may need to be reviewed for CN212 departures if 70 dBA were to be validated at the protection threshold.

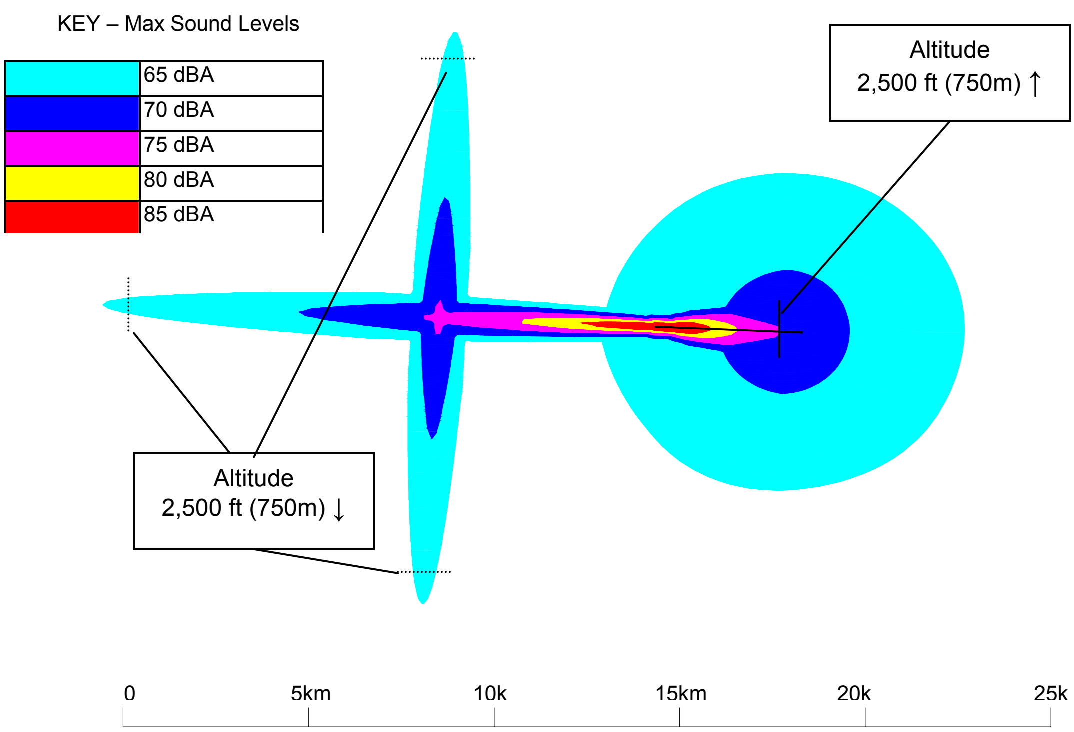


Figure 6.
Generic Single Event Noise Contour Plot for CN212 –400 aircraft.

It should be noted that whilst the approach path shows three discrete directions of approach, this may not be the case in practice. Depending upon operational procedures ultimately adopted by Skytraders, it is feasible that the CN 212 may join the approach from any direction, not just on base leg or straight-in. Hence, the approach exposure area could also be modelled, like the departure, as a circular pattern, and this should be taken into account in assessing the impact upon noise sensitive areas. Further, it is feasible that the

CASA approved CN212 operations procedures may permit circuit flying. This would mean that aircraft may join base leg much closer than 3nm, thereby reducing the significant exposure area. Nonetheless, in either scenario aircraft on approach will generate noise emissions that exceed the notional harmful levels, and that some restrictions on flight paths may be necessary, whatever the procedures adopted.

Similar issues apply to departures. Given that departures can occur in any direction, the noise contours are shown as omni-directional, with a significant proportion of the potential flight paths generating more than the 70dBA notional harmful level. For many locations, this area would encompass the noise sensitive zones, and some restrictions would therefore be required on departure tracks as well.

In order to assess how constrained these tracks should be, Figures 7 and 8 show the noise contours repeated, but for a departure on only the runway or skiway heading, and a departure on runway or skiway heading but with a 30 degree turn after the aircraft attained an altitude of 1500ft. This demonstrates that the exposed area would be about 1 km either side of track for a straight line departure, widening to about 1.5 km at the turning point where a turn is involved. The potential for such track limitations is discussed in the following sections in relation to the overlays of the generic noise plot onto the topographic information.

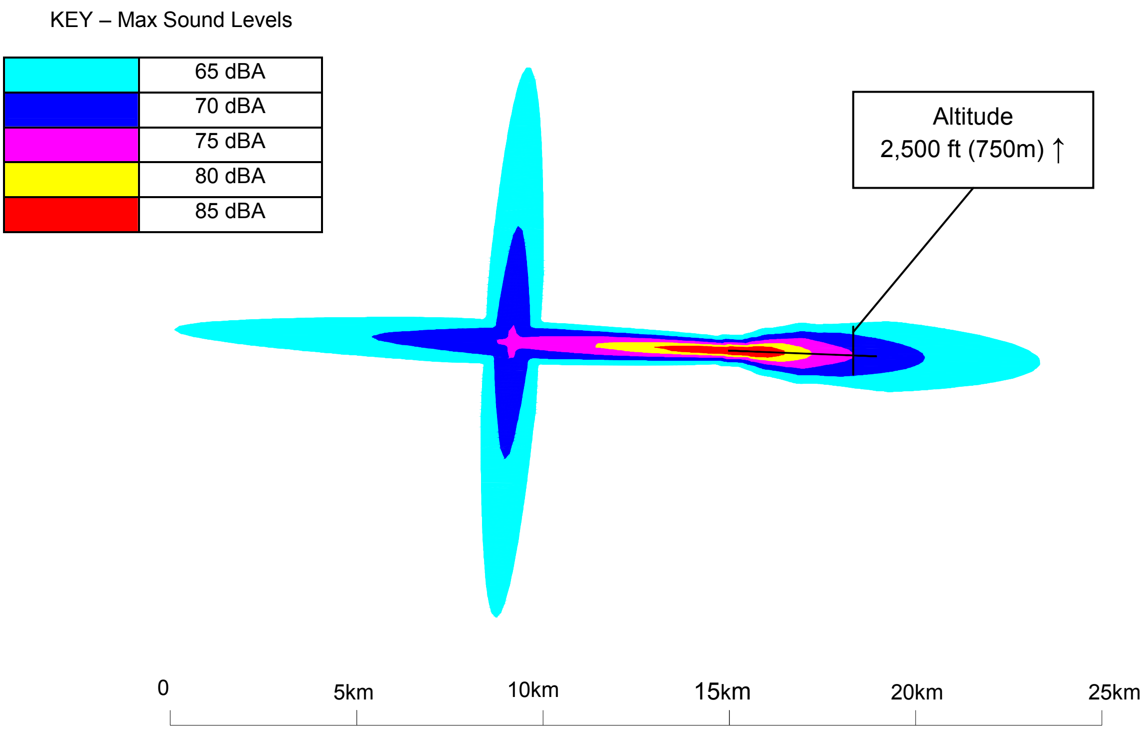


Figure 7.
Generic Single Event Noise Contour Plot for CN212 –400 aircraft
Departure on Runway Heading Only

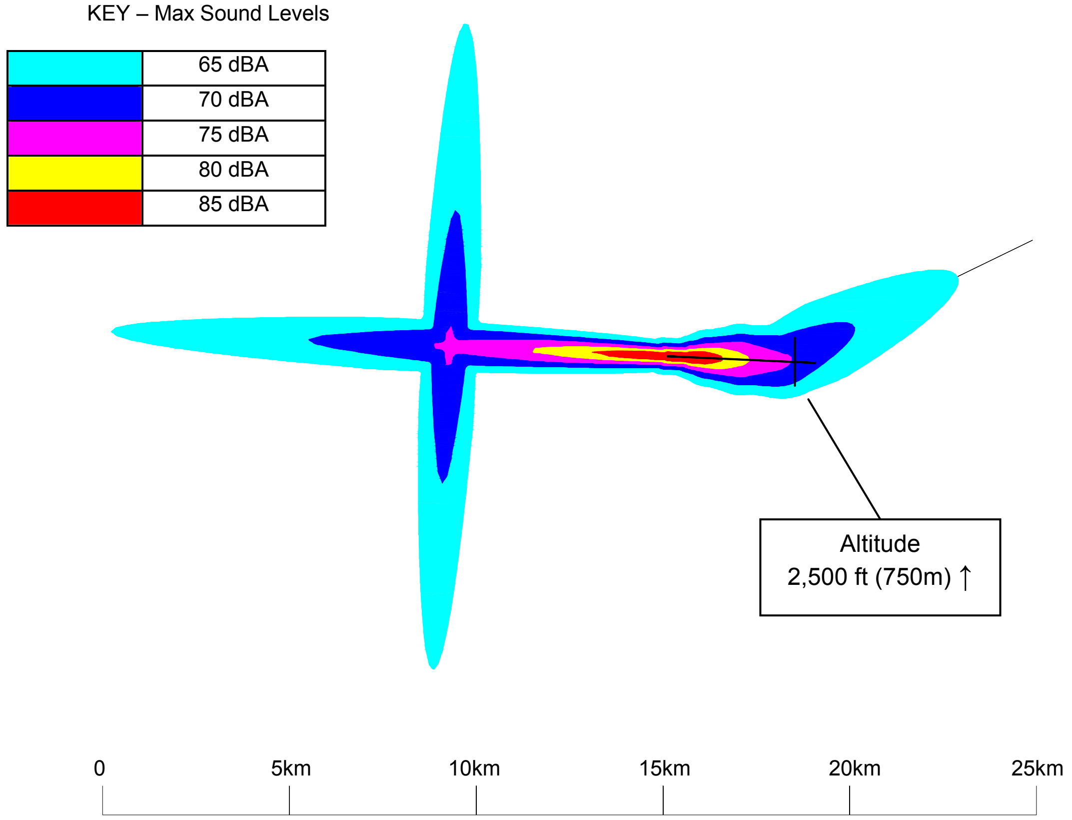


Figure 8.
Generic Single Event Noise Contour Plot for CN212 –400 aircraft
Departure on Runway Heading Followed by 30 Degree Turn

4.2.1 Casey Station/ Bailey Peninsula Skiway

Referring to Figure 9, the overlay plots show that aircraft approaching the Bailey Peninsula Skiway from the west will generate noise levels in excess of 70 dBA in the restricted areas at the western most end of the Peninsula. Departures in the same direction will not affect noise sensitive areas.

The incursion on approach could be minimised or eliminated by orienting the skiway slightly more south-east/north-west, or displacing the whole strip around 250m to the south, if there was sufficient land area available. In the first instance, consideration would need to be given to the effect of additional crosswind. However, a shift in strip orientation of 5 degrees to 10 degrees would be unlikely to be operationally significant.

Approaches from the eastern side of the Bailey Peninsula strip do not infringe on the noise sensitive area, but as Figure 10 shows, departures to the west can exceed the notional target noise levels in all of the Bealll Island/Shirley Island/McMullin Island and Bailey Peninsula restricted areas. This direction of operations is understood to be quite rare, as the prevailing wind is off the plateau. Elimination of this exposure would require reorientation or repositioning the strip as for the western approach, as well as restricting aircraft tracks. This would involve precluding aircraft from adopting initial tracks in the arcs 208T to 248T and 254T to 030T, as measured from the centre of the skiway location shown on the map (these figures are approximate), until the aircraft has reached an altitude of about 3,000ft.

4.2.2 Casey Plateau Skiway

Figures 11 and 12 show that similar issues apply to the plateau site as to the Bailley Peninsula site, in that approaches from and departures to the west will encroach the same two noise sensitive areas with high noise levels. This time the constraints are a little less severe, in that the encroachment is at 2-3 nm from the western end of the skiway. Close-in circuit patterns could, in VMC, be used to avoid incursions of the restricted areas on approaches from the west. Further, the departure tracks may only need to be constrained to avoid passing directly over Casey Station itself until after reaching around 3,000 ft.

Conversely, if a straight in approach from the west is required (as would be necessitated by a GPS approach in instrument flight conditions), then an incursion is unavoidable. This could be ameliorated by re-orienting the strip clockwise by about 5 degrees, or displacing it to the north by about 700m. However, any such changes should be accompanied by a check to ensure there is no consequent further encroachment of the Bailley Pensinula area on departures. Another technique would be to establish a bend in the approach path from the west, as envisaged by the shaded “fixed wing flight path” designated by AAD. Such a bend could be accommodated in VMC, and provision exists for same in ICAO Standards and Recommended Procedures, where there are extenuating circumstances. However, it is not advisable on safety grounds to have reasonably heavy aircraft such as the CN212 departing from a stable approach so late in the approach sequence, particularly in instrument conditions. CASA have relatively recently produced a recommendation that aircraft conducting regular public transport should be established on a stable approach no less than 3nm from touchdown.

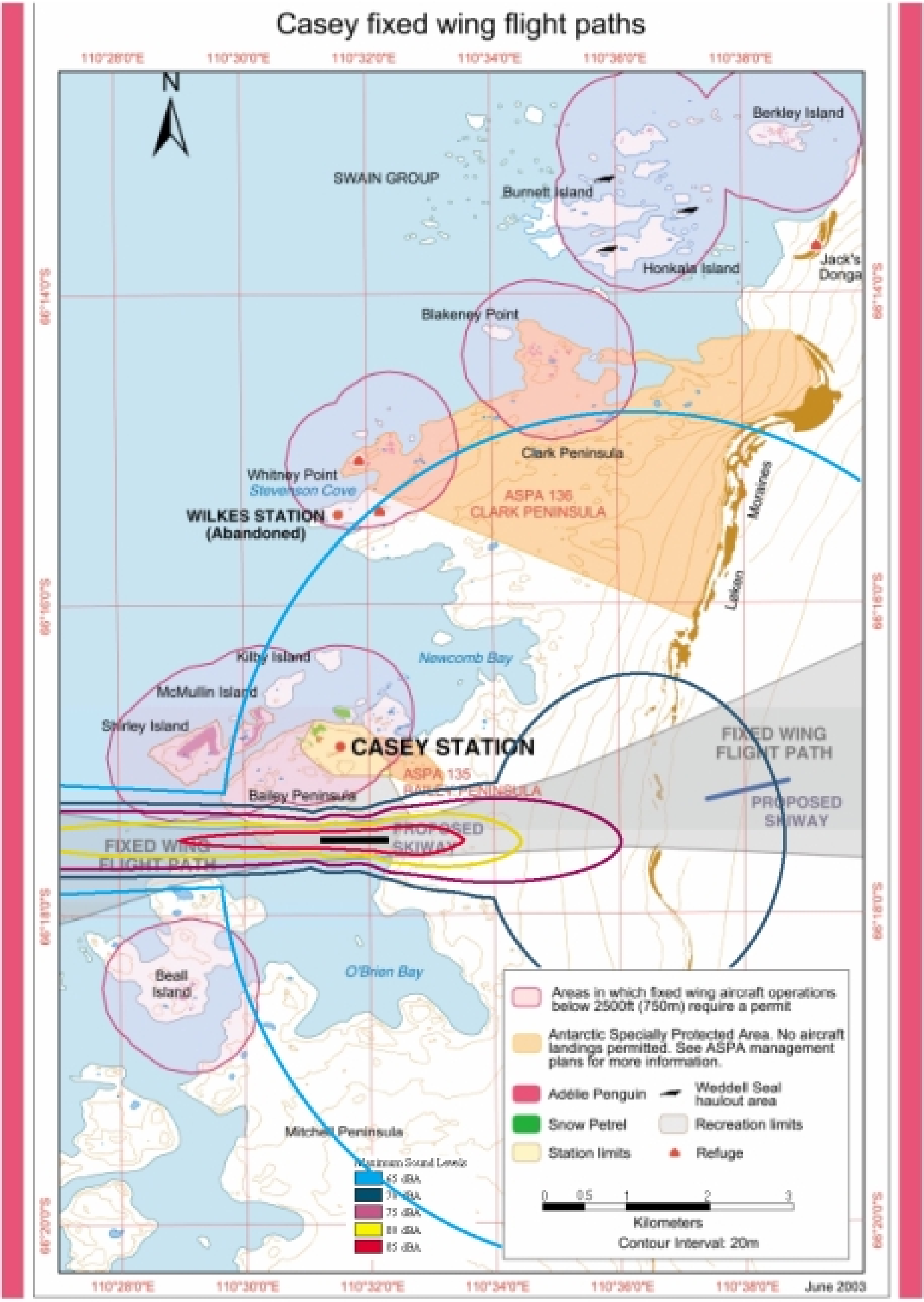


Figure 9.
Noise Contour Overlay
Casey Station Bailey Peninsula Skiway, Eastern Approach

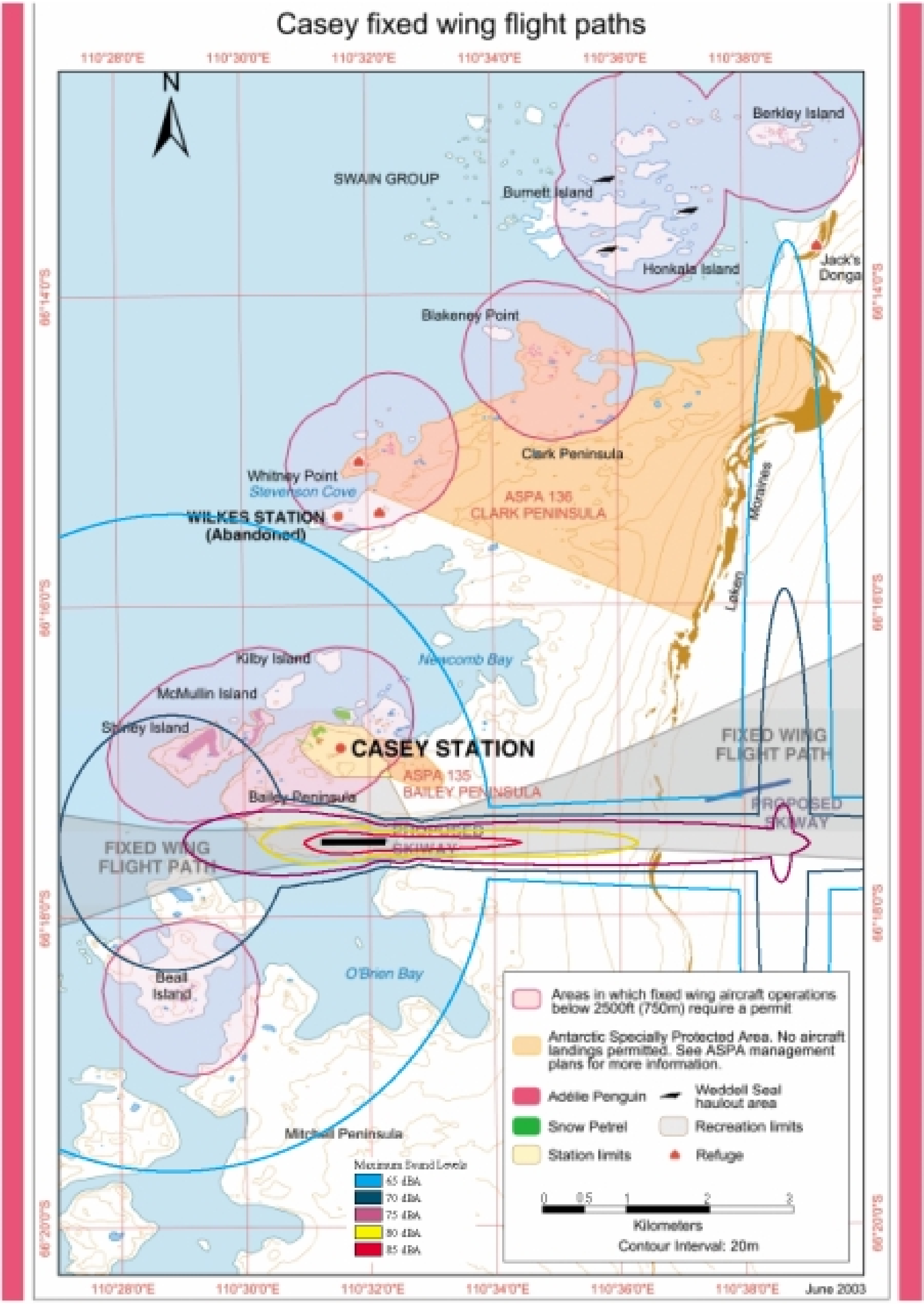


Figure 10.
Noise Contour Overlay
Casey Station Bailey Peninsula Skiway, Eastern Approach

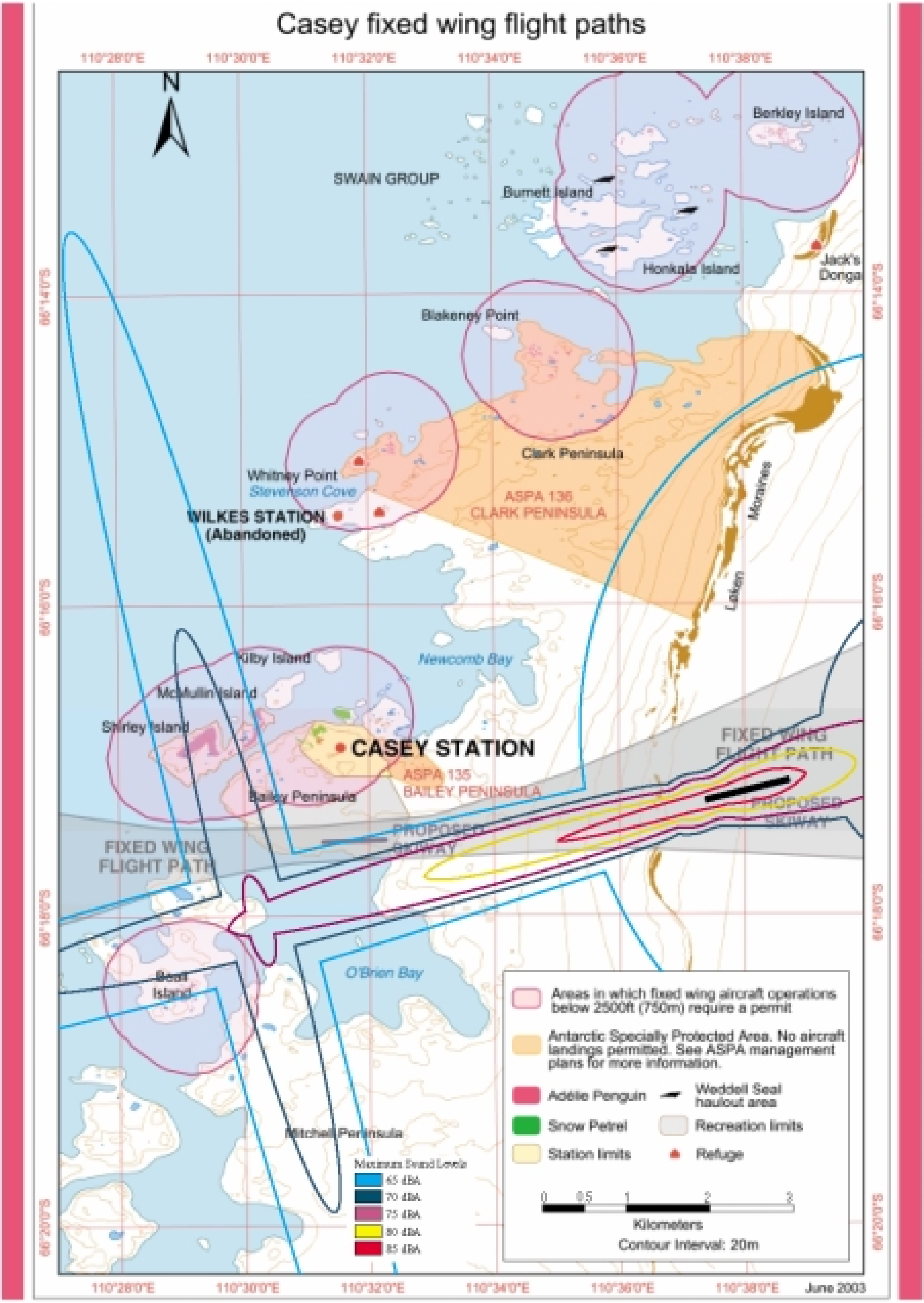


Figure 11.
Noise Contour Overlay
Casey Station Plateau Skiway, Western Approach

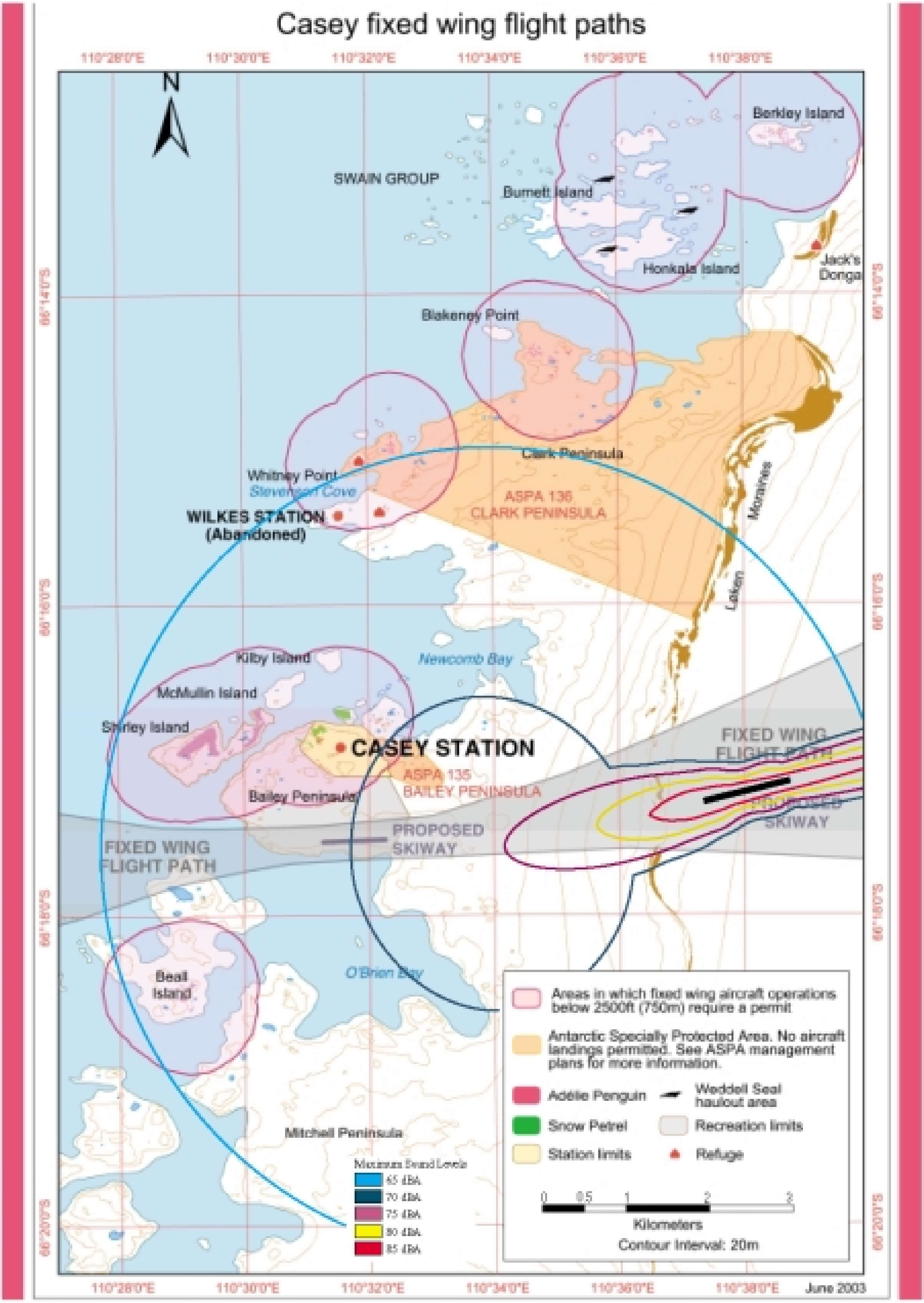


Figure 12.
Noise Contour Overlay
Casey Station Plateau Skiway, Eastern Approach

4.2.3 Davis Sea Ice Strip

Figures 13 and 14 provide the plots for both directions of operation at the designated sea ice strip off the coastline near Davis Station. These show that arrivals from the south intrude on the Warriner Island restricted area with noise levels in excess of 70 dBA, whereas departures in this direction have no impact on any of the designated areas. As with the situation at Casey, this exposure would be ameliorated for straight-in approaches by either a clockwise reorientation of the strip by about 10 degrees, or a displacement of the strip seawards by about 500 m, or placing a bend in the straight-in approach. However aircraft joining from the south east on a 3 mile base leg, as used by the noise model, would still not be able to avoid the Warriner Island exposure. Again close-in circuits in VMC could address this latter problem, as envisaged by the shaded “fixed wing flight path” on the map.

With operations in the opposite runway or skiway direction, Figure 14 shows that whilst arrivals from the north will not cause any incursions of restricted areas, departures to the south will expose both the Gardner Island and Warriner Island restricted areas. This exposure will not be improved by relocation or reorienting the strip, and could only be managed by restricting any departures to the south east to a track of approximately 233T, or otherwise tracks less than 190T. Tracks to the west would similarly need to be constrained from flying over Gardiner Island until past 3,000ft.

4.2.4 Davis Plateau Strip

Mapping information held for this site was limited, and accordingly Figures 15 and 16 show only the geographical proximity of the skiway to Davis Station and restricted areas near Davis. In the absence of data on any other restricted areas near the Davis plateau strip, it is assumed that there would be no restrictions, from a noise sensitivity perspective, upon operations in either direction from this strip.

4.2.5 Mawson Sea Ice Strip

Figures 17 and 18 provide plots of the noise impacts from operations in both directions to and from the sea ice strip located off the coast adjacent to Mawson Station. These show that arrivals from the north west and departures to the south east avoid all noise sensitive areas. Accordingly, aircraft operations in this direction will be largely unconstrained. However, circuit operations would need to be precluded to prevent exposure of the Jocelyn Islands and Bechervaise Island/Stinear Island noise-sensitive areas.

4.2.6 Mawson Plateau Strip

Operations to and from the north of the plateau skiway at Mawson will provide above-threshold noise exposure to the Flat Islands restricted areas, as shown in Figures 19 and 20. In addition, northerly departures have the potential to expose the Jocelyn Islands restricted area. The exposure from the north west approach path can be eliminated by re-orienting the strip by approximately 15 degrees clockwise, by shifting the site north east by about 1km or by introducing a dog-leg approach. However, none to these changes will reduce the exposure from departures to the north unless operations procedures continue to restrict overflight of the restricted areas on departure to 3,000 ft and above.

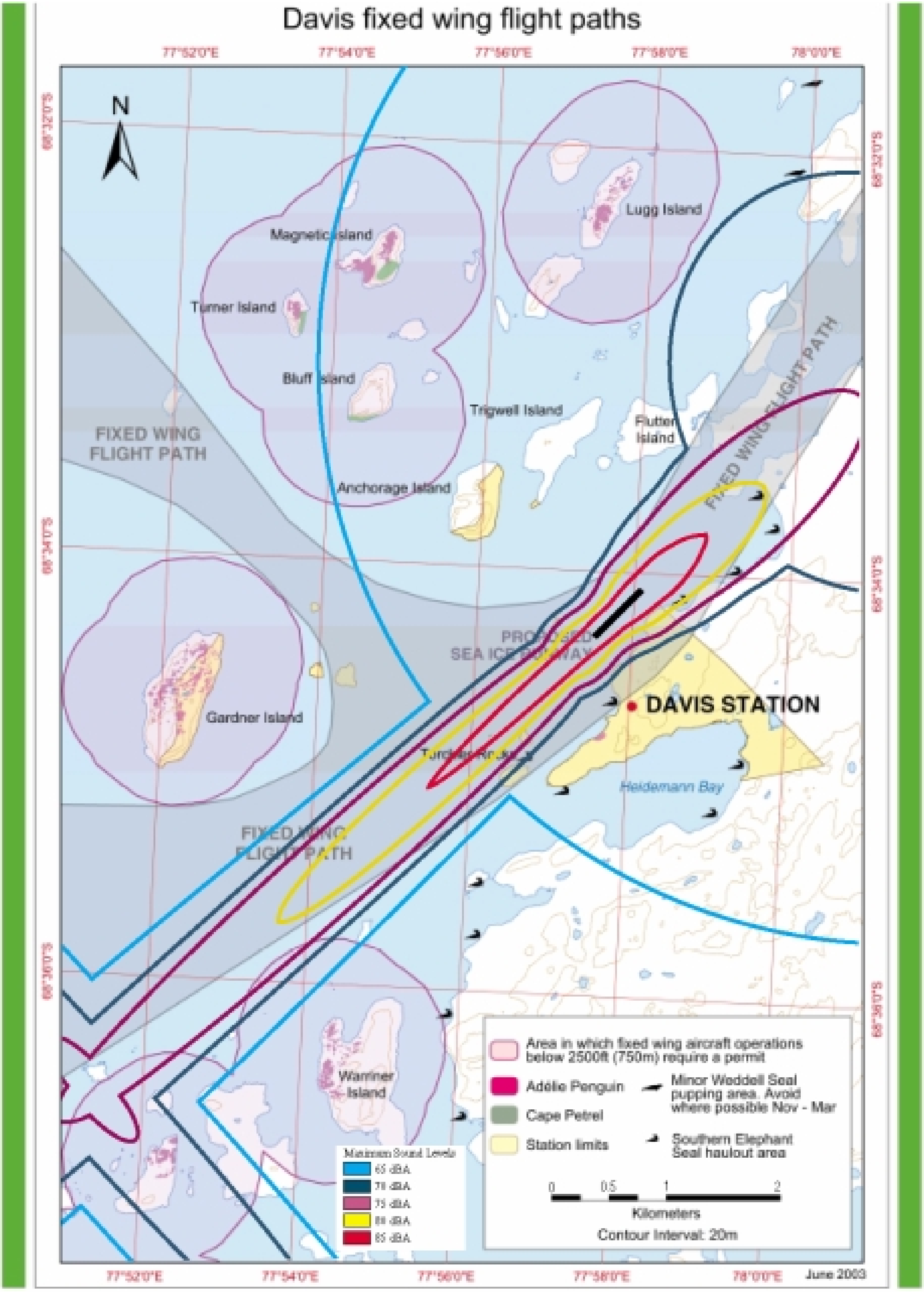


Figure 13.
Noise Contour Overlay
Davis Station Sea-Ice Skiway, Southern Approach

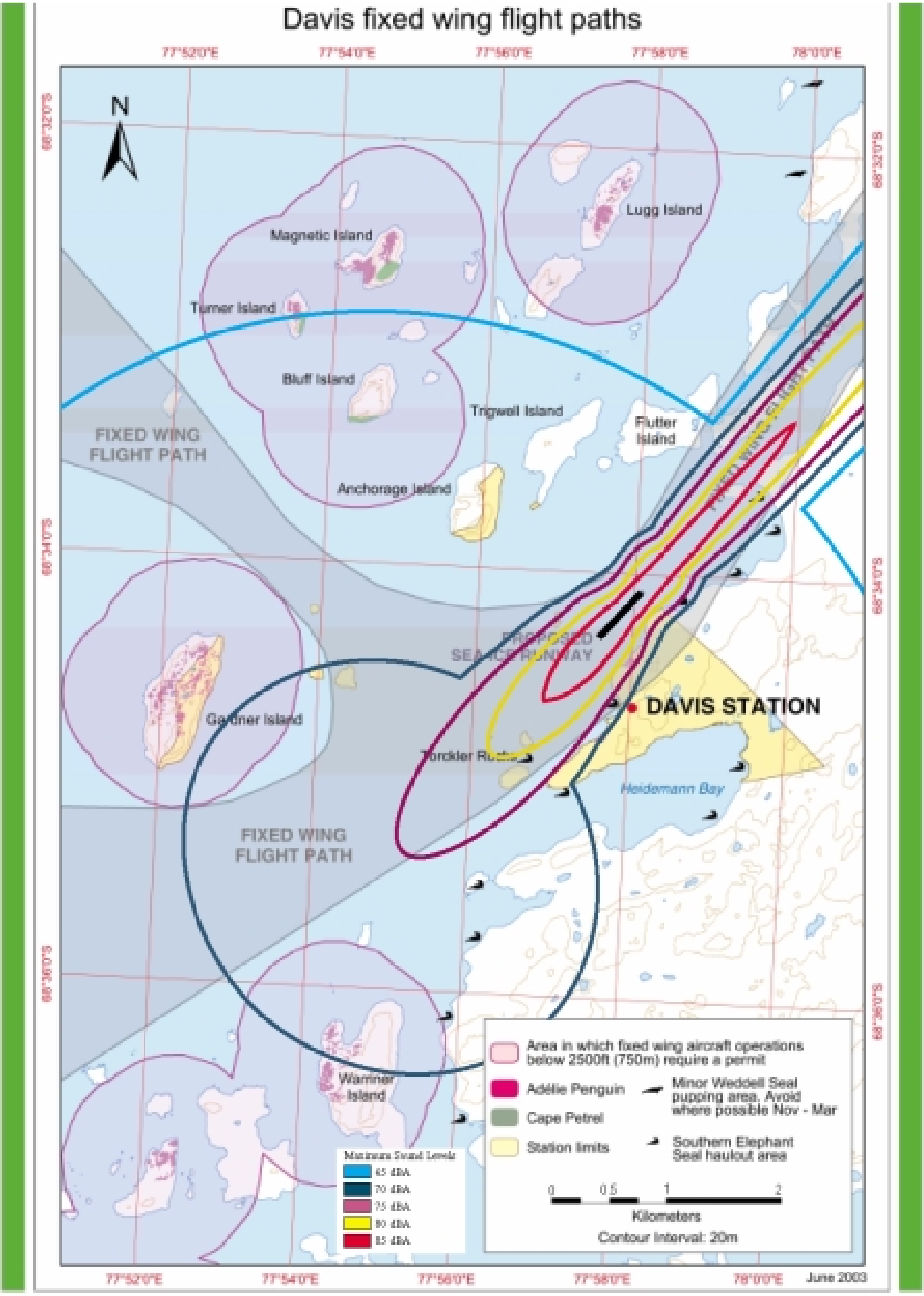


Figure 14.
Noise Contour Overlay
Davis Station Sea-Ice Skiway, Northern Approach

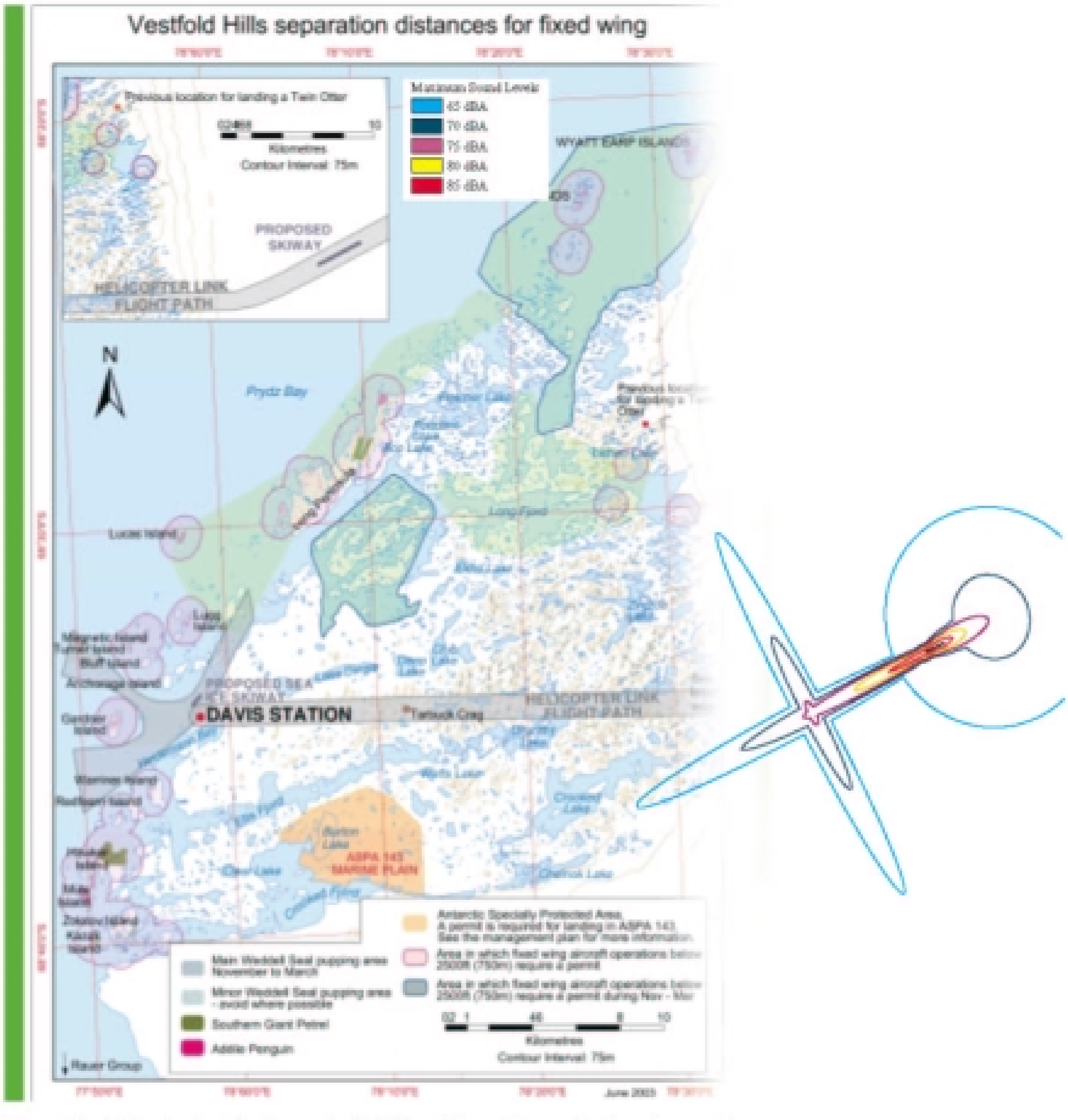


Figure 15.
Noise Contour Overlay
Davis Station Plateau Skiway, Southern Approach

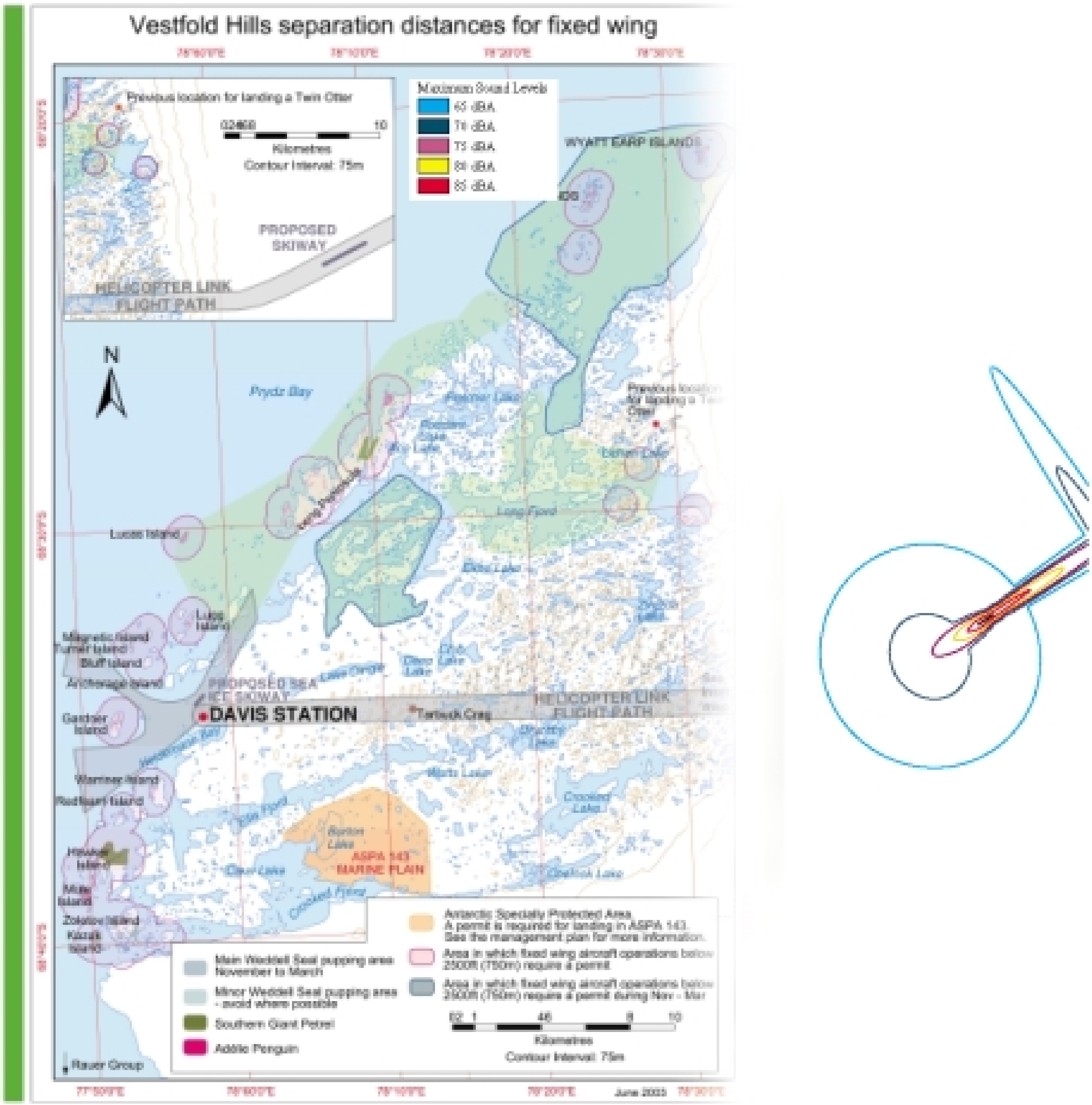


Figure 16.
Noise Contour Overlay
Davis Station Plateau Skiway, Northern Approach

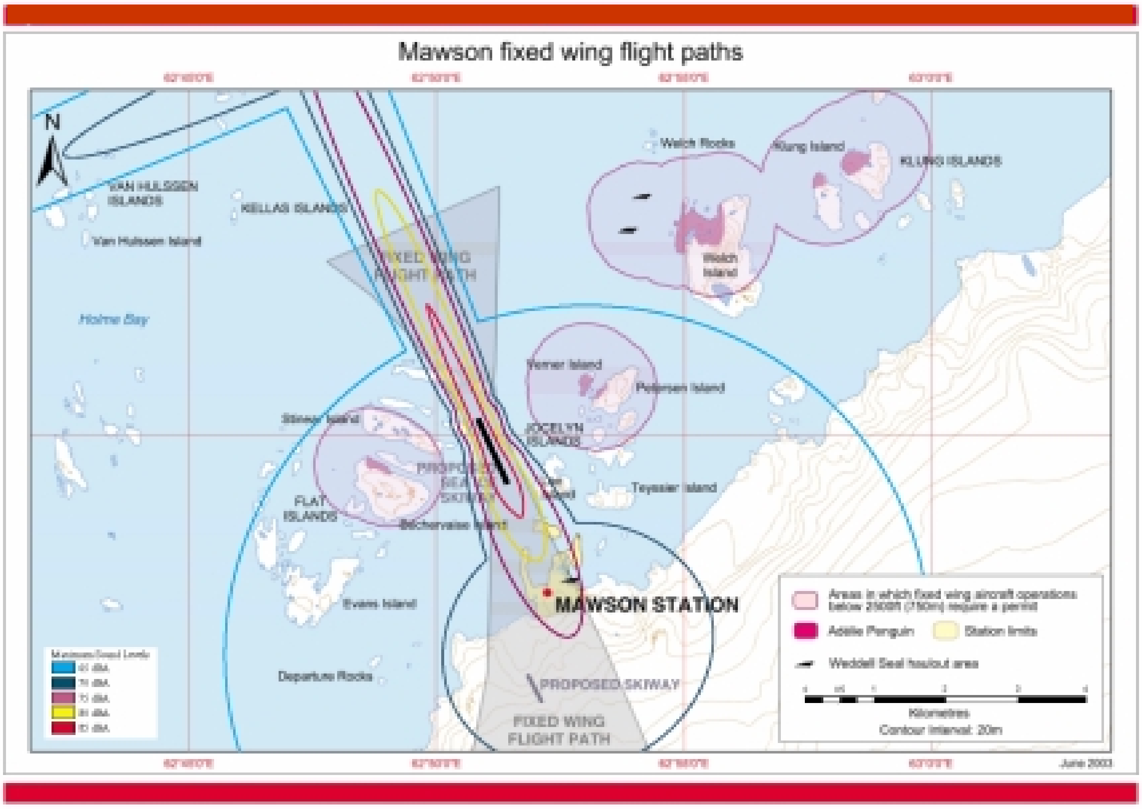


Figure 17. Noise Contour Overlay
Mawson Station Sea-Ice Skiway, Northern Approach

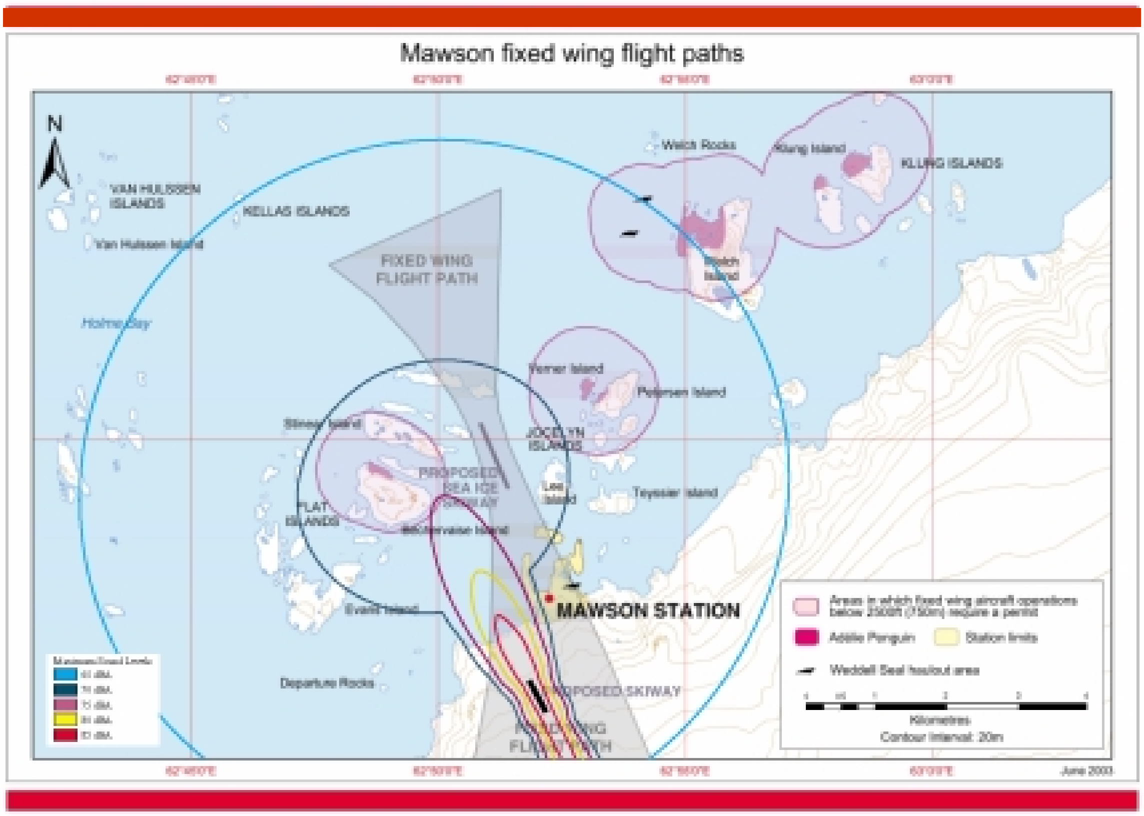


Figure 18. Noise Contour Overlay
Mawson Station Sea-Ice Skiway, Southern Approach

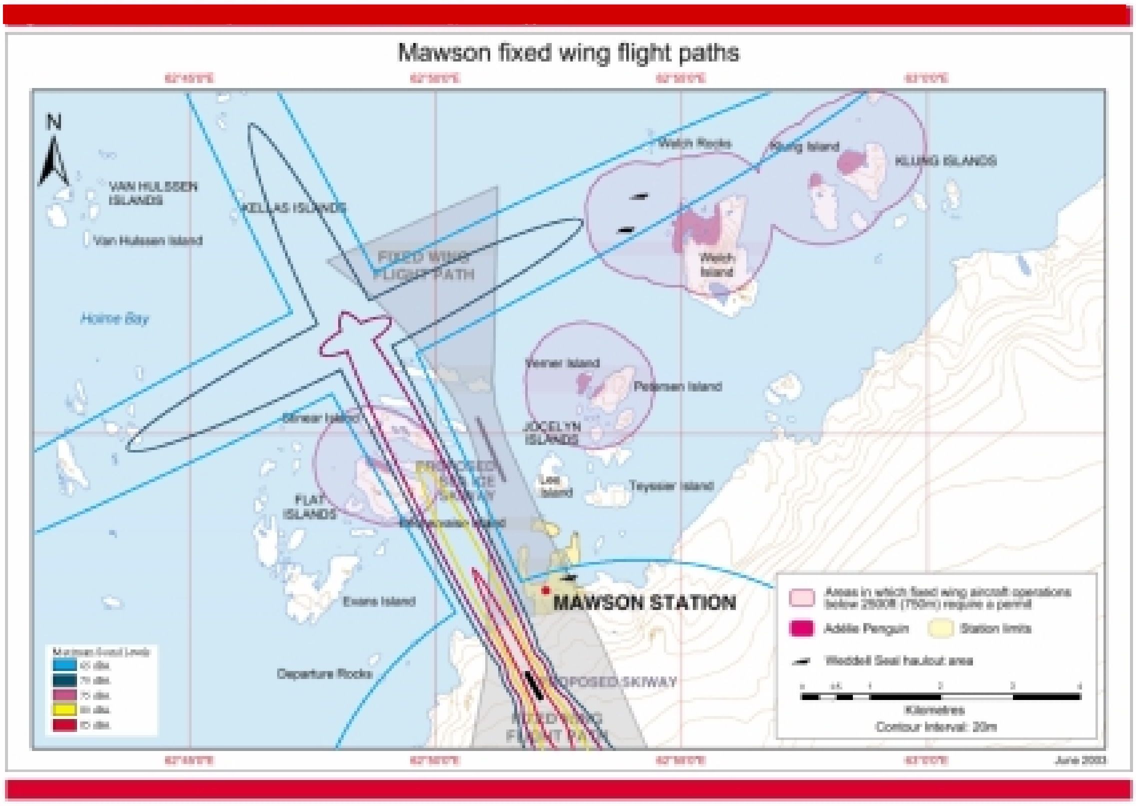


Figure 19. Noise Contour Overlay
Mawson Station Plateau Skiway, Northern Approach

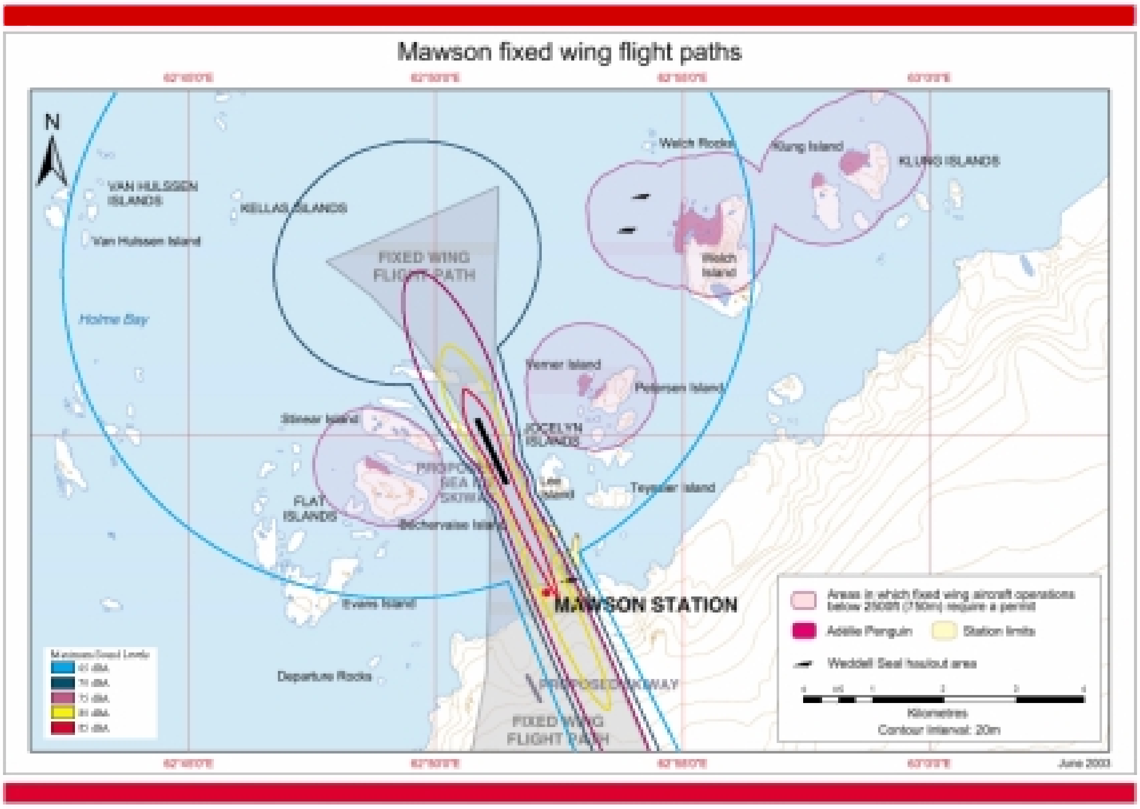


Figure 20. Noise Contour Overlay
Mawson Station Plateau Skiway, Southern Approach

5. Summary and Conclusions

The above analysis identifies that there are significant aircraft noise emissions observable at ground level in the vicinity of airstrips and skiways in Antarctica. An assessment of current practices has suggested that a single event threshold of 70dBA may be appropriate in the absence of other information, as a target threshold beyond which disturbance to sensitive wildlife might occur. Using this parameter, the noise exposure predictions indicate that the threshold level can be contained within about 3 nm of the airstrips or skiways. For the Falcon operations this would appear not to present an exposure to any sensitive wildlife populations. For CN212 operations from plateau skyways this is also generally true except where the strips are close the coast. For most of the CN212 Skiways located on sea ice however, the proximity to sensitive wildlife populations means that some restrictions on operations are required. The situation is summarised in Table 1 below.

Station	Scenario	Exposure	Restriction	Other remediation
Casey	Inter-continental blue glacial ice runway	None anticipated	None anticipated	N/A
	Bailey Peninsula Skiway	Approaches from and departures to the west.	Western Departure tracks restricted below 3,000ft.	Strip reorientation or displacement.
	Plateau Skiway	Approaches from and departures to the west.	Circling approaches from the west restricted; departure tracks to the west restricted below 3.000ft.	Strip reorienting and shifting, dog -leg approach from west, but not desirable operationally.
Davis	Sea Ice Skiway	Arrivals from and departure to the south.	Circling approaches from the south limited to close-in; departures to south track limited till 3,000ft.	Re-orientation or displacement of strip, dog-leg approach from the south, but not desirable operationally.
	Plateau Skiway	None anticipated	None anticipated	N/A
Mawson	Sea Ice Skiway	None anticipated	No circling approaches.	N/A
	Plateau Skiway	Arrivals from and departures to the north/north west.	Departure tracks to the north restricted. Close in circling approaches preferred.	Re-orientation or displacement of skiway, dogleg approach from north, but not desirable.

Table 1
Summary of Noise Exposure Scenarios

As identified in Table 1, in all locations where there are potential adverse noise impacts there are also several potential premeditating measures, summarised as follows:

i) *Re-orientation or relocation of the skiways.* A minor re-orientation or lateral displacement will generally allow approach paths (particularly instrument approach paths) to avoid the noise sensitive areas. It is understood that the locations and alignments change from season to season, and the noise issues can thus be potentially accommodated in the site selection process. However, if re-orientation is involved, due consideration will need to be taken of the prevailing wind and the maximum allowable crosswind component for the aircraft.

ii) *Restricting departure tracks*. In all cases, noise sensitive areas can be protected by restricting departure tracks until the aircraft is at an altitude where the noise impact is deemed minima (see iii below).

iii) *Restricting flyover altitudes.* The current approach of prohibiting overflights at levels below 2,500ft over sensitive areas reasonably correlates to a 70dBA exposure level for a CN212 or Twin Otter in cruise or descent, and helicopters in cruise. However, both the CN212 and Twin Otter aircraft on climb, and helicopters on climb and descent would likely exceed this level. If consistency with existing attitude restrictions is sought, then a 75dBA threshold would be more appropriate. If as used in this report, a 70dBA threshold is set, then the altitude restrictions for fixed wing aircraft should be increased to around 3,000ft for departures only.

iv) *Constraining circling approaches.* Where circling approaches are approved for Skytraders operations in VMC, noise sensitive areas can be avoided by adopting tight circuit patterns, where the sensitive areas would otherwise be infringed by straight-in approaches, or 3-mile base legs.

v) *Dog-leg approaches.* In a number of circumstances, near straight-in approaches can be accommodated if a slight bending of the approach path is adopted. In general, it is desirable to avoid such bends (particularly in instrument conditions) as it is safer for aircraft to be established in a stable approach path. A similar issue applies to circling approaches in an aircraft such as the CN212.

Overall, there would appear to be a number of flight operations methodologies that can be adopted to minimise or eliminate adverse noise impacts of the air service operations. The information provided in this study can thus be used as input to AAD, Skytraders and CASA as flight operations procedures are developed for the new air services. Further, the study has highlighted the merit of more detailed analysis of the vulnerability of wildlife habitats to aircraft noise, with the objective of further refining appropriate exposure levels in the relatively low traffic environment in Antarctica. On a final note, the reader is reminded of the limitations of the noise predictions, and in due course, it would be desirable for these noise exposure calculations be verified by actual measurements.

The Ambidji Group Pty Ltd
August 2003

APPENDIX A

AIRSTRIP AND WAYPOINT COORDINATE CALCUATIONS

APPENDIX A
AIRSTRIP AND WAYPOINT COORDINATE CALCULATIONS
1. Casey Inter-Continental Strip

Ellipsoid **WGS84**

Station 1	Casey Intercontinental Ice Rwy W	**Station 2**	Casey I/C Ice Rwy E
Latitude (j1)	-66° 41.4	**Latitude (j2)**	-66° 41.5
Longitude (l1)	111° 29.2	**Longitude (l2)**	111° 34.6
Spheroidal Dist. (S)	3,980		
Azimuth 1-2 (a12)	92° 43' 04.8"		User input
Azimuth 2-1(a21)	272° 38' 07.3"		Result

Ellipsoid **WGS84**

Station 1	Casey I/C Ice Rwy W	**Station 2**	12 nm from W threshold
Latitude (j1)	-66° 41.40	**Azimuth (a12)**	272° 38' 07.3"
Longitude (l1)	111° 29.20	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-66° 40.00 48.1 "		
Longitude (l2)	110° 59.00 03.5 "	Reverse Azimuth (a21)	93° 05' 48.1"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Casey I/C Ice Rwy W	**Station 2**	3 nm from W threshold
Latitude (j1)	-66° 41.40	**Azimuth (a12)**	272° 38' 07.3"
Longitude (l1)	111° 29.20	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-66° 41.00 15.6 "		
Longitude (l2)	111° 21.00 39.7 "	Reverse Azimuth (a21)	92° 45' 02.6"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Casey I/C Ice Rwy W	**Station 2**	12 nm from W threshold
Latitude (j1)	-66° 41.40	**Azimuth (a12)**	272° 38' 07.3"
Longitude (l1)	111° 29.20	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-66° 40.00 48.1 "		
Longitude (l2)	110° 59.00 03.5 "	Reverse Azimuth (a21)	93° 05' 48.1"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Casey I/C Ice Rwy E	**Station 2**	3 nm from E threshold
Latitude (j1)	-66° 41.50	**Azimuth (a12)**	092° 43' 04.8"
Longitude (l1)	111° 34.60	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-66° 41.00 38.3 "		
Longitude (l2)	111° 42.00 08.3 "	Reverse Azimuth (a21)	272° 36' 09.4"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Casey I/C Ice Rwy E	**Station 2**	12 nm from E threshold
Latitude (j1)	-66° 41.50	**Azimuth (a12)**	092° 43' 04.8"
Longitude (l1)	111° 34.60	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-66° 42.00 01.1 "		
Longitude (l2)	112° 4.00 45.9 "	Reverse Azimuth (a21)	272° 15' 22.6"

COLOUR KEY
User input
Result

2. Casey Bailey Peninsula Skiway

Ellipsoid **WGS84**

Station 1	Casey SK1 W		**Station 2**	Casey SK1 E	
Latitude (j1)	-66°	18'	**Latitude (j2)**	-66°	17.51
Longitude (l1)	110°	31'	**Longitude (l2)**	110°	32.30
Spheroidal Dist. (S)	793.188				
Azimuth 1-2 (a12)	88°	39' 55.662"		User input	
Azimuth 2-1(a21)	268°	38' 57.429"		Result	

Ellipsoid **WGS84**

Station 1	Casey SK 1 W		**Station 2**	12 nm from W threshold	
Latitude (j1)	-66°	18'	**Azimuth (a12)**	268°	38' 55.662"
Longitude (l1)	110°	31'	**Ellipsoidal Dist (s)**	22,224	
Latitude (j2)	-66°	17' 45.3 "			
Longitude (l2)	110°	01' 32.1 "	Reverse Azimuth (a21)	89°	06' 07.6"

COLOUR KEY: User input; Result

Ellipsoid **WGS84**

Station 1	Casey SK 1 W		**Station 2**	3 nm from W threshold	
Latitude (j1)	-66°	18'	**Azimuth (a12)**	268°	38' 55.662"
Longitude (l1)	110°	31'	**Ellipsoidal Dist (s)**	05,556	
Latitude (j2)	-66°	17' 35.3 "			
Longitude (l2)	110°	23' 48.9 "	Reverse Azimuth (a21)	88°	45' 43.6"

COLOUR KEY: User input; Result

Ellipsoid **WGS84**

Station 1	Casey SK 1 E		**Station 2**	3 nm from E threshold	
Latitude (j1)	-66°	17.51	**Azimuth (a12)**	088°	39' 55.700"
Longitude (l1)	110°	32.30	**Ellipsoidal Dist (s)**	05,556	
Latitude (j2)	-66°	17.00 26.2 "			
Longitude (l2)	110°	39.00 43.5 "	Reverse Azimuth (a21)	268°	33' 07.8"

COLOUR KEY: User input; Result

Ellipsoid **WGS84**

Station 1	Casey SK 1 E		**Station 2**	12 nm from E threshold	
Latitude (j1)	-66°	17.51	**Azimuth (a12)**	088°	39' 55.700"
Longitude (l1)	110°	32.30	**Ellipsoidal Dist (s)**	22,224	
Latitude (j2)	-66°	17.00 11.1 "			
Longitude (l2)	111°	1.00 59.6 "	Reverse Azimuth (a21)	268°	12' 44.5"

COLOUR KEY: User input; Result

3. Casey Plateau Skiway

Ellipsoid **WGS84**

Station 1	Casey SK2 W	**Station 2**	Casey SK2 E
Latitude (j1)	-66° 17.28'	**Latitude (j2)**	-66° 17.15'
Longitude (l1)	110° 37.35'	**Longitude (l2)**	110° 38.70'
Spheroidal Dist. (S)	1038.609		
Azimuth 1-2 (a12)	76° 33' 30.7"		User input
Azimuth 2-1(a21)	256° 32' 16.5"		Result

Ellipsoid **WGS84**

Station 1	Casey SK 2 W	**Station 2**	12 nm from W threshold
Latitude (j1)	-66° 17.28'	**Azimuth (a12)**	256° 32' 16.5"
Longitude (l1)	110° 32.35'	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-66° 20' 01.1 "		
Longitude (l2)	110° 03' 24.6 "	Reverse Azimuth (a21)	76° 58' 46.6"
			COLOUR KEY
			User input
			Result

Ellipsoid **WGS84**

Station 1	Casey SK 2 W	**Station 2**	3 nm from W threshold
Latitude (j1)	-66° 17.28'	**Azimuth (a12)**	256° 32' 16.5"
Longitude (l1)	110° 32.35'	**Ellipsoidal Dist (s)**	05,556
	-66 -17' -58.389288		
Latitude (j2)	-66° 17' 58.4 "	Reverse Azimuth (a21)	76° 38' 53.4"
Longitude (l2)	110° 25' 07.5 "		**COLOUR KEY**
			User input
			Result

Ellipsoid **WGS84**

Station 1	Casey SK 2 E	**Station 2**	3 nm from E threshold
Latitude (j1)	-66° 17.15'	**Azimuth (a12)**	076° 33' 30.7"
Longitude (l1)	110° 38.70'	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-66° 16' 27.1 "		
Longitude (l2)	110° 45' 55.1 "	Reverse Azimuth (a21)	256° 26' 54.1"
			COLOUR KEY
			User input
			Result

Ellipsoid **WGS84**

Station 1	Casey SK 2 E	**Station 2**	12 nm from E threshold
Latitude (j1)	-66° 17.15'	**Azimuth (a12)**	076° 33' 30.7"
Longitude (l1)	110° 38.70'	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-66° 14' 19.5 "		
Longitude (l2)	111° 07' 32.0 "	Reverse Azimuth (a21)	256° 07' 07.0"
			COLOUR KEY
			User input
			Result

4. Davis Sea Ice Skiway

Ellipsoid **WGS84**

Station 1	West Davis W end	**Station 2**	West Davis E end
Latitude (j1)	-68° 34.32	**Latitude (j2)**	-68° 34.08
Longitude (l1)	77° 57.57	**Longitude (l2)**	77° 58.17
Spheroidal Dist. (S)	604.5		
Azimuth 1-2 (a12)	42° 26 21.187"		User input
Azimuth 2-1(a21)	222° 25 47.676"		Result

Ellipsoid **WGS84**

Station 1	West Davis W end	**Station 2**	12 nm from W threshold
Latitude (j1)	-68° 34.32	**Azimuth (a12)**	222° 25' 47.7"
Longitude (l1)	77° 57.57	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-68° 43.00 07.2 "		
Longitude (l2)	77° 35.00 22.1 "	Reverse Azimuth (a21)	42° 46' 28.4"
			COLOUR KEY
			User input
			Result

Ellipsoid **WGS84**

Station 1	West Davis W end	**Station 2**	3 nm from W threshold
Latitude (j1)	-68° 34.32	**Azimuth (a12)**	222° 25' 47.7"
Longitude (l1)	77° 57.57	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-68° 36.00 31.5 "		
Longitude (l2)	77° 52.00 02.8 "	Reverse Azimuth (a21)	42° 30' 56.2"
			COLOUR KEY
			User input
			Result

Ellipsoid **WGS84**

Station 1	West Davis E end	**Station 2**	3 nm from E threshold
Latitude (j1)	-68° 34.08	**Azimuth (a12)**	042° 26' 21.2"
Longitude (l1)	77° 58.17	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-68° 31.00 52.4 "		
Longitude (l2)	78° 3.00 40.5 "	Reverse Azimuth (a21)	222° 21' 13.7"
			COLOUR KEY
			User input
			Result

Ellipsoid **WGS84**

Station 1	West Davis E end	**Station 2**	12 nm from E threshold
Latitude (j1)	-68° 34.08	**Azimuth (a12)**	042° 26' 21.2"
Longitude (l1)	77° 58.17	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-68° 25.00 14.0 "		
Longitude (l2)	78° 20.00 05.0 "	Reverse Azimuth (a21)	222° 05' 57.9"
			COLOUR KEY
			User input
			Result

5. Davis Plateau Skiway

Ellipsoid **WGS84**

Station 1	Davis Pleateau 1 (Nth)	**Station 2**	12 nm to south of ARP
Latitude (j1)	-68° 30.00 00.0000"	**Azimuth (a12)**	245°
Longitude (l1)	78° 50.00 37.0000"	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-68° 35.00 00.5 "		
Longitude (l2)	78° 20.00 58.3 "	Reverse Azimuth (a21)	65° 27' 35.4"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Davis Pleateau 1 (Nth)	**Station 2**	3 nm to south of ARP
Latitude (j1)	-68° 30.00 00.0000"	**Azimuth (a12)**	245°
Longitude (l1)	78° 50.00 37.0000"	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-68° 31.00 15.6 "		
Longitude (l2)	78° 43.00 13.6 "	Reverse Azimuth (a21)	65° 06' 52.6"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Davis Pleateau 1 (Nth)	**Station 2**	3 nm to north of ARP
Latitude (j1)	-68° 30.00 00.0000"	**Azimuth (a12)**	065°
Longitude (l1)	78° 50.00 37.0000"	**Ellipsoidal Dist (s)**	05,556
Latitude (j2)	-68° 28.00 44.1 "		
Longitude (l2)	78° 57.00 59.6 "	Reverse Azimuth (a21)	244° 53' 08.2"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Davis Pleateau 1 (Nth)	**Station 2**	12 nm to north of ARP
Latitude (j1)	-68° 30.00 00.0000"	**Azimuth (a12)**	065°
Longitude (l1)	78° 50.00 37.0000"	**Ellipsoidal Dist (s)**	22,224
Latitude (j2)	-68° 24.00 54.3 "		
Longitude (l2)	79° 20.00 02.5 "	Reverse Azimuth (a21)	244° 32' 37.8"

COLOUR KEY
User input
Result

6. Mawson Sea Ice Skiway

Ellipsoid **WGS84**

Station 1	Mawson SK1 (Sea Ice) ARP		**Station 2**	12 nm to Nth of ARP	
Latitude (j1)	-67°	35' 06.7000"	**Azimuth (a12)**	337°	00' 00.000"
Longitude (l1)	62°	51' 10.8000"	**Ellipsoidal Dist (s)**	22,224	
Latitude (j2)	-67°	24' 05.9079 "			
Longitude (l2)	62°	39' 02.0916 "	Reverse Azimuth (a21)	157°	11' 13.208"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK1 (Sea Ice) ARP		**Station 2**	3 nm to Nth of ARP	
Latitude (j1)	-67°	35' 06.7000"	**Azimuth (a12)**	337°	00' 00.000"
Longitude (l1)	62°	51' 10.8000"	**Ellipsoidal Dist (s)**	05,556	
Latitude (j2)	-67°	32' 21.5890 "			
Longitude (l2)	62°	48' 07.5655 "	Reverse Azimuth (a21)	157°	02' 49.363"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK1 (Sea Ice) ARP		**Station 2**	3 nm to Sth of ARP	
Latitude (j1)	-67°	35' 06.7000"	**Azimuth (a12)**	157°	00' 00.000"
Longitude (l1)	62°	51' 10.8000"	**Ellipsoidal Dist (s)**	05,556	
Latitude (j2)	-67°	37' 51.7524 "			
Longitude (l2)	62°	54' 14.7462 "	Reverse Azimuth (a21)	336°	57' 09.923"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK1 (Sea Ice) ARP		**Station 2**	12 nm to Sth of ARP	
Latitude (j1)	-67°	35' 06.7000"	**Azimuth (a12)**	157°	00' 00.000"
Longitude (l1)	62°	51' 10.8000"	**Ellipsoidal Dist (s)**	22,224	
Latitude (j2)	-67°	46' 06.5545 "			
Longitude (l2)	63°	03' 30.8971 "	Reverse Azimuth (a21)	336°	48' 35.368"

COLOUR KEY
User input
Result

7. Mawson Plateau Skiway

Ellipsoid **WGS84**

Station 1	Mawson SK2 (Plateau) ARP	**Station 2**	12 nm to Nth of ARP
Latitude (j1)	-67° 37' 21.0000"	**Azimuth (a12)**	337° 00' 00.000"
Longitude (l1)	62° 52' 06.2000"	**Ellipsoidal Dist (s)**	22,224.000
Latitude (j2)	-67° 26' 20.2101 "		
Longitude (l2)	62° 39' 56.3508 "	Reverse Azimuth (a21)	157° 11' 14.443"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK2 (Plateau) ARP	**Station 2**	3 nm to Nth of ARP
Latitude (j1)	-67° 37' 21.0000"	**Azimuth (a12)**	337° 00' 00.000"
Longitude (l1)	62° 52' 06.2000"	**Ellipsoidal Dist (s)**	05,556.000
Latitude (j2)	-67° 34' 35.8897 "		
Longitude (l2)	62° 49' 02.6767 "	Reverse Azimuth (a21)	157° 02' 49.675"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK2 (Plateau) ARP	**Station 2**	3 nm to Sth of ARP
Latitude (j1)	-67° 37' 21.0000"	**Azimuth (a12)**	157° 00' 00.000"
Longitude (l1)	62° 52' 06.2000"	**Ellipsoidal Dist (s)**	05,556.000
Latitude (j2)	-67° 40' 06.0516 "		
Longitude (l2)	62° 55' 10.4375 "	Reverse Azimuth (a21)	336° 57' 09.608"

COLOUR KEY
User input
Result

Ellipsoid **WGS84**

Station 1	Mawson SK2 (Plateau) ARP	**Station 2**	12 nm to Sth of ARP
Latitude (j1)	-67° 37' 21.0000"	**Azimuth (a12)**	157° 00' 00.000"
Longitude (l1)	62° 52' 06.2000"	**Ellipsoidal Dist (s)**	22,224.000
Latitude (j2)	-67° 48' 20.8506 "		
Longitude (l2)	63° 04' 27.4770 "	Reverse Azimuth (a21)	336° 48' 34.093"

COLOUR KEY
User input
Result

<u>Appendix 7</u>

Monitoring Project - Outcomes for 2002-03

Data available on request or from
http://www.aad.gov.au/default.asp?casid=12307

Appendix 8

Historic Adélie penguin data in the Windmill Islands

Appendix 8.1 Census data from Adélie penguin breeding localities in the Windmill Islands 1955 onwards. Count types are designated as adults (A), nests (N) or chicks (C) with an estimate of the accuracy of the count provided as a number between 1 and 5: 1 (±5%), 2 (±5 – 10%), 3 (±10 – 15%), 4 (±25-50%) and 5 (order of magnitude).

Nelly Island 66 12S, 110 11E

Date	Count		Colonies	Source
23 Jan 1956	250	(A4)		
1961	100	(N3)	1	Orton (1963)
Jan 1972			2	M. D. Murray, unpub. photographs
1 Feb 1974	250	(A3)		
14 Feb 1980	68	(A2)		
24 Dec 1989	554	(N2)	3	Woehler et al. (1991)
16 Dec 1990	**707**	**(N1)**	**3**	**INCOMPLETE COVERAGE**

Chappel Island 66 11S, 110 26E

Date	Count		Colonies	Source
1961	1 200	(N3)		Orton (1963)
1972	8 000	(N3)		
Jan 1972			48	M. D. Murray, unpub. photographs
14 Feb 1980	2 618	(A2)		
25 Dec 1989	5 780	(N2)	44	Woehler et al. (1991)
16 Dec 1990	**6 958**	**(N1)**	**48**	**COMPLETE COVERAGE**

Berkley Island 66 13S, 110 39E

Date	Count		Colonies	Source
1961	500	(N3)		Orton (1963)
14 Nov 1974	3 000	(N3)	58	ANARE
14 Feb 1980	2 388	(A3)		
19 Dec 1989	5 141	(N2)	59	Woehler et al. (1991)
16 Dec 1990	**5 947**	**(N1)**	**73**	**COMPLETE COVERAGE**

Cameron Island 66 13S, 110 37E

Date	Count		Colonies	Source
1961	350	(N3)		Orton (1963)
Jan 1972			14	M. D. Murray, unpub. photographs
14 Nov 1974	600	(N3)	11	ANARE
14 Dec 1980	540	(A3)		
19 Dec 1989	1 347	(N2)	13	Woehler et al. (1991)
16 Dec 1990	**1 713**	**(N1)**	**12**	**COMPLETE COVERAGE**

Blakeney Point 66 14S, 110 35E (ASPA 136)

Date	Count		Colonies	Source
1961	3 500	(N3)		Orton (1963)
Jan 1972			≥20	M. D. Murray, unpub. photographs
Dec 1972	2 000	(N4)		D. J. Luders, unpublished map
14 Nov 1974	1 000	(N3)		ANARE
3 Dec 1974	1 100	(N3)		ANARE
1980	2 967	(A3)		
3 Dec 1989	5 604	(N2)	29	Woehler et al. (1991)
16 Dec 1990	**>4 578**	**(N1)**	**28**	**INCOMPLETE COVERAGE**

Whitney Point 66 15S, 110 32E (ASPA 136)

Date	Count		Colonies	Source
1959	1 122	(N1)	14	Martin *et al*. (1990)
1960	1 323	(N1)	14	Martin *et al*. (1990)
1961	1 155	(N1)	14	Martin *et al*. (1990)
1961	1 300	(N3)		Orton (1963)
27 Oct 1961	1 000	(A4)		
27 Nov 1963	1 465	(N1)	13	Woehler & Burton (unpub. data)
25 Nov 1964	1 329	(N1)	13	Woehler & Burton (unpub. data)
19 Dec 1971	2 043	(N1)	16	ANARE
29 Oct 1972	1 175	(A3)		ANARE
3 Dec 1974	1 727	(N2)		ANARE
14 Feb 1980	828	(A4)		
15 Dec 1983	4 199	(N2)	28	Martin *et al*. (1990)
30 Nov 1984	4 181	(N2)	28	Woehler & Burton (unpub. data)
2 Dec 1989	3 803	(N1)	30	Woehler et al. (1991)
16 Dec 1990	**4 553**	**(N1)**	**31**	**COMPLETE COVERAGE**

Shirley Island 66 17S, 110 30E

Date	Count		Colonies	Source
1961	3 000	(N3)		Orton (1963)
1 Dec 1968	7 344	(N1)	45	ANARE
7 Dec 1971	7 580	(N1)	45	ANARE
26 Jan 1972	9 687	(C1)		
10 Nov 1972	8 534	(N1)	45	ANARE
Dec 1972	8 410	(N3)		D. J. Luders, unpublished map
27 Jan 1973	4 366	(C1)		
10 Nov 1973	8 012	(N1)		
18 Nov 1974	7 303	(N1)		
26-28 Nov 1976	7 362	(A1)		
1 Dec 1977	7 049	(N1)	45	ANARE
4 Jan 1985	8 286	(N2)	49	ANARE
7 Dec 1989	7 637	(N2)	52	Woehler et al. (1991)
16 Dec 1990	**8 888**	**(N1)**	**53**	**COMPLETE COVERAGE**

Beall Island 66 18S, 110 29E

Date	Count		Colonies	Source
1961	2 800	(N2)		
1 Dec 1968	4 349	(N1)	24	ANARE

12 Dec 1971	4 713	(N3)	24	ANARE
1972	4 000	(N3)	33	
Dec 1972	5 000	(N4)		D. J. Luders, unpublished map
31 Dec 1972	6 510	(N3)		
5 Dec 1989	5 224	(N2)	28	Woehler et al. (1991)
16 Dec 1990	**>5 147**	**(N1)**	**24**	**INCOMPLETE COVERAGE**

Hollin Island 66 19S, 110 24E

Date	Count		Colonies	Source
1961	300	(N3)		Orton (1963)
17 Dec 1972	2 500	(N4)		
23 Jan 1980	1 289	(A2)		
24 Dec 1989	2 801	(N2)	18	Woehler et al. (1991)
16 Dec 1990	**>1 538**	**(N1)**	**18**	**INCOMPLETE COVERAGE**

Midgley Island 66 20S, 110 24E

Date	Count		Colonies	Source
1961	4 200	(N3)		Orton (1963)
2 Dec 1961	4 500	(N4)		
17 Dec 1972	7 500	(N4)		
23 Jan 1980	2 022	(A3)		
26 Dec 1989	7 436	(N2)	37	Woehler et al. (1991)
16 Dec 1990	**>7 067**	**(N1)**	**39**	**INCOMPLETE COVERAGE**

Odbert Island 66 22S, 110 33E ASPA 3

Date	Count		Colonies	Source
1961	3 500	(N3)		Orton (1963)
1972	1 000+	(N4)		
6 Dec 1972	20 000	(N4)		
Dec 1972	15 000	(N4)		D. J. Luders, unpublished map
7+9 Jan 1990	10 689	(N2)	58	Woehler et al. (1991)

Holl Island 66 25S, 110 25E

Date	Count		Colonies	Source
1961	3 000	(N3)		Orton (1963)
1972	11 000	(N3)		
1 Jan 1990	11 875	(N2)	56	Woehler et al. (1991)
16 Dec 1990	**>11 644**	**(N1)**	**54**	**INCOMPLETE COVERAGE**

O'Connor Island 66 25S, 110 28E

Date	Count	Colonies	Source

1961	2 000	(N3)		Orton (1963)
1972	5 000	(N3)		
Jan 1972	2 300	(C3)	8	M. D. Murray, unpub. photographs
1 Jan 1990	4 748	(N2)	5	Woehler et al. (1991)
16 Dec 1990	**7 275**	**(N1)**	**22**	**COMPLETE COVERAGE**

Peterson Island 66 28S, 110 32E

Date	Count		Colonies	Source
1961	4 500	(N3)		
1972	5 000	(N3)		
6 Dec 1972	10-15 000	(N4)		ANARE
1 Feb 1974	8-10 000	(A3)		
13 Feb 1980	5 946	(A3)		
7+9 Jan 1990	20 453	(N2)	83	Woehler et al. (1991)
16 Dec 1990	**>18 481**	**(N1)**	**60**	**INCOMPLETE COVERAGE**

Appendix 8.2 Percentage increases (between 1961 and 1989) in the breeding populations of Adélie penguins at 14 breeding localities at the Windmill Islands.

The percentage increase is also expressed as a mean annual percentage increase.

Breeding locality	Percentage increase	Mean annual percentage increase
Nelly Island	454	6.1
Chappel Island	382	5.6
Berkley Island	928	8.3
Cameron Island	285	4.8
Blakeney Point	60	1.7
Whitney Point	229	4.3
Shirley Island	155	3.3
Beall Island	87	2.2
Hollin Island	833	8.0
Midgley Island	77	2.0
Odbert Island	205	4.0
Holl Island	296	4.9
O'Connor Island	137	3.1
Peterson Island	355	5.4
Windmill Islands	**209**	**4.0**