Perth Airport | New Runway Project

New Runway Project

FINAL
MAJOR DEVELOPMENT PLAN

VOLUME B: ENVIRONMENT, HERITAGE AND TRAFFIC ASSESSMENT SECTIONS 8-18

FEBRUARY 2021

New Runway Project

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Volume B describes the initial conditions, impacts and mitigation strategies associated with the on-ground construction and operation activities of the New Runway Project. It also provides details for environment, heritage and traffic management for the project.

The Final Major Development Plan for the New Runway Project is presented in four volumes:
- Executive Summary
- Volume A: Background and Need (Sections 1-7)
- Volume B: Environment, Heritage and Traffic Assessment (Sections 8-18) – this volume
- Volume C: Airspace Management Plan (Sections 19-26)

This volume should be read in conjunction with all other volumes.

This Final Major Development Plan for the New Runway Project has been prepared by Perth Airport Pty Ltd (Perth Airport) (ABN 24 077 153 130) to satisfy the requirements of the *Airports Act 1996* (Cth).

While all care has been taken in the preparation of this Final Major Development Plan for the New Runway Project:
- it is based on certain forecasts and assumptions, and Perth Airport makes no claim as to the accuracy or completeness of any of the information or the likelihood of any future matter,
- it should not be relied upon by any other party for any purpose,
- it does not commit Perth Airport to any particular development, and
- Perth Airport accepts no liability whatsoever to any person who in anyway relies on any information in this Final Major Development Plan for the New Runway Project (including making any decision about development or any other activity on or off Perth Airport).

ACKNOWLEDGMENT OF COUNTRY
Hello, this is Whadjuk Country! Perth Airport operates on the traditional lands of the Whadjuk people of the Noongar Nation. We respect their ongoing cultural connection to this region. We value the insights and guidance of the Noongar signatories to the Perth Airport Partnership Agreement, as we work together to preserve and honour this connection.

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08 Environment, Heritage and Ground Transport Assessment Introduction

This section provides an overview of the process taken to assess the environmental, heritage and traffic impacts during construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What is the major development plan process?
- What is the environmental and heritage assessment methodology?
- What is the ground transport assessment methodology?
- How were the environmental assessments undertaken?
- How was the heritage assessment undertaken?
- What was the State heritage process and what was involved?
- How was the ground transport assessment undertaken?

8.1 Introduction

This Volume provides an overview of the process taken to assess the on-ground environmental, heritage and traffic impacts of the construction and operation of the New Runway Project (NRP) at Perth Airport.

To understand the impact of the NRP, assessments to quantify the on-ground impacts have been undertaken. This volume describes the existing conditions, impacts and mitigation strategies associated with activities that occur within the NRP area. It also outlines the environment and heritage management for the project, including environmental offsets.

A ground transport assessment has also been completed for the NRP. To assess the impact of the construction of the new runway on the road network surrounding the airport, a traffic model was developed showing how the network would perform, both with and without the runway constructed.

8.2 Major Development Plan

The construction of the new runway and associated infrastructure will result in physical changes to the NRP area. The *Airports Act 1996* (Airports Act) requires an approved Major Development Plan (MDP) for the construction and operation of a new runway. The contents of a MDP, as outlined in section 91 of the Airports Act, includes the assessment of the environmental impacts that might reasonably be expected to be associated with the development as well as the plans for dealing with the identified environmental impacts.

A MDP is also required to be referred to the Commonwealth Minister for the Environment for advice pursuant to section 160 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An environmental and heritage assessment has therefore been completed to meet the Airports Act and EPBC Act requirements for on-ground environmental impacts.

A detailed description of the regulatory framework is provided in Section 1.

The Airports Act also requires that the traffic impacts of a proposed development be considered.

The MDP is a detailed approvals document that has been structured and prepared to meet regulatory requirements of the Airports Act and the EPBC Act.

The NRP MDP has been prepared to address the various legislative approvals required for a new runway at Perth Airport and provides a combined approvals document to ensure a whole of project is represented.

8.2.1 Approval Process

The legislative approvals process for the NRP is shown in Figure 8-1.

Further detail about the regulatory framework is provided in Section 1.

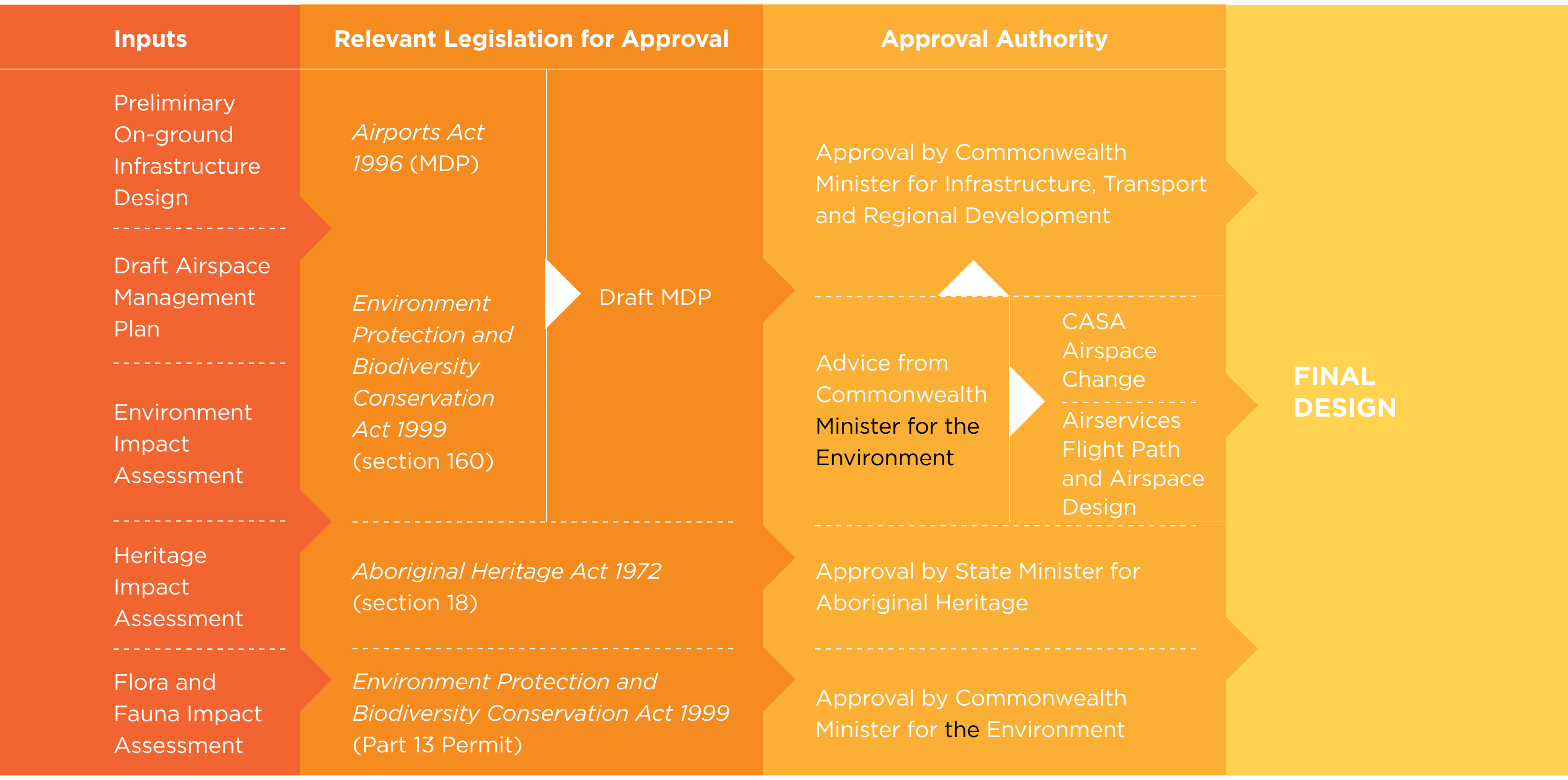


Figure 8-1 Legislative approvals process for the New Runway Project
Source: Perth Airport

8.2.2 Major Development Plan Structure

The NRP MDP is presented in four volumes:

- Executive Summary
- Volume A: Background and Need Sections 1-7
- Volume B: Environment, Heritage and Traffic Assessment Sections 8-18 (this volume)
- Volume C: Airspace Management Plan Sections 19-26.

This volume should be read in conjunction with the Executive Summary, Volume A: Background and Need, and Volume C: Airspace Management Plan.

Table 8-1 provides details of the content and scope of each of the volumes of the MDP.

Section	Description	Scope
Executive Summary		
Volume A: Background and Need		
01	Introduction	Volume A sets the scene for the project. It describes the background and need for the new runway, alternative options that have been considered, as well as provides a description of the NRP and how it will be constructed.
02	Need for additional capacity	
03	Options and alternatives	
04	Benefits of the New Runway Project at Perth Airport	
05	Consistency with State and Local government planning	
06	Project description and construction	
07	Consultation	
Volume B: Environment, Heritage and Traffic Assessment		
08	Environment, Heritage and Ground Transport Introduction	Volume B describes the initial conditions, impacts and mitigation strategies associated with the on-ground construction and operation activities of the NRP. It also provides details for environment, heritage and traffic management for the project.
09	Geology and soils	
10	Wetlands and hydrology	
11	Flora and vegetation	
12	Fauna	
13	Ground-based noise	
14	Air quality and greenhouse gas (ground)	
15	Landscape and visual	
16	Heritage	
17	Environment and heritage management	
18	Ground transport	
Volume C: Airspace Management Plan		
19	Airspace management plan introduction	Volume C outlines the plan for airspace management. It also describes the impacts and mitigation strategies proposed as a result of the operation of the new runway.
20	Background and existing airspace management	
21	Airspace management plan	
22	Aircraft noise	
23	Air quality and greenhouse gas (air based)	
24	Health	
25	Social	
26	Hazards and risks to airport operations	

Table 8-1 Content and scope of the New Runway Project Major Development Plan
Source: Perth Airport

8.2.3 Public Comment

In accordance with the requirements of a major development plan, under the Airports Act, Perth Airport released a Preliminary Draft MDP for 60 business days of public consultation. The public comment period ran from 31 May 2018 to 5pm (WST) 24 August 2018.

8.2.4 Project Overview

The NRP includes:

- construction, including clearing and site preparation, of a new runway up to 3,000 metres long with associated infrastructure, and
- development of an airspace management plan that will cater for the changes to current airspace and flight paths to accommodate operations of the new runway.

To meet future capacity demand, the new runway is expected to be operational between 2023 and 2028, subject to actual demand and a commercial agreement with airlines being reached. To meet this timeframe, Perth Airport is seeking to complete the approvals process for the new runway by 2019 to be ready for the construction and commissioning phase to begin.

The new runway will occupy approximately 293-hectares and will be located parallel to the existing main runway with a two-kilometre separation so that both runways can be used independently.

The location of the NRP is consistent with the Perth Airport Master Plan 2014 approved in January 2015, the subsequent Master Plan 2014 Minor Variation approved in June 2017, and the Perth Airport Master Plan 2020 approved in March 2020.

8.3 Environment, Heritage and Ground Transport Assessment Overview

Volume A addresses the need for the new runway and details the NRP infrastructure and construction activities. Volume C details the design of flight paths and the associated airborne considerations.

The on-ground environmental and heritage impacts associated with the construction and operation of the NRP are described in this Volume B, in discipline specific sections as follows:

- Geology and soils (Section 9),
- Wetlands and hydrology (Section 10),
- Flora and vegetation (Section 11),
- Fauna (Section 12),
- Ground-based noise (Section 13),
- Air quality and greenhouse gas (ground) (Section 14),
- Landscape and visual impact (Section 15), and
- Heritage (Section 16).

Section 9 Geology and Soils

Section 9 describes the impacts on geology, soils and contamination resulting from the construction and operation of the NRP.

The assessment considers the changes that may occur as a result of the clearing and use of fill to change levels, as well as the excavation of soils for drainage channels and conduits for services. It also details the extent of contamination across the NRP site and how this will be managed during construction activities.

Section 10 Wetlands and Hydrology

The NRP requires the realignment of the major stormwater drains that run through the estate.

The hydrology assessment describes the impact of the drainage realignment on surface water and groundwater. Information is provided on how the drainage systems will be designed to cater for expected rain events, and the flood modelling that was undertaken to assess storm event scenarios.

This section also discusses the design of pollution capturing basins and infiltration basins to control the velocity of water flow, maintain water quality, and protect Munday Swamp.

Section 11 Flora and Vegetation

Perth Airport has undertaken a series of field surveys and studies, dating back to 1994, to understand flora and vegetation across the estate. Section 11 describes the impacts on flora and vegetation resulting from the construction and operation of the NRP and the management and mitigation measures that have been identified.

The flora and vegetation community assessment has drawn from the extensive desktop reviews and field surveys, including targeted assessments of the Banksia woodlands of the Swan Coastal Plain threatened ecological community, conservation-significant plant species, and aquatic flora within Munday Swamp. To assist in soil management during construction of the NRP, the assessment has also considered Commonwealth-listed weeds of national significance (that pose a risk to species and communities) and *Phytophthora cinnamomi* (dieback disease).

Section 12 Fauna

The NRP area has vegetation that provides habitat for various fauna. Section 12 describes the surveys undertaken to identify species within the project area, including threatened and priority fauna and the proposed mitigation measures.

Section 13 Ground-Based Noise

There are a number of ground-based noise sources at an airport, including auxiliary power units used by parked aircraft, the ground running of aircraft engines for maintenance purposes, taxiing of aircraft, changes in road traffic volumes, and construction activities.

This assessment considers how ground-based noise will change during construction and operation of the new runway. The environmental noise forecasting and modelling is described, as well explaining how noise impacts can be exacerbated by certain weather conditions.

Section 14 Air Quality and Greenhouse Gas (Ground)

Section 14 describes the assessment of air quality, odour and greenhouse gas for existing and predicted future ground-based conditions. It considers the change in ground-based emissions (all emissions from airport-related activities other than emissions released by aircraft) expected as a result of the construction and operation of the NRP.

Section 15 Landscape and Visual Impact

Section 15 describes the impact of changes to the visual landscape resulting from the construction and operation of the NRP. The visual amenity will be altered through new airside roads and fencing, the runway and associated taxiways and aprons, and the installation of high intensity approach lighting at the northern and southern extents of the new runway.

The assessment identifies what parts of the NRP can be viewed from different locations around Perth and the expected changes in visual appearance.

Section 16 Heritage

Section 16 provides information regarding the Aboriginal, European and natural heritage values associated with the NRP area.

To quantify and understand heritage values, Perth Airport has undertaken a number of studies, including numerous ethnographic and archaeological assessments. This section identifies the changes Perth Airport has made to the design of the NRP in recognition of the Aboriginal heritage values within the estate. It also describes the approvals process under State legislation, and details the consultation undertaken with the Noongar community who are the Traditional Custodians of the land.

Section 17 Environmental and Heritage Management

Section 17 describes the environmental management proposed for the project. Additional investigations will be undertaken if required with management strategies developed as the detailed design of the NRP is finalised.

The key mitigation and management strategies as outlined in Section 17 will provide the basis for the development of a Construction Environment Management Plan (CEMP) and an Operational Environment Management Plan (OEMP) for the NRP.

Section 18 Ground Transport

This volume also includes an assessment of the changes to vehicle traffic and ground transport associated with the NRP, for example change in road layout and impacts of increased vehicle movements. A detailed traffic model was developed that considered impacts to internal and external road networks.

Consistent with the environmental and heritage impacts, an opening year of 2025 was considered.

8.4 Assessment Overview

Each section describes the existing conditions in the NRP area, assesses the potential impacts and identifies mitigation and management for the impacts identified.

The identification of environmental values and their significance is based on data attained by site investigations and information obtained over the short and long term. Based on the information available, the environmental values of the NRP are described and defined by Commonwealth and State legislation, policy and guidance. Where relevant, a whole of estate context on relative values is also provided.

A risk-based impact assessment framework has been applied to identify the significance of potential impacts and residual impacts after mitigation has been applied as described in Section 8.4.2. Table 8-2 shows the general layout of each section of this volume.

8.4.1 Terminology and Basis of Assessment

This section outlines common information and assumptions used across the studies and highlights where there may be variances.

Section	Description
Introduction	The scope of the section and relevant environmental issues. The NRP development activities that are relevant to the assessment of that issue. The relevant legislation, policies and guidelines that were considered in the assessment.
Methodology	How the studies were undertaken, including a description of the study area and assumptions, where applicable, used to determine the existing conditions and potential impacts.
Existing Conditions	A description of the existing conditions within the NRP area.
Impact Assessment	A discussion of the potential impacting processes.
Mitigation	This section outlines mitigation measures to reduce or ameliorate impacts.
Summary of Impacts	A summary of the section including an assessment of residual impacts in accordance with the impact assessment framework.

Table 8-2 Section layout
Source: Perth Airport

Figure 8-2 New Runway Project area
Source: Perth Airport

8.4.1.1 Year of Opening

Based on aircraft movement forecasts, Perth Airport has adopted a 'plan for high' and anticipate to 'deliver at central' approach to additional runway capacity.

A likely opening range of 2023 to 2028 for the new runway allows industry to balance capital expenditure with appropriate levels of service and delays. Considering this range of dates, 2025 has been used as the point of reference where a technical study has considered the impact of the NRP from day of opening.

Further information on the timing of the new runway is provided in Section 2.

8.4.1.2 New Runway Project Area and Study Areas

The physical infrastructure for the NRP will be built within the footprint referred to as the NRP area, shown in Figure 8-2.

Detailed information on what will be delivered and the construction methodology is outlined in Section 6.

To ensure that impacts are appropriately captured and understood some studies required a wider study area that may be different to the NRP area. As an example, the fauna impacts discussed in Section 12 considers the impact of the NRP within a 12-kilometre radius of Perth Airport.

8.4.1.3 Calculation variance

Due to different spatial systems used to assess areas within the NRP, total areas calculated in different sections of the MDP may vary slightly. Similarly, variances may exist in total area due to rounding used.

8.4.1.4 Climate Conditions

Climatic conditions assist in understanding the environment of the NRP area, as well as influencing the development of construction management measures.

The Perth region has a Mediterranean climate, experiencing hot, dry summers and mild, wet winters. The annual average rainfall is 769.5 millimetres, with most of the rain falling between May and August, with mean daily minimum temperatures ranging between 8.0°C and 17.5°C. From December to March the climate is typically dry and hot with mean daily maximum temperatures ranging between 17.9°C in winter and 32°C in summer. Historical annual averages from the Bureau of Meteorology station located at Perth Airport are summarised in Figure 8-3.

Winds and the seasonality of rainfall in the Perth region are factors that influences stormwater, dust control and sediment, and erosion control management strategies. The Perth region experiences strong westerly winds or gales in winter and strong easterly winds and south-westerly sea breezes in summer.

Perth Airport also acknowledges that climatic conditions may change during the life of the NRP. The design of the runway and associated infrastructure have included additional tolerances that make it adaptable to forecast changes in weather patterns.

8.4.1.5 Requirement for Clearing

The clearance from obstacles for runways, taxiways and aprons are defined within local and international aviation and airport standards and are necessary for the safe operation of aircraft on the ground. The CASA Manual of Standards Part 139, the

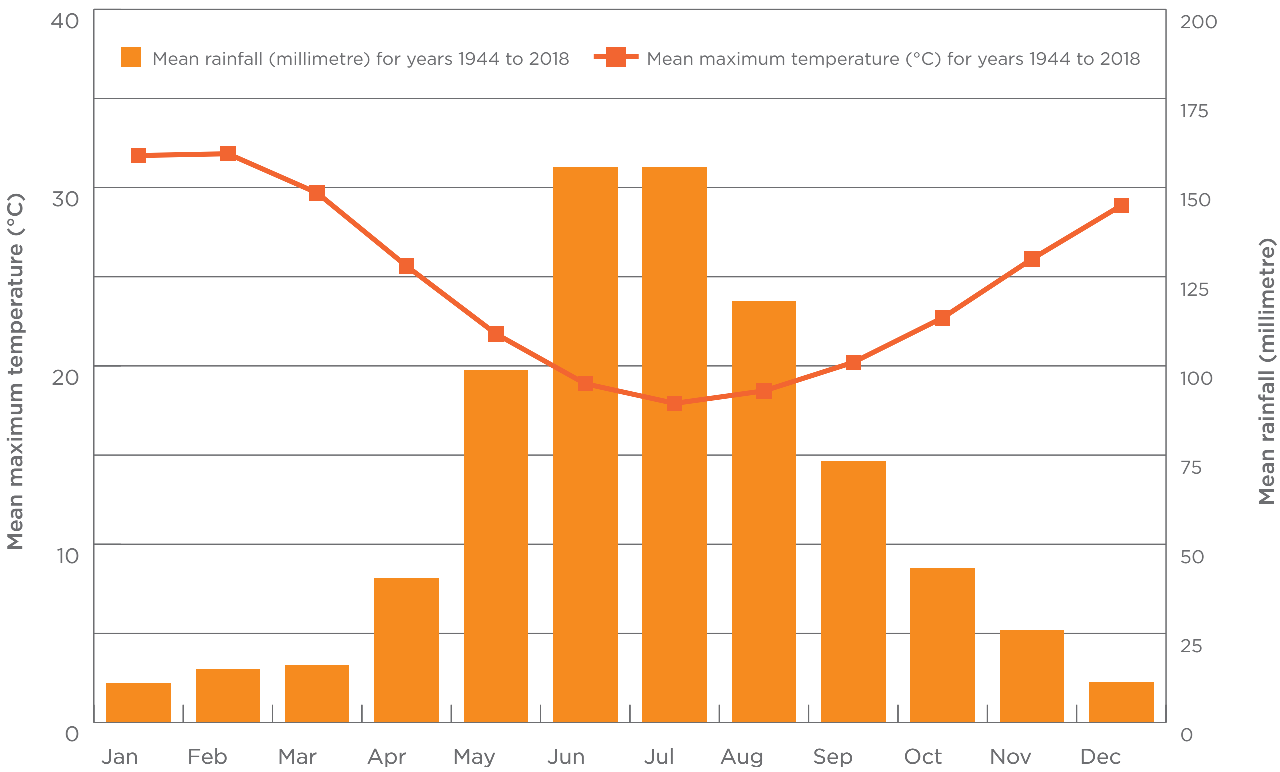


Figure 8-3 Climate data for Perth Airport
Source: Bureau of Meteorology

specific standard that applies to airports within Australia, requires Perth Airport to ensure the airfield is clear of obstructions and vegetation that could impact on the safety of aircraft operations and operators on the ground. The standard sets out minimum separation and clearance distances that must be complied with. The standard also requires surfaces are kept clear of obstacles to protect aircraft engines and also to ensure obstacles and people are safe from the effects of engine jet blast.

Security standards also determine specific clearance areas for perimeter fences which must be complied with.

8.4.2 Impact Assessment Framework

To quantify the extent to which these changes impact the environment, Perth Airport has adopted a risk-based approach. An impact assessment framework was established to assess the potential impacts of the project and identify appropriate mitigation.

Perth Airport employed a two-stage assessment process. The first stage involved risk characterisation and assigning a level of risk based on the application of standard mitigation measures. If the risk rating was found to be medium, high or very high, additional mitigation measures were applied and the risk rating reassessed after consideration of any change to the likelihood and consequence of the risk activity. This step results in the assignment of a residual risk rating for the activity. Figure 8-4 shows the impact assessment framework for the NRP.

The risk level of an activity is assigned based on the consideration of two factors:

i) the significance criteria which describes the magnitude of the impacting process including an assessment of how long the change will last, and
ii) the likelihood, or possibility, of the impact occurring.

The combination of these two criteria defines the level of risk associated with an activity. Table 8-3 has been used to quantify the resulting risk.

		Impact Significance				
		Negligible	Minor Adverse	Moderate Adverse	High Adverse	Major Adverse
Likelihood	Highly Unlikely	Very low	Very low	Low	Low	Medium
	Unlikely	Very low	Low	Low	Medium	Medium
	Possible	Low	Low	Medium	Medium	High
	Likely	Low	Medium	Medium	High	Very High
	Almost Certain	Low	Medium	High	High	Very High

Table 8-3 Risk evaluation matrix
Source: Perth Airport

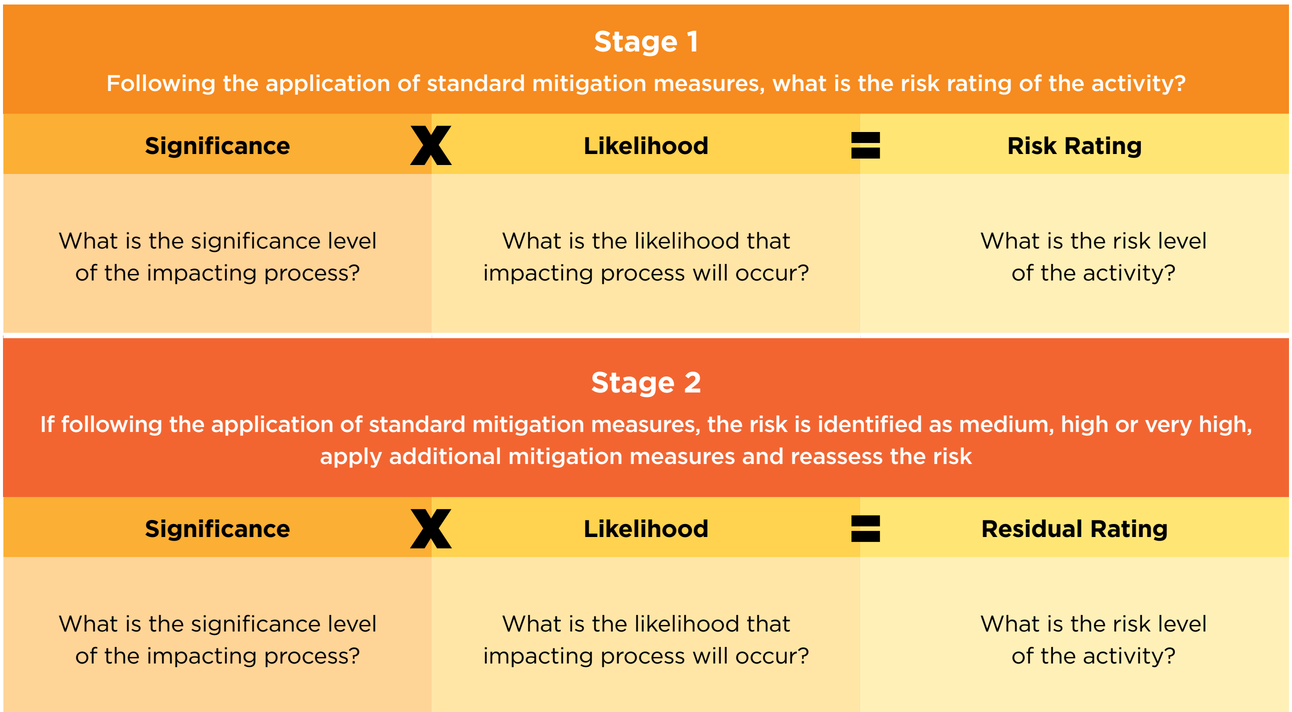


Figure 8-4 Impact assessment framework
Source: Perth Airport

8.4.2.1 Definition of Impact Significance Criteria

Significance criteria provide consistent impact descriptors to help identify the scale of impact on the environment across different environmental aspects. These descriptions consider the scale and duration of the impact and the sensitivity of the environmental receptors. Table 8-4 provides an example of the significance criteria, which have been tailored for each section of the MDP. Descriptions for the duration are provided in Table 8-5 while the description of the likelihood of an impact is shown in Table 8-6.

Magnitude Description	Example Criteria
Major Adverse	Impacts considered critical to the decision-making process. They tend to be permanent, or irreversible, or otherwise long term, and/or can occur over large scale areas. Environmental receptors are extremely sensitive, and/or the impacts are of national significance. Typically, mitigation measures are unlikely to remove such effects.
High Adverse	Impacts likely to be of importance in the decision-making process. They tend to be permanent, or otherwise long to medium term, and/or can occur over large or medium scale areas. Environmental receptors are high to moderately sensitive, and/or the impacts are of State significance.
Moderate Adverse	Impacts relevant to decision making, particularly for determination of environmental management requirements. These impacts tend to range from long to short term, and/or occur over medium scale areas or are focused within a localised area. Environmental receptors are moderately sensitive, and/or the impacts are of regional or local significance.
Minor Adverse	Impacts recognisable, but acceptable within the decision-making process. They are still important in the determination of environmental management requirements. These impacts tend to be short term, or temporary and at the local scale.
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.
Beneficial	The NRP results in an improvement in the baseline situation, for example, improved downstream water quality.

Table 8-4 Significance criteria
Source: Perth Airport

Relative Duration of Environmental Impacts	
Temporary	days to months
Short Term	up to one year
Medium Term	from one to five years
Long Term	from five to 50 years
Permanent / Irreversible	more than 50 years

Table 8-5 Duration of environmental impacts
Source: Perth Airport

8.4.2.2 Likelihood of Impact

The likelihood categories used in the assessment of impacts are provided in Table 8-6.

Likelihood of Impacts	Risk Probability Categories
Highly Unlikely	May occur only in exceptional circumstances - can be assumed not to occur during periods of the project (probability less than ten per cent)
Unlikely	Event is unlikely to occur, but it is possible during periods of the project (probability ten to 30 per cent)
Possible	Event could occur during periods of the project (probability 30 to 70 per cent)
Likely	Event likely to occur once or more during periods of the project (probability 70 to 90 per cent)
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting periods (probability greater than 90 per cent)

Table 8-6 Likelihood of impacts
Source: Perth Airport

8.4.2.3 Mitigation

Mitigation is a process of lessening the risk associated with an activity. Mitigation measures come in many forms such as the use of procedures, actions or behaviours that attempts to alter the risk level associated with an activity.

Mitigation measures have been identified with consideration of the following hierarchy:

i) avoided if possible through appropriate location of infrastructure associated with the NRP, or
ii) 'designed-out' where practicable, thereby minimising significant impacts to environmental values, or
iii) mitigated through implementation of environmental management plans to measure and minimise any impacts to the greatest practicable extent, or
iv) compensated for where impacts cannot be adequately mitigated and residual effects predominate.

Mitigation is addressed in two ways in the impact assessment framework.

The first assessment considers what would be the 'standard mitigation' approach to implementing the NRP, i.e. taking account of standard practice and statutory obligations. For example, the implementation of erosion and sediment control would be a standard mitigation requirement that could reasonably be assumed to be in place for the construction phase. The initial description and assessment of impacts in accordance with the study specific significance criteria includes a description of these standard measures.

The second assessment of mitigation is 'additional mitigation' which is aimed at reducing the significance, likelihood or risk of an identified impact occurring. Additional mitigation may not be necessary for all impacts but would be relevant to impacts identified as medium, high or very high risk. For example, additional mitigation may include a species-specific management or translocation plan to minimise an impact, or the inclusion of cut-off trenches in the design to minimise migration of contaminants in groundwater.

The risk assessment is then summarised in table form. An example table has been provided in Table 8-7.

8.4.2.4 Cumulative Impacts

Cumulative impacts are the successive, incremental and combined environmental impacts of one or more activities. The NRP is the first of a series of development projects planned within the Perth Airport estate as detailed in Master Plan 2014. These projects are summarised in Table 8-8.

Each of these projects will have their own MDP to ensure that as far as practical, impacts to the matters listed in Table 8-8 will be avoided, minimised, and mitigated. Any residual impact will be offset as per the EPBC Offset Policy.

Given these future projects are still in the early to mid-planning phases, the environmental impacts cannot be quantified and therefore cannot be considered in this MDP. Future MDPs will include the impacts of the NRP, and as applicable, other finalised projects, in their cumulative impact assessment.

There may also be some overlap between indirect impacts from the NRP and direct impacts on future projects. This potential overlap will be taken into account in any future cumulative impact assessments.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Example Construction of new Northern Main Drain and Southern Main Drain	Disturbance, management and treatment of acid sulfate soils resulting in acidification of surface or groundwater or impacts to ecological receptors	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance	Moderate Adverse	Almost certain	High	Further investigation prior to construction to delineate area of higher risk of encountering acid sulfate soils along Northern Main Drain and Southern Main Drain so that management can be targeted to high risk areas	Minor Adverse	Unlikely	Low

Table 8-7 Impact summary table structure
Source: Perth Airport

Action	Detail	Matters Potentially Impacted	Status
Airport Central Development	Upgrades to the international terminal at Perth Airport and supporting infrastructure including apron, taxiways and carparks	Banksia Woodlands of Swan Coastal Plain, Black Cockatoo Foraging Habitat,	Planning Stage and Exposure Draft
Airport West Development	Commercial development of Perth Airport estate's Western Precinct	Banksia Woodlands of Swan Coastal Plain, Black Cockatoo Foraging Habitat,	Planning stage
Airport North Development	Multi use development of Perth Airport estate's Northern Precinct	Banksia Woodlands of Swan Coastal Plain, Black Cockatoo Foraging Habitat,	Conceptual Planning
Airport South Development	Commercial Development of Perth Airport estate's Southern Precinct	Banksia Woodlands of Swan Coastal Plain, Black Cockatoo Foraging Habitat,	Conceptual Planning

Table 8-8 Future Projects at Perth Airport
Source: Perth Airport

09 Geology and Soils

This section describes the impacts on geology, soils and contamination resulting from the construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What are the geology and soils in the NRP area?
- How will the impacts of construction be mitigated?
- What is the extent of contamination across the NRP area?
- What is the approach to the management of contamination?

9.1 Introduction

This section describes the impacts on geology, soils and contamination resulting from the construction and operation of the New Runway Project (NRP) and is broken into two separate areas:

- geology and soils, and
- potential contaminants.

The NRP will impact geology, soils and contamination across the site as a result of:

- clearing the NRP area,
- the use of fill to change levels across the site,
- excavation of soils for drainage channels and conduits for services, and
- the construction of the new runway and associated infrastructure.

Studies were undertaken to examine the existing conditions within the NRP area, assess the impacts of the NRP and identify appropriate mitigation measures with the results reflected in a risk register.

Additional information on clearing and construction of the new runway and associated infrastructure can be found in Section 6.

9.2 Key Findings

The key findings from investigations into geology and soils include:

- Any disturbance of soils close to (within one metre) or below the groundwater table during the construction of the NRP should be assumed to be disturbing acid sulfate soils and therefore likely to release acidity. Active acid sulfate soil management (stockpiling) and treatment (addition of lime) will be required to protect local soil and groundwater from the release of acidity and metals.
- The erosion potential of the shallow soils within the NRP area have been identified as very high, and erosion control and management will be necessary throughout construction and during operations in accordance with industry practices.
- Per- and poly fluoroalkyl substances (PFAS) concentrations within the NRP area are below the laboratory limit of reporting (LOR) in all soil samples. However, PFAS was reported above the laboratory LOR and adopted assessment criteria in surface water and groundwater samples. Appropriate mitigation measures will be put in place to reduce risk to workers and the environment during construction.
- An Acid Sulfate Soil Dewatering Management Plan will include periodic monitoring of the groundwater and surface water, including assessment for PFAS, during construction, to assess for changes in PFAS concentrations from groundwater abstraction. Dewater effluent will be managed in a manner that does not result in an unacceptable increase in contamination risk, an increase in off-site release risk or an increase in risk to groundwater and surface water. Based on the relatively minor concentrations of PFAS in groundwater compared to the wider Airport Estate and the absence of any identified PFAS source areas within the project area treatment of abstracted water for PFAS is not required during dewatering.
- To manage the impacts of ground movement during construction, a further geotechnical study to inform consolidation and settlement will occur prior to construction. Detailed analysis and design of excavation and soil retaining systems will also occur along with careful construction sequencing during excavation. Settlement will be monitored and early intervention undertaken if needed.
- Spills of hazardous substances and hydrocarbons may occur during the construction phase of the NRP. It is intended that low impact and low toxicity chemicals are used where practical during the construction phase to reduce the risk.

The NRP construction and operation will include a range of management measures including preparation and implementation of an Acid Sulfate Soil and Dewatering Management Plan. Remediation of the existing contaminants will result in a beneficial impact where contaminants are removed, and appropriate risk minimisation will be undertaken where contaminants are left in situ.

9.3 Policy Context and Legislative Framework

Commonwealth and State Government policy and guidelines have been referenced for this assessment as they provide specific guidance relevant to geology and soils, in particular acid sulfate soils and contamination.

The following guidance was referred to:

- Western Australian Planning Commission, State Planning Bulletin 64 – Acid Sulfate Soils,
- Identification and Management of Acid Sulfate Soils and Acidic Landscapes, State Department of Water and Environmental Regulation (DWER) June 2015,
- Treatment and Management of Soil and Water in Acid Sulfate Soil Landscapes, Final Version, June 2015,
- IECA 2008, Best Practice Erosion and Sediment Control. International Erosion and Sediment Control Association (Australasia), Picton NSW,
- Airports (Environment Protection) Regulations (AEPR) 1997,
- *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act),*
- *Contaminated Sites Act 2003,*
- Contaminated Sites Regulations 2006,
- Assessment and Management of Contaminated Sites, DWER December 2014,
- Interim Guideline on Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), DWER January 2017,
- Department of Infrastructure and Regional Development – Management Actions Advice (Guideline for Environmental Management - GEM-002 2016),
- National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013, published by the National Environment Protection Council, and
- Heads of the Environmental Protection Authority (HEPA), January 2018, PFAS National Management Plan (NEMP) (HEPA 2018)

At the time of undertaking studies, the PFAS National Environment Management Plan (HEPA 2018) was not released. Assessments were completed in line with guidelines available at the time. Subsequent to this, Perth Airport has now reassessed the NRP against the PFAS HEPA 2018 guidelines.

Figure 9-1 Geology and soils study area
Source: Golder and Associates

9.4 Geology and Soils

9.4.1 Methodology

As shown in Figure 9-1, the study area for the geology and soils assessments extends beyond the NRP area to allow collection and interpretation of peripheral data considered to be relevant to assessment of impacts to geology and soils during both the construction and operational phase of the NRP.

A desktop review of publicly available information, and information from prior studies was undertaken. Based on the interpretation of this data, a fieldwork plan was developed, and a field investigation conducted in the study area in 2016 to fill data gaps for the geological and soil conditions across the NRP area to inform the baseline and impact assessments.

The information collated during the desktop review, combined with the results of the field investigation, are presented in this section and form the basis of the baseline geology and soils assessment.

The primary intent of the field investigation was to:

- summarise the baseline geological and stratigraphic condition across the NRP area,
- collect information on the erosion potential of shallow soils for consideration during the impact assessment for the drain realignments planned for the NRP, and
- collect information for the interpretation of acid sulfate soils risk in the shallow and intermediate soils across the NRP area.

A drilling program was carried out between April and December 2016 to collect geological, stratigraphic and soil chemistry data in accordance with the sampling analysis and quality plan developed for the NRP.

Details of the activities carried out are summarised below:

- drilling of 14 shallow boreholes (3.5 to 7.5 metres deep),
- drilling of four deep boreholes (27 to 37.5 metres deep),
- excavation of 19 test pits (2.1 to 3.2 metres deep),
- cone pentameter testing at ten locations (13.9 to 22 metres deep), and
- logging of soil materials recovered and collection of samples for the following testing:
  - chemical - acid sulfate soils and PFAS analysis, cation exchange capacity and phosphorus retention indices and soil leaching, and
  - geotechnical – particle size distribution, soaked California Bearing Ratio, Atterberg limits and linear shrinkage and Emerson crumb.

9.4.2 Existing Condition

The estate covers an area of 2,105 hectares and is located on the Swan Coastal Plain approximately three-and-a-half kilometres south of Guildford and approximately 12 kilometres east of Perth CBD. Ground elevations vary from less than five metre Australian Height Datum (AHD) up to approximately 30 metre AHD across the estate. The NRP is located on the east of the estate. This area is relatively flat with elevations generally ranging between 17 metres and 21 metres AHD with a slight regional gradient from west to east. The one metre topographic contours of the NRP area are shown in Figure 9-2.

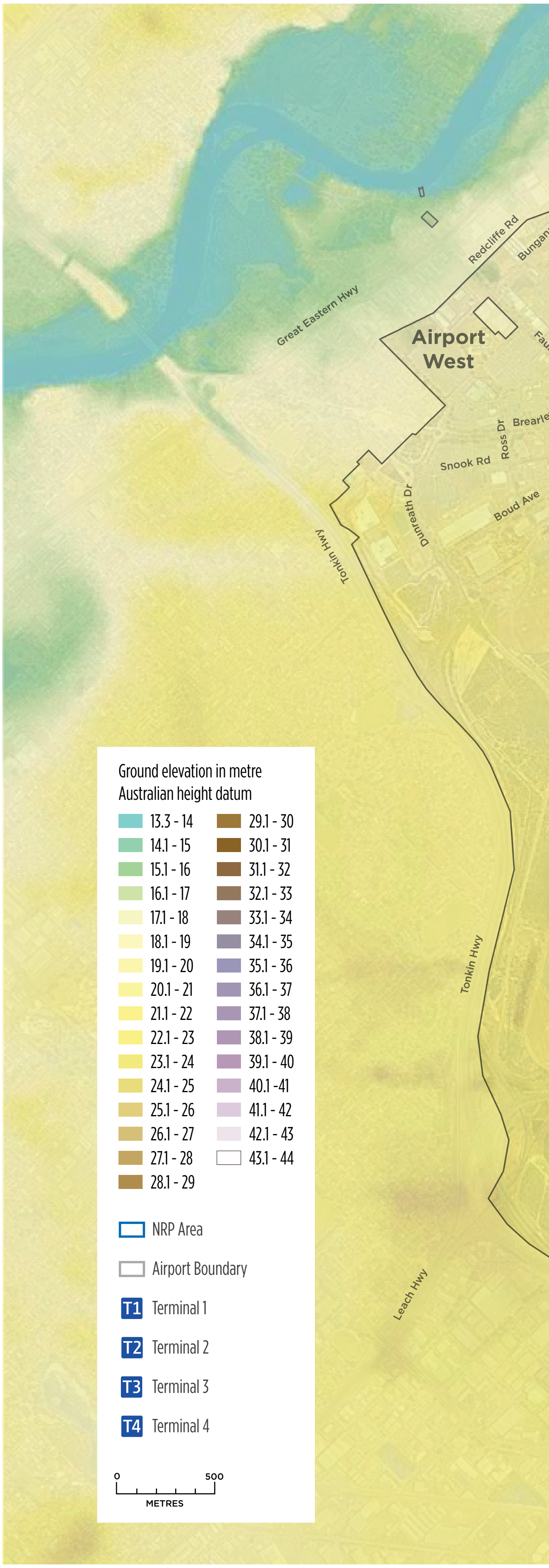


Figure 9-2 Topographic contours for the New Runway Project area and surrounds
Source: Golder and Associates

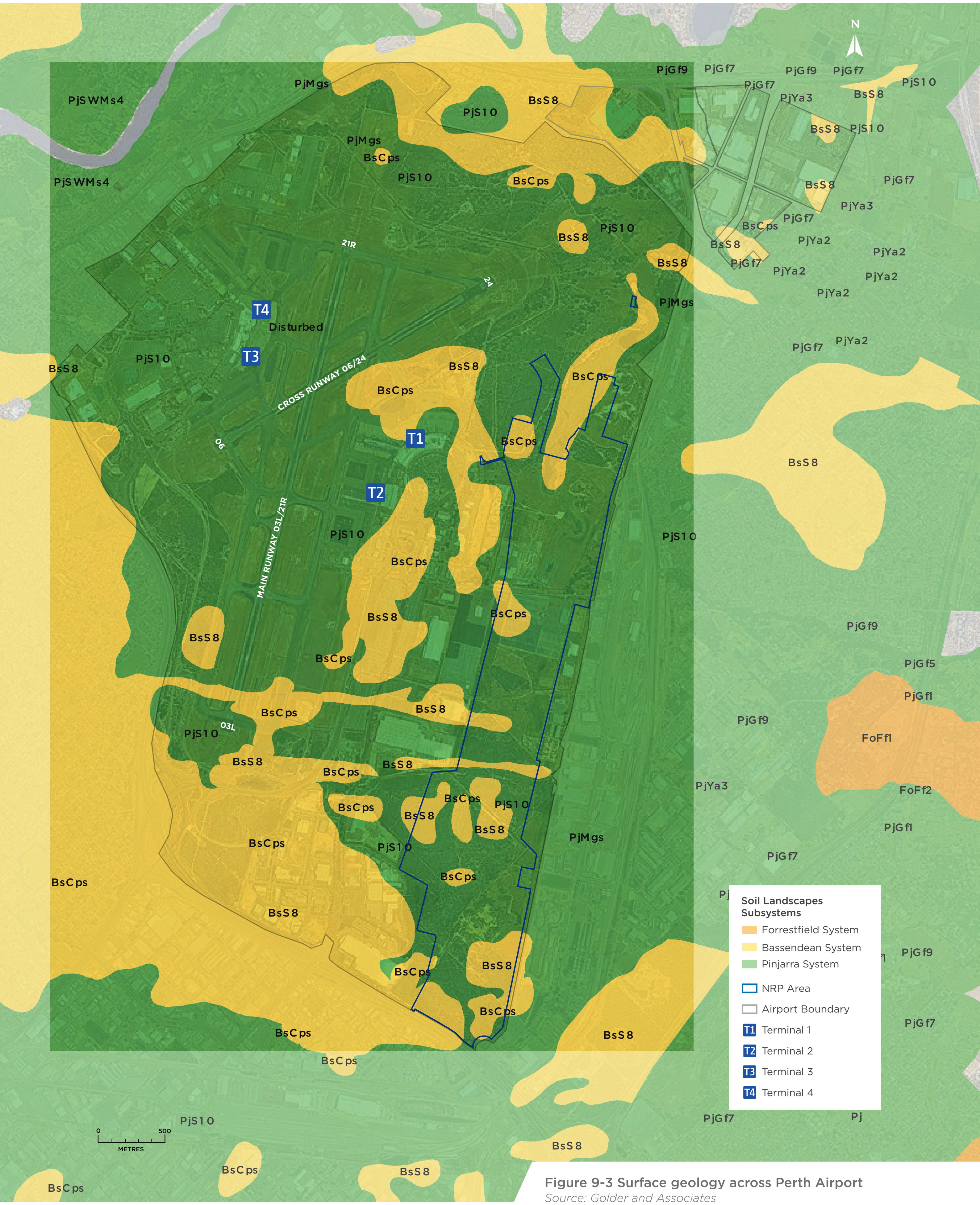


Figure 9-3 Surface geology across Perth Airport

Source: Golder and Associates

9.4.2.1 Geomorphology and Geology

The surface geology across the estate is shown in Figure 9-3. The surficial soils across the NRP area can be broadly characterised into two groups, the Bassendean Sand Plain (and associated infilled areas) and the Pinjarra Plain.

The majority of surface materials within the NRP area comprise both sand of the deflated Bassendean Dune system and interdunal depressions previously containing swamps, wetlands and damplands that have been infilled during development of the area. In some instances, infilling has been completed by excavating local sand for fill. Anecdotal evidence, from previous projects in the area, suggests that infilling has modified the current surface level by up to five metres in some areas.

The eastern boundary of the NRP area contains small sections that can be considered part of the Pinjarra Plain, which generally comprises alluvial fan deposits extending out from the Perth Hills to the east. In these areas, a thin layer (one metre to two metre thickness) of Bassendean Sand covers most of the alluvial fan deposits.

Table 9-1 presents a summary of local geological units relevant to the NRP area and draws on the data acquired for the NRP in concert with experience from other projects completed by consultants in the area.

Geological Unit			
Name	Unit Colour	Typical Description	Unit Thickness (metre)
Fill (MG)		Primarily fine to medium grained yellow to brown sand. Also road base and other types of fill.	
Bassendean Sand (BS)		Sand, light grey, yellow, dark brown, fine to medium grained, loose to dense, fining upwards where fluvial in origin, with thin (up to one to two metre) localised iron cemented and or pyritic layers. May contain peaty sand, silty and clay associated with wetland or dampland interdunal deposits.	One to five metre Coffee rock (up to 0.8 metres at MW04)
Guildford Formation (GF)		Clayey sand, silty sand, sand and clay, blue-green, green-grey, brown, pale grey, fine grained layers stiff to hard and low plasticity, coarse grained layers are medium dense to very dense with some fine grained loose zones near contact with Ascot Formation. Often pyritic, particularly in the more clay dominated zones. Includes potential sand deposits of the Yoganup Formation in an area that is north of Grogan Road and west of Abernethy Road. With Gnangara Sand across the majority of the NRP area.	Ten to 20 metre (thickest at south-east extent of the site)
Gnangara Sand (GS)		Sand and silty sand, blue-green, dark green, fine grained, loose to dense.	Two to five metre (pinches out towards the east
Ascot Formation (AF)		Carbonate sandy gravel, gravelly sand and sand, fine to medium grained sand, grey, dark-grey, blue-grey, yellow, medium dense to dense, some siliceous calcarenite layers, some pyritic nodules. Polished rounded black phosphatic gravel can be present at the base contact with underlying Osborne Formation. High strength conglomerate boulders may also be present at the base of this unit but have only been previously noted in the vicinity of the Air Traffic Control tower to date.	Five to 15 metre (pinches out towards the east)
Osborne Formation (OF)		Mirrabooka Member (MM): Sand, silty sand and clayey sand, dark green to dark grey, medium to coarse grained, dense to very dense, siliceous and glauconitic. Includes the Molecap Greensand. Pyritic.	100 to 150 metre (decreasing thickness to the east)
		Kardinya Shale Member fines dominated (KS): Sandy mudstone and sandy siltstone, black and dark green, moderately weathered to fresh, extremely low to medium strength. Pyritic.	

Table 9-1 Geological units in the New Runway Project area
Source: Golder and Associates

Three interpreted geological cross-sections in the NRP area are presented in Figure 9-4, Figure 9-5 and Figure 9-6 with the alignment of long sections shown in Figure 9-7.

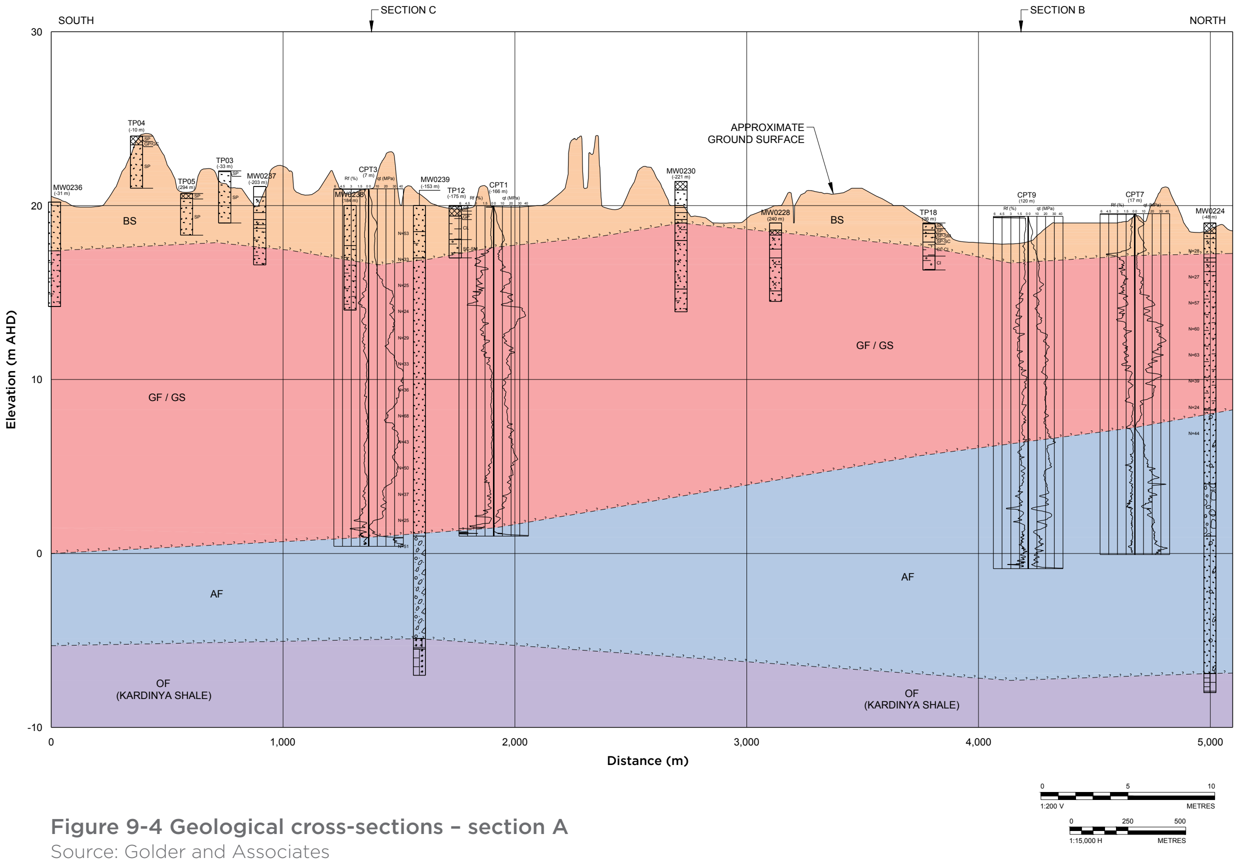


Figure 9-4 Geological cross-sections – section A

Source: Golder and Associates

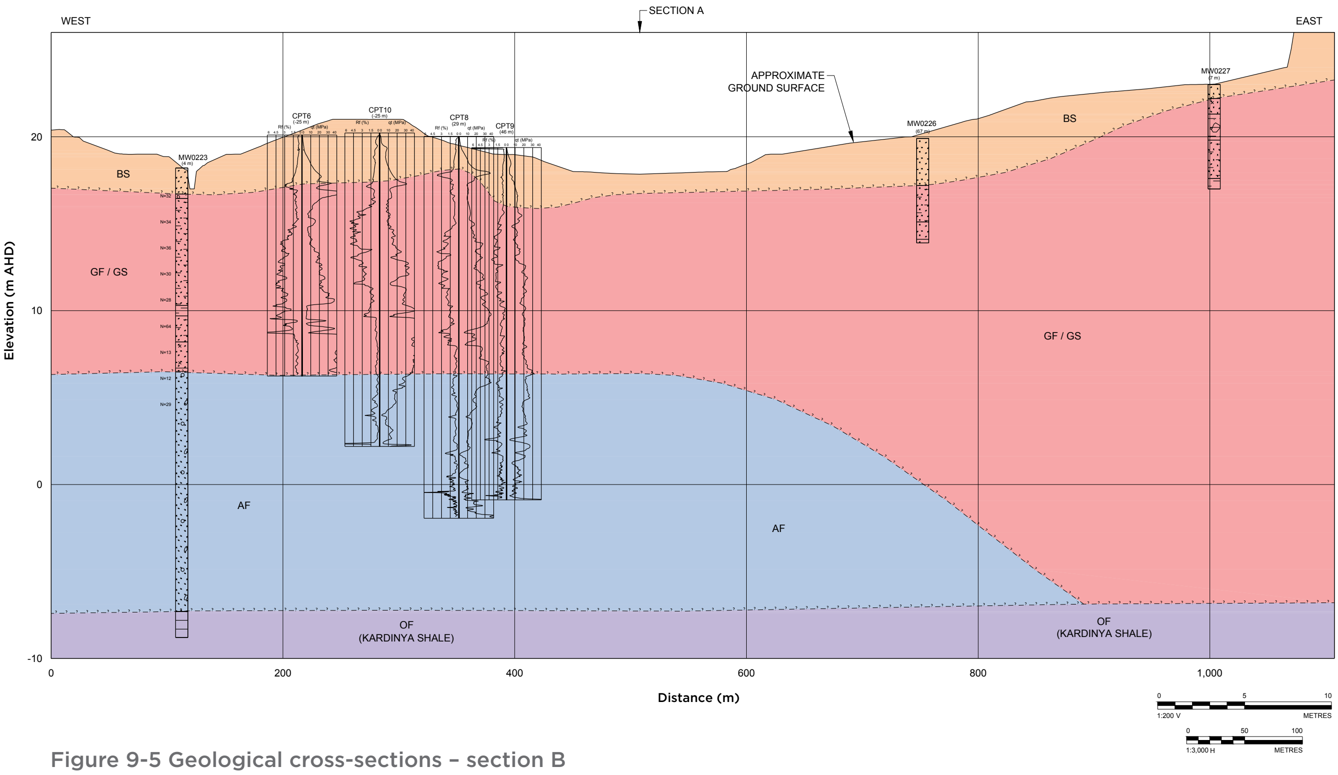
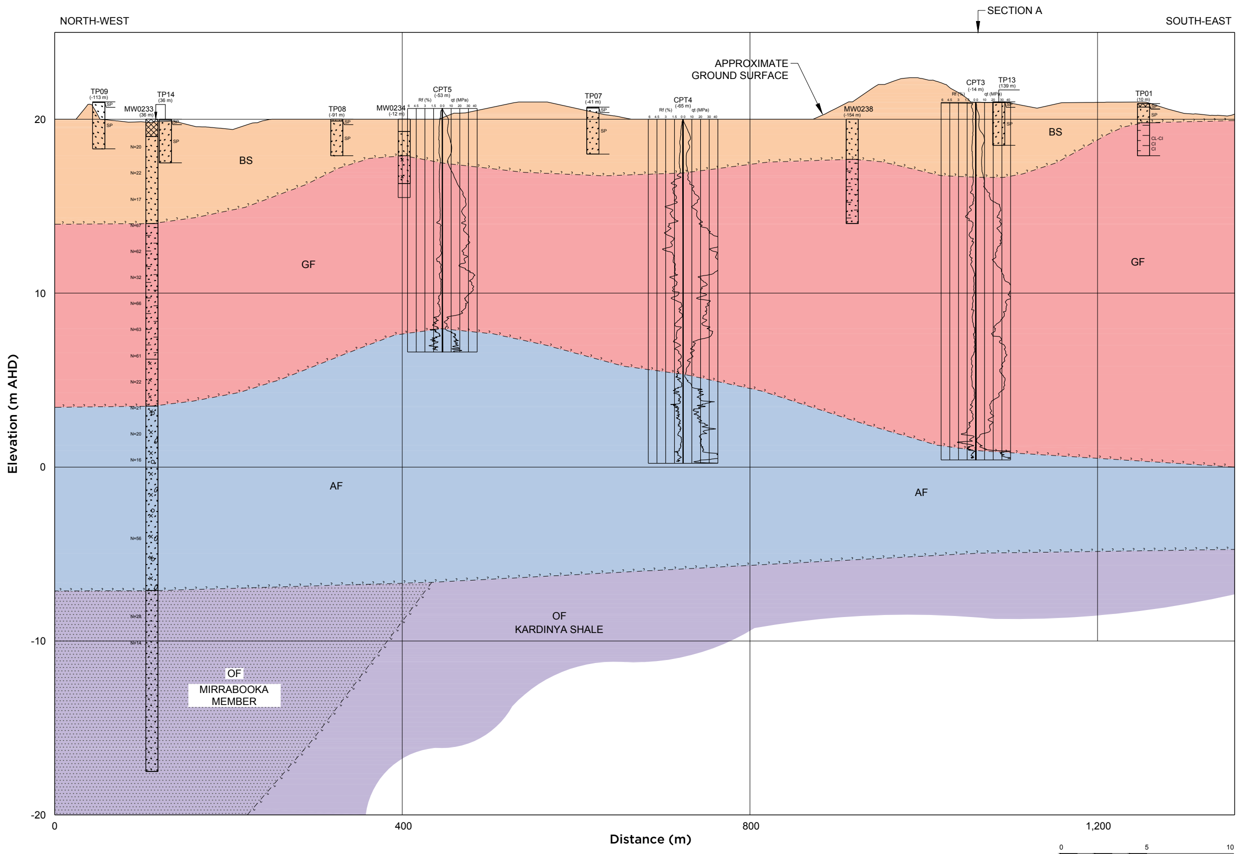


Figure 9-5 Geological cross-sections – section B

Source: Golder and Associates



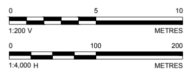
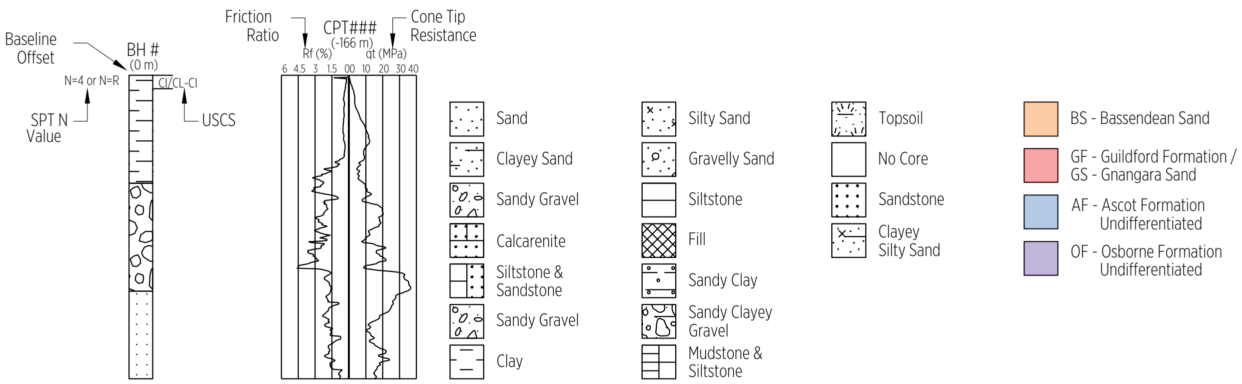


Figure 9-6 Geological cross-sections – section C

Source: Golder and Associates

Legend



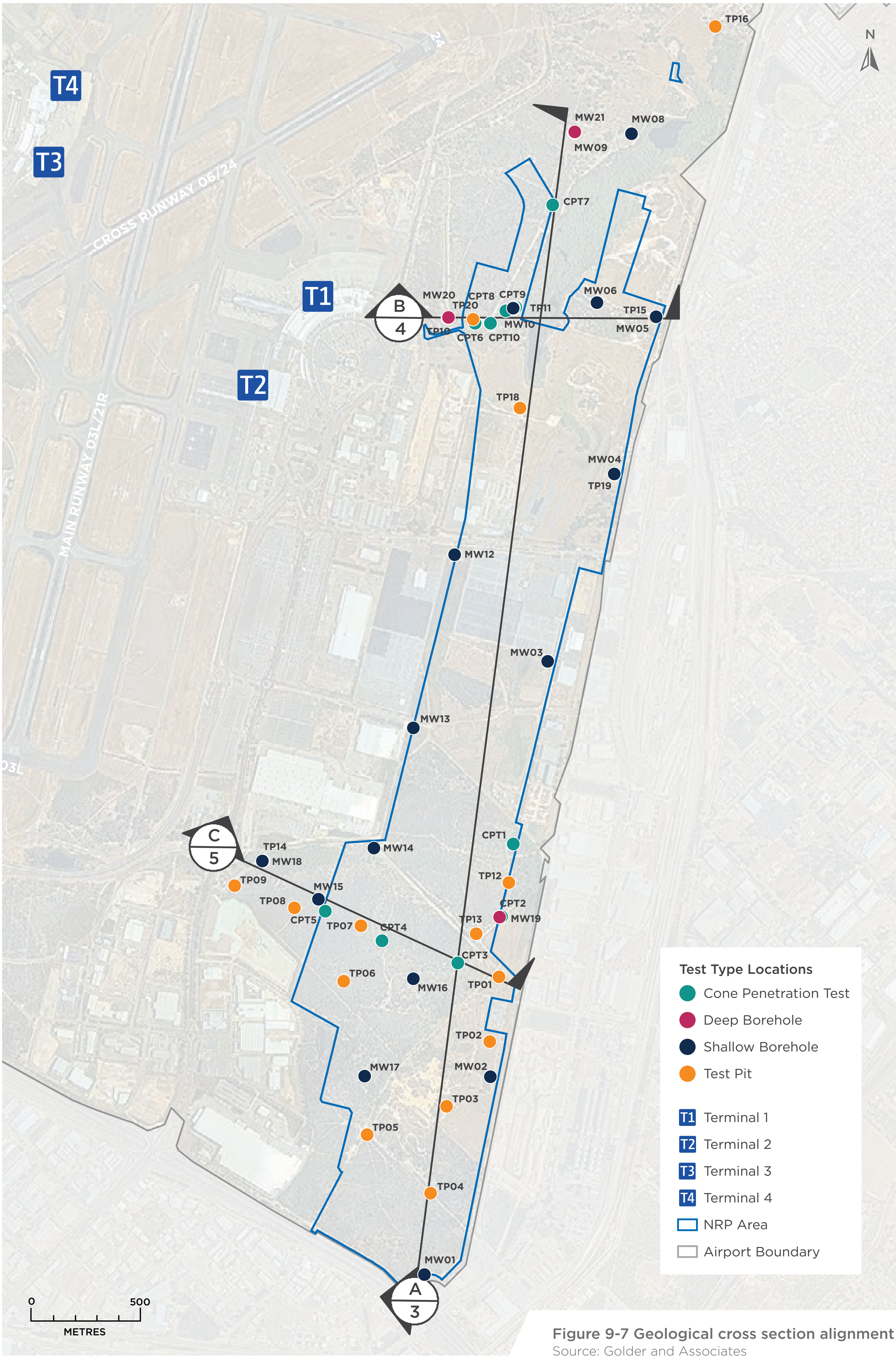


Figure 9-7 Geological cross section alignment
Source: Golder and Associates

9.4.2.2 Soil Erosion Potential

Physical and chemical laboratory testing including Emerson Class, phosphorus retention and cation exchange capacity were conducted. The objective of this testing was to provide a description of the physical and chemical properties of the soils that will influence the soil erosion potential and possible surface water quality within the NRP area. For instance, the Emerson Class Number describes the likelihood that soils will release a cloud of fine clay particles when brought into contact with water; Phosphorus retention describes the phosphorus retention capacities of virgin Western Australian soils, particularly those on the Swan Coastal Plain, as this can impact on the level of nutrients in the soil; while cation exchange capacity describes the soils ability to hold onto essential nutrients and provide a buffer against soil acidification.

Soil samples tested were generally collected from shallow depths (three metres below ground level) as these were most likely to be disturbed or affected by the construction and operation of the NRP, such as from excavations for stormwater drains and basins. Most of the soil samples were collected from the Bassendean Sand as well as sand and clay materials within the Guildford Formation. Samples collected from fill and gravel materials were also tested.

The results of the laboratory testing are summarised below:

- the Bassendean Sands have low cation exchange capacity. The majority of the cation exchange capacity results from calcium and magnesium exchangeable ions,
- clayey materials within the Bassendean Sand and Guildford units are dispersive with moderate cation exchange capacity, and
- phosphorus retention indices reflect the clay content of a soil, the higher the clay (fines) content the greater the potential to retain phosphorus.

The Emerson Class was either two or eight for the materials tested, with most samples tested returning a class of two. Emerson Class definitions are provided below:

- Emerson Class two soils are highly likely to discolour water if the soils are exposed to rainfall or flowing water, and
- Emerson Class eight soils are non-dispersive soils which do not react or swell on contact with water.

Construction activities proposed in areas containing Emerson Class 1 or 2 soils have a very high pollution potential. Emerson Class 2 soils should not be used for retaining structures unless adequately treated or covered with non-dispersible soils (IECA 2008).

9.4.2.3 Acid Sulfate Soils

Acid sulfate soils are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials. In an anaerobic state, these materials remain benign and do not pose a significant risk to human health or the environment. However, disturbing acid sulfate soils and exposing them to oxygen, has the potential to cause significant environmental impacts. Typically, this occurs through the release of acidity and dissolution of metals into groundwater thereby deteriorating its beneficial use, such as for drinking and irrigation, and potentially causing harm to groundwater-dependent ecosystems and vegetation.

Potential acid sulfate soils are sulfidic soils which have the potential to release acidity if allowed to oxidise through physical disturbance (excavation) or in situ dewatering. Actual acid sulfate soils are soils where acid sulfate soils have been allowed to oxidise and release their potential acidity. A review of the acid sulfate soils risk-mapping across the NRP area was carried out as part of the desktop data review to provide an initial indication of the likelihood of encountering acid sulfate soils within three metres of the ground surface.

The acid sulfate soils risk classification across the NRP area is shown in Figure 9-8. This mapping indicates that areas interpreted as high risk are aligned with the areas mapped as 'swamp deposits' in the 1:50,000 Environmental Geology Series mapping produced by the Geological Survey of Western Australia (Gozzard, 1986). No materials were identified during the fieldwork (test pitting or drilling of boreholes) that indicate the presence of swamp deposits, such as peat and organic clays. Areas mapped as moderate to low risk align with the mapped boundary of Bassendean Sands and areas mapped as no known risk align with the mapped boundary of the Guildford Formation.

9.4.2.4 Geological Units

Bassendean Sands typically contain sulfides at or below the State Department of Water and Environmental Regulation (DWER) action criteria of 0.03 per cent. Layers of friable limonitic cemented sands (colloquially known as coffee rock) occur within the Bassendean Sand, at or near the zone of groundwater table fluctuation and are typically associated with the presence of acid-generating pyrite. The Bassendean Sands typically have very low acid-buffering capacity due to their well leached and predominantly quartz sand composition. The lack of ability for these sands to buffer against acidity from pyrite oxidation, in combination with their relatively high hydraulic conductivity, means that the Bassendean Sands is the most susceptible geological unit for the occurrence and widespread nature of potential impacts from soil (acid sulfate soils) disturbance.

The Guildford Formation is well characterised across the Perth area as containing interbedded sands, silts and clays. The presence of acid-generating pyrite in the Guildford Formation is typically higher than in the Bassendean Sands as the less permeable clay materials reduce exposure of the pyritic nodules to oxygen (i.e. acid-forming pyrite is retained in-situ rather than being oxidised and leached as with the Bassendean Sands). A further element protecting in situ pyrite in the Guildford Formations is that it typically underlies the Bassendean Sand, and the groundwater table, minimising oxidation.

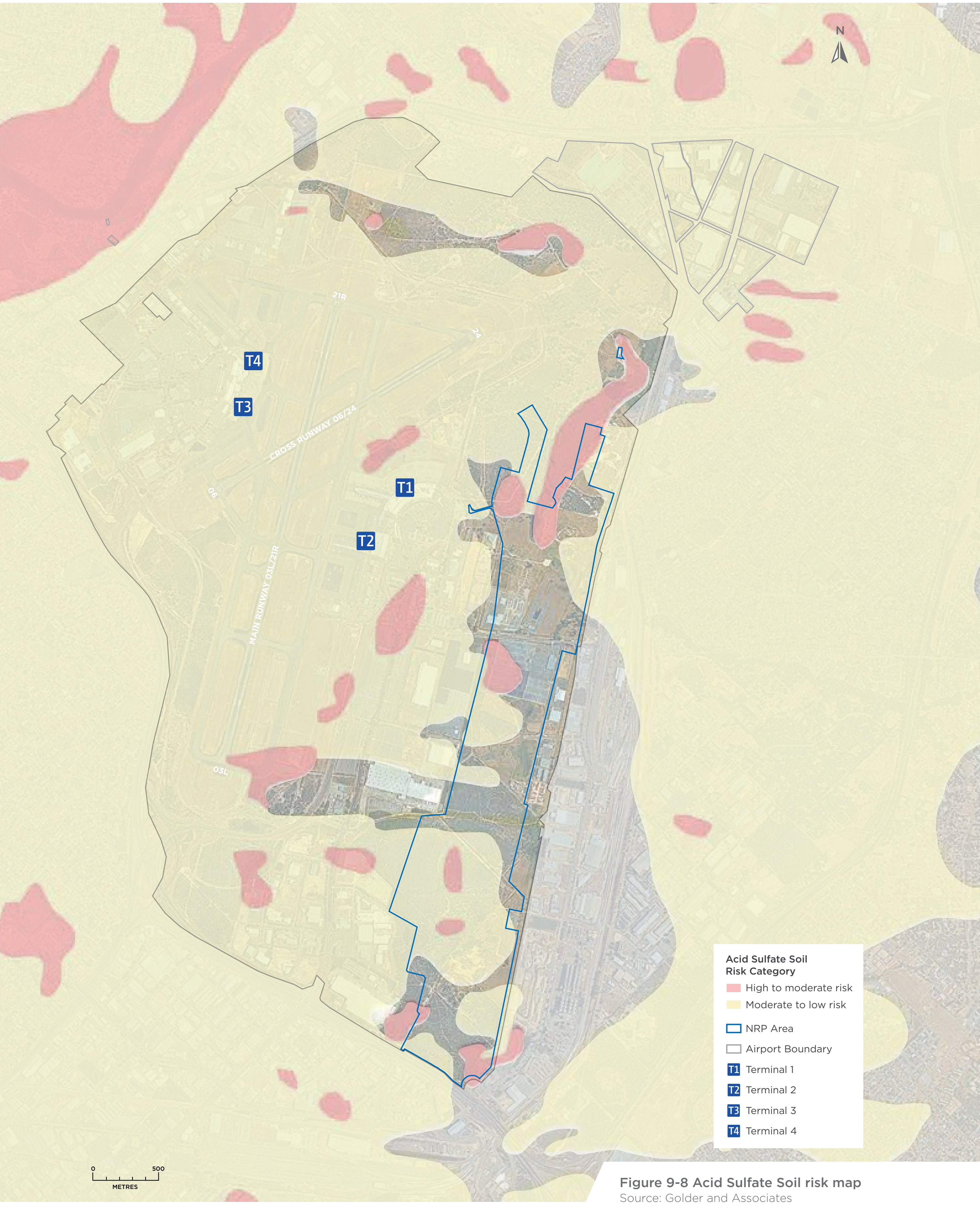


Figure 9-8 Acid Sulfate Soil risk map
Source: Golder and Associates

Due to the higher concentrations of clay within the Guildford Formation, it contains greater amounts of carbonates, iron and aluminium oxides, aluminosilicates and feldspar, which all have demonstrated acid-buffering capacity. Therefore, although typically higher concentrations of pyritic sulfide are present in the Guildford Formation, the risk of impacts due to acidification is potentially offset by this greater acid buffering capacity. Accordingly, disturbance and excavation of this unit is considered to be low risk with respect to the potential release of acidity into the environment (soil and groundwater).

The Ascot Formation is noted as containing pyritic nodules and therefore is a potential risk for acid generation due to oxidation of acid sulfate soils through disturbance. However, the Ascot Formation comprises predominantly calcareous sands and gravels which have strong mineral-buffering capacity, though this is strongly dependent on the availability (particle size and distribution) of these carbonates as this controls their availability to act as acid-buffering materials. For these reasons, it is considered that the Ascot Formation is a low risk for disturbance and excavation resulting in impacts to soil and groundwater as a result of acidification of acid sulfate soils.

9.4.2.5 Results of field investigations

Soil samples were collected from all borehole and test pit locations on the estate during the field investigation. A subset of 51 samples, collected from both the Bassendean Sand and Guildford Formation, were selected for acid sulfate soils field-screening testing. Samples were submitted from these two geological units since they are the most likely to be disturbed during the NRP development and they are the two highest risk units for impacts due to disturbance of acid sulfate soils. One sample was subjected to screening for both chromium reducible sulfur (CRS) analysis and screening for cations and total organic compounds, explaining the discrepancy in sampling numbers in the following results.

The results of field-screening testing indicate 35 low-risk results, 12 medium-risk results and four high-risk results.

Based on the results of the field testing, the 15 highest-risk samples (including samples from both geological units) were submitted to the laboratory for CRS analysis. The results of the testing confirmed the presence of pyrite in both the Bassendean Sands and Guildford Formation and therefore these soils should be considered acid sulfate soils.

The results of the desktop review, coupled with the results of the field investigation and laboratory testing, confirm that acid sulfate soils are present in both the Bassendean Sand and Guildford Formations.

9.4.2.6 Groundwater

One of the principal impacts from acid sulfate soils is the potential impact to surface water and groundwater due to the release of acidity and mobilisation of metals. In Western Australia, the criteria shown in Table 9-2 are used to assess the likelihood of acidification occurring for surface water and groundwater.

The median pH and total alkalinity of groundwater samples collected from across the NRP area was 7.2 and 144 milligrams per litre, respectively. The median pH alkalinity of surface water samples collected was 7.8 and 105 milligrams per litre, respectively. In both cases, in accordance with the above criteria, this indicates that surface and groundwater at the site is of high alkalinity and is generally adequate to maintain acceptable alkalinity levels. This means that without the release of a significant amount of acidity from the disturbance of acid sulfate soils, impacts to surface water and groundwater should be minimal.

Designation	Milligrams per litre	pH	Description
Very high alkalinity	>180	>6.5	Generally adequate to maintain acceptable pH levels
High alkalinity	60-180	>6.0	Generally adequate to maintain acceptable pH levels
Moderate alkalinity	30-60	5.5-7.5	Inadequate to maintain acceptable pH levels in areas vulnerable to acidification
Low alkalinity	10-30	6	Inadequate to maintain stable acceptable pH levels
Very low alkalinity	<10	<6	Unacceptable pH level under all circumstances

Table 9-2 Department of Water and Environmental Regulation guidance on alkalinity and risk of groundwater acidification
Source: Department of Water and Environmental Regulation

9.4.3 Geology and Soil Impact Assessment

Significance criteria have been used to assess the potential impacts that may arise from the NRP with respect to geology and acid sulfate soils. The significance criteria in Table 9-3 have been derived from the generic criteria provided in Section 8.

The various risks identified and mitigation strategies to reduce resulting impacts are discussed in detail in the following sections and are summarised in Table 9-5.

The results of the impact risk assessment are summarised in Section 9.4.5.

Magnitude description	Geology and Soils Criteria
Major Adverse	Impacts tend to be permanent, irreversible or otherwise long term and can occur over large scale areas, outside the estate. Uncontrolled disturbance of high level acid sulfate soils, or uncontrolled and widespread erosion, resulting in contamination of groundwater and receiving environment and long term adverse impacts to matters of national or international significance
High Adverse	Impacts tend to be permanent or irreversible or otherwise long to medium term, and can occur over large or medium-scale areas, including outside the estate. Disturbance of high-level acid sulfate soils, resulting in deterioration of groundwater quality and that of the receiving environment and adverse medium to long-term effects on sites of state or national significance if unmanaged. The excavation or placement of substantial quantities of soil on-site, resulting in subsidence, instability or substantial erosion. Sufficient to cause detectable erosion and obvious impact on local waterways that can contribute to longer term siltation impacts on the receiving environment.
Moderate Adverse	Impacts can range from long term to short term in duration, can occur over medium-scale areas or otherwise represent a significant impact at the local scale. Disturbance of acid sulfate soils, resulting in short-term degradation of groundwater quality and/or local receiving environment. The excavation or placement of significant quantities of soil on-site, or the exposure of areas of soils in areas prone to runoff. Sufficient to cause localised erosion and limited impact to local waterways and also contribute to the cumulative long-term siltation impacts on the receiving environment. Appropriate management measures can mitigate most adverse effects.
Minor Adverse	Impacts tend to be short term or temporary and/or occur at local scale (within NRP area). Disturbance of low-level acid sulfate soils, resulting in generation of periodic or continual low yield acid runoff consistent with seasonal variations. The unmanaged excavation or placement of soil on-site, or the exposure of soils in areas prone to runoff, resulting from minor works. Sufficient to cause small-scale or temporary localised erosion. Unlikely to significantly impact on waters within the receiving environment.
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath levels of detection, impacts that are consistent with seasonal variations, within the normal bounds of variation, or impacts that are within the margin of forecasting error.
Beneficial	Where management of construction involving acid sulfate soils results in a reduction of contaminant levels or where groundwater is directly treated to improve quality. The risk of adverse environmental impact will be reduced and the receiving environment enhanced.

Table 9-3 Significance criteria – geology and soils
Source: Golder and Associates

9.4.3.1 Acid Sulfate Soils

The impact assessment has been carried out based on the interpreted potential changes to the baseline conditions as a result of the NRP construction and subsequent ongoing operation of the new runway and associated infrastructure.

Any disturbance of soils close to (within one metre) or below the groundwater table during the construction of the NRP should be assumed to be disturbing acid sulfate soils and therefore likely to release acidity. Active acid-sulfate soils management (stockpiling) and treatment (addition of lime) will be required to protect local soil and groundwater from the release of acidity and metals.

Although there is potentially acid-buffering capacity present in the Guildford and Ascot Formations, these soils will still need to be managed or treated (appropriately stockpiled and treated with lime) since the amount and availability of this buffering capacity is not accurately known. The Bassendean Sand unit is the highest acid-sulfate soils risk unit at the site as it has demonstrated acid-generating capacity and no acid-buffering capacity and therefore will also need to be assessed and treated via a risk-based approach during construction.

General Cut and Fill

To prepare the NRP area for construction of the new runway and taxiway pavements, areas of low and high surface topography will need to be filled and cut to create a level grade. The amount of cut and fill required will be dependent on the final design for the runway. The requirement to manage acid sulfate soils during the construction phase will be restricted to the areas where soil is excavated, particularly if excavation extends below the groundwater table.

A map showing the extent of the proposed bulk cut and fill depths across the NRP area is shown in Figure 9-9. The depth to groundwater, prepared as part of the surface and groundwater baseline and impacts assessment, is shown in Figure 9-10.

Figure 9-9 shows that most cut required to achieve a level grade for the NRP is less than three metres below the current surface elevation. Areas of deeper cut coincide with areas of current high topography. Therefore, the areas where the most excavation (or cut) is required are located above the groundwater table and the risk of excavating, disturbing and generating acid from acid sulfate soils during general excavation at the site is low.

Surface and groundwater at the site has been demonstrated to have (on average) high alkalinity and therefore with appropriate management of disturbance to acid sulfate soils during the development, the risk of impacting surface water and groundwater during cut and fill of the site is low.

Proposed New Northern Main Drain and Southern Main Drain Construction

The alignment of the proposed Northern Main Drain (NMD) and Southern Main Drain (SMD) is shown in Figure 9-11. Excavations for the construction of the proposed NMD and SMD will extend to either below the groundwater table or to within the zone of seasonal fluctuation. Therefore, the risk of disturbing potential acid sulfate soil and releasing acidity during construction of the proposed NMD and SMD is high. Further details and other impacts of the main drain works are described in Section 10.

9.4.3.2 Soil Erosion

The NRP will involve excavation of new drains and compensating basins for both groundwater and surface water. Risks associated with erosion include:

- erosion of dispersive soil materials on exposed batters of new drains and basins (either completed or during construction) could lead to sediment loading into surface waters and offsite discharge,
- unstable slopes during construction could lead to failure within the excavation during construction, and
- erosion and slope failures along drainage infrastructure could cause deposition that may reduce efficiency and incur ongoing maintenance costs.

Erosion and slope stability risks are applicable to both the construction and operation phases of the NRP. The erosion potential of the shallow soils within the NRP area has been identified as very high. As a result erosion control and management will be necessary throughout construction and during operations in accordance with industry practices.

To inform detailed design, an additional geotechnical study will be completed that will fully inform consolidation and settlement potential with the NRP area. An Acid Sulfate Soil and Dewatering Management Plan will be developed and implemented in accordance with DWER guidelines. Detailed analysis and design of a dewatering system will also be undertaken in association with careful dewatering sequencing during construction and monitoring of settlement and early intervention if needed. Undertaking these measures will reduce the risk to low.

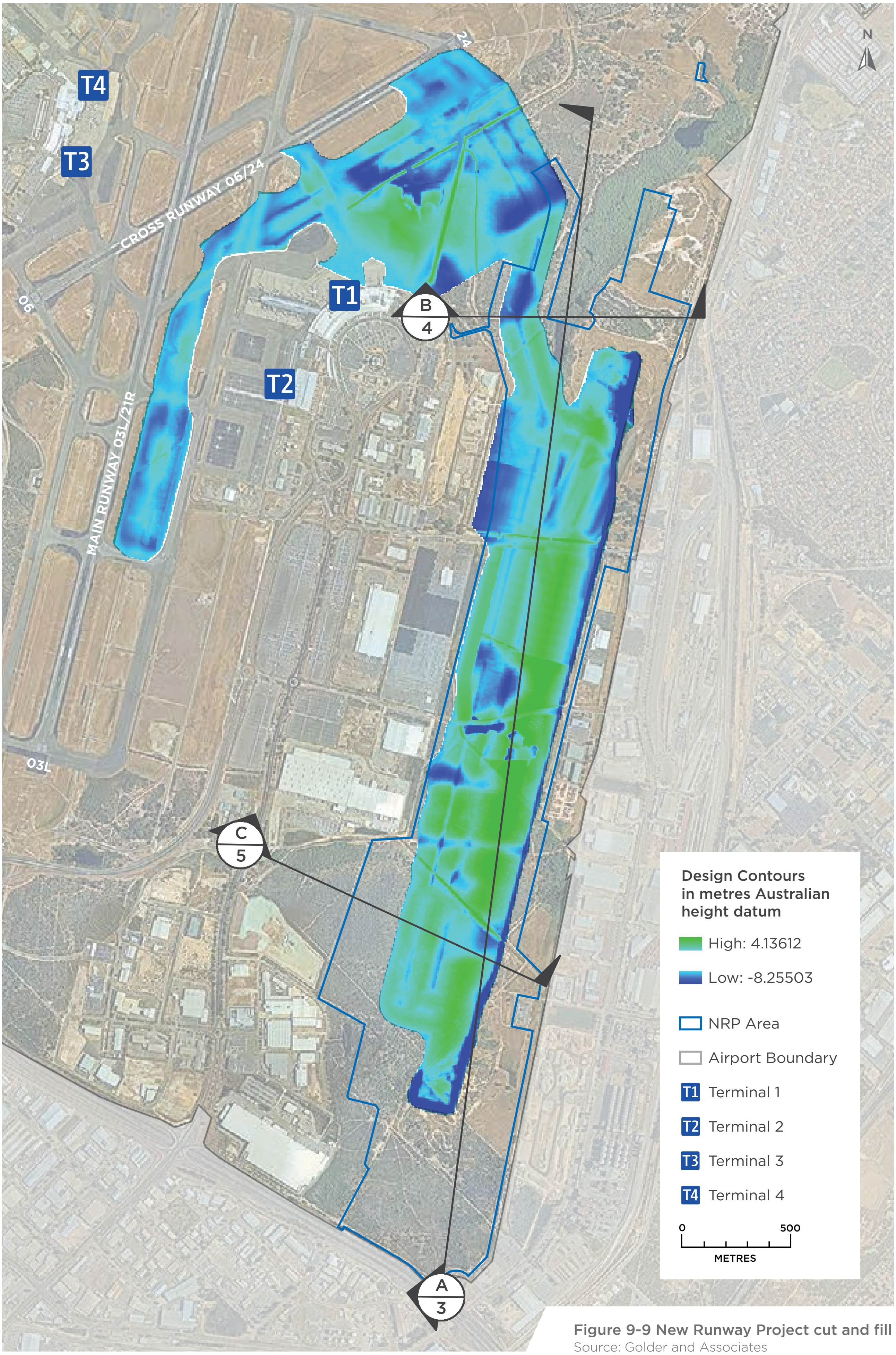


Figure 9-9 New Runway Project cut and fill
Source: Golder and Associates

Figure 9-10 Inferred depth to groundwater table - seasonal maximum
Source: Golder and Associates

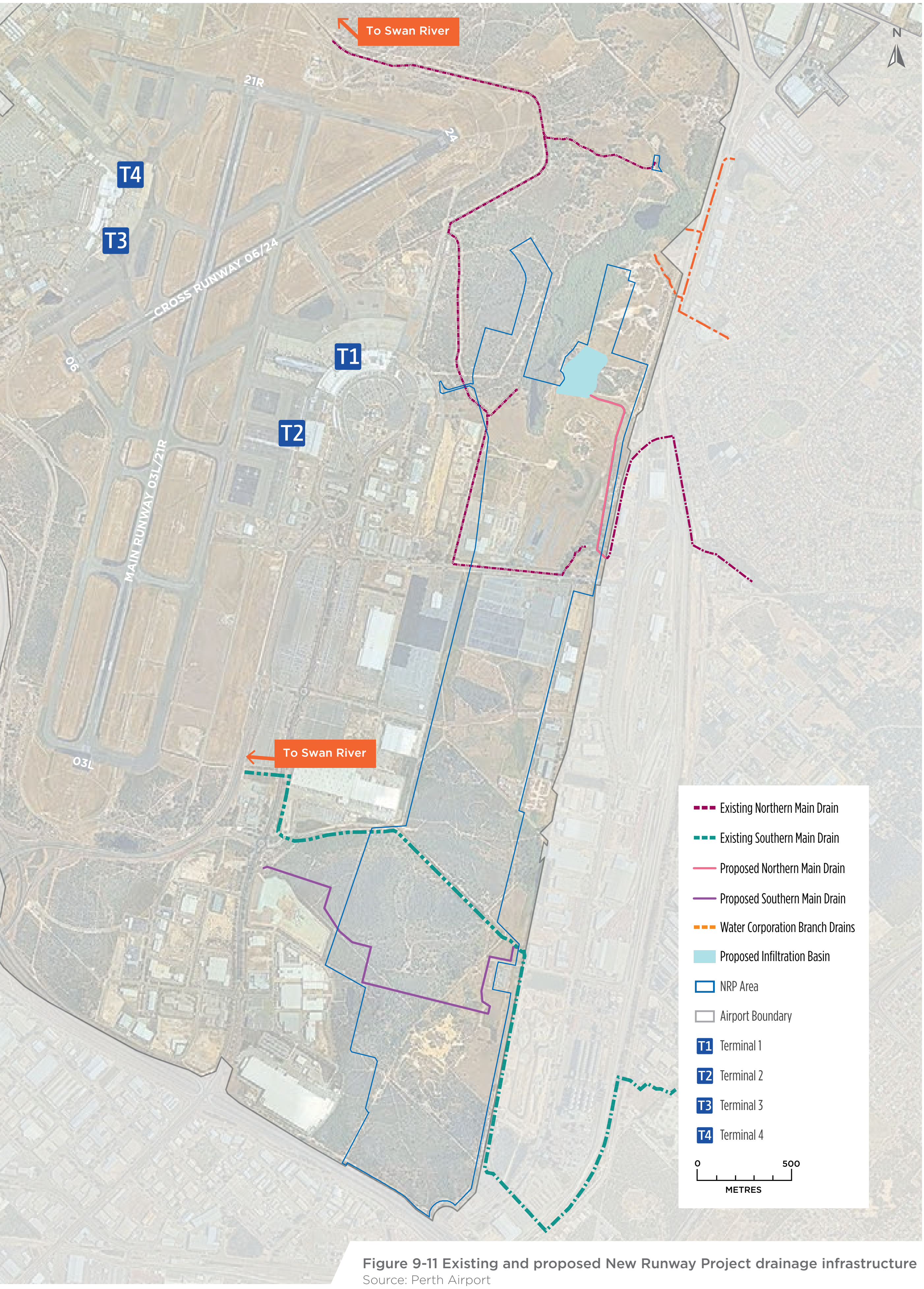


Figure 9-11 Existing and proposed New Runway Project drainage infrastructure
Source: Perth Airport

9.4.3.3 Geotechnical

Ground Movement

Ground movements may cause damage to existing structures, services, roads and airport infrastructure. Ground movements may be caused by:

- loading soils with heavy buildings, other infrastructure, stockpiled soils or placement of a significant thickness of fill,
- natural consolidation over the timeframe of the project,
- lateral movement of soil during excavations or construction of retaining structures depending on excavation methods, and
- settlement of ground outside of excavations, for example as a result of groundwater-level lowering caused by dewatering.

Ground movements may be mitigated by careful and detailed analysis and design of all NRP elements and careful construction sequencing.

Ground movement risks are applicable to both the construction and operation phases. Ground investigations, by their nature, involve the use of point data to provide a broad generalisation of soil types across an area. Consequently, unforeseen ground conditions may occur on site due to heterogeneous soil conditions.

Investigations to date have shown variable ground conditions are present within a number of the geological units encountered across the NRP study area. Material conditions could change from coarse grained soils (sand and gravel) to fine grained soils (silt and clay) over short distances and depths. Variation in material conditions was observed and could be expected within the Guildford Formation and Ascot Formation units.

Variable and unforeseen ground conditions could affect foundation design, imported fill quantities, and treatment cost of excavated materials (such as acid sulfate soils). Depending on the variability, impacts could be either positive (less imported fill required) or negative (more imported fill required).

To manage the impacts of ground movement during construction a geotechnical study to inform consolidation and settlement will be undertaken prior to construction. Detailed analysis and design of excavation and soil-retaining systems will also occur along with careful construction sequencing during excavation. Settlement will also be monitored and early intervention undertaken if needed.

Geotechnical Risk	Proposed Treatment
LOW Soils that are typically moist or dry, sand with variable amounts of silt and clay; not expected to be leachable and excavated materials re-use onsite is expected, some soil conditioning may be needed.	• lime may not be required if material can remain dry, • if material is placed within one metre of the water table, liming may be required, • generally, geotechnically suitable for use as fill, and • lime addition will alter geotechnical properties of the material.
MEDIUM Soils or other materials containing a range of soil types and moisture conditions including sand, silt, and clay; re-use in some form as a construction material is expected and some soil conditioning and blending may be needed.	• clays need to be dried and may require multiple phases of treatment to allow for effective addition of lime, • treatment bund will need to be constructed, • water will need to be collected and treated, • validation of treatment is required prior to use, • lime addition will alter geotechnical properties of the material, and • may need to be blended with other materials to become geotechnically suitable for use as fill.
HIGH Soils or other materials below the groundwater table, very clayey soils, and other material that would be leachable and potentially impact surface and or groundwater quality; soil conditioning methods would be needed such as dewatering, drying, and soil amendment.	• will need to be dried and may require multiple phases of treatment to allow for effective addition of lime, • treatment with lime must occur on a raised pad to isolate from the surrounding environment, • water will need to be collected and treated, • validation of treatment is required prior to use, • lime addition will alter geotechnical properties of the material, and • generally, geotechnically unsuitable for re-use as fill.

Table 9-4 Geological risk terms for reuse materials as fill
Source: Golder and Associates

Suitability of Materials to be Used as Fill

Fill may be used within the NRP area from other areas of the estate, imported from off the estate or excavated from in the NRP area during construction. Perth Airport may also use spoil from the Forrestfield-Airport Link project. However, Perth Airport is still considering the potential for using spoil as fill within the NRP. Any spoil or fill will need to be assessed for geotechnical suitability, potential acid sulfate soil risks or contamination. Assessment for contamination will include the assessment of PFAS concentrations and will be completed in accordance with the requirements of the Department of Water and Environmental Regulation (DWER) Assessment and management of contaminated sites, Contaminated Sites Guidelines (DWER 2014) and the Heads of the Environmental Protection Authority (HEPA), January 2018, PFAS National Management Plan (NEMP) (HEPA 2018). Depending on the properties of the fill material, it may require treatment to make it suitable for use. The geotechnical risk terms for reuse of materials as fill following excavation can be quantified as either high, medium or low as described in Table 9-4. The table describes the geotechnical risk and the proposed treatment for fill.

9.4.4 Mitigation

Additional mitigation measures are required for those impacts that have a risk rating of medium, high or very high.

Based on the impact assessment, risks associated with acid sulfate soils while constructing the proposed Northern and Southern Main Drain were identified as high with risks from soil erosion and geotechnical work rated low or very low. As such, additional treatment of the impact from the proposed Northern and Southern Main Drains is warranted.

9.4.4.1 Acid Sulfate Soils – Proposed Northern Main Drain and Southern Main Drain

Acid sulfate soils investigations have determined that prior to the construction of the NMD and the SMD, additional studies will be required to delineate areas of higher risk acid sulfate soils so that appropriate management plans in line with the Acid Sulfate Soil and Dewatering Management Plan can be implemented. As part of this process an Acid Sulfate Soil Management Plan will be developed in line with DWER guidelines. This additional mitigation measure will maintain the impact of the NRP as low.

9.4.4.2 Residual Risk

Perth Airport identified that the construction of the NMD and SMD would require additional mitigation due to the prevalence of acid sulfate soils across the NRP area. A further geological study, prior to construction, will be undertaken so that management can be targeted at high-risk areas. This treatment is anticipated to reduce the risk level to low.

9.4.5 Summary of Impacts

Table 9-5 presents a summary of the impacts to acid sulfate soils, geotechnical and soil erosion impacts assessed, as well as standard and additional mitigation measures and associated risk rankings.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Vegetation Clearing	Soil disturbance causing erosion and sediment mobilisation to local and downstream environments	Construction	Implementation of a CEMP including site-specific erosion and sediment control plan(s): • implementation of staged development planning and installation of water quality and erosion and sediment control measures prior to construction, • regular monitoring and maintenance of water quality control and treatment measures, and • regular monitoring of surface water downstream of the project development	Minor Adverse	Possible	Low	No additional mitigation measures identified			
General site preparation – cut and fill	Disturbance, management and treatment of acid sulfate soils resulting in acidification of surface or groundwater or impacts to ecological receptors	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance	Moderate Adverse	Highly Unlikely	Low	No additional mitigation measures identified			
Construction of new Northern Main Drain and Southern Main Drain	Disturbance, management and treatment of acid sulfate soils resulting in acidification of surface or groundwater or impacts to ecological receptors	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance	Moderate Adverse	Almost Certain	High	Further investigation prior to construction to delineate areas of higher risk of acid sulfate soils along Northern Main Drain and Southern Main Drain so that management can be targeted	Minor Adverse	Unlikely	Low

Table 9-5 Geology and Soils - Summary of impacts, risks and mitigation measures
Source: Perth Airport

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Construction of new Northern Main Drain and Southern Main Drain and installation of services	Construction dewatering resulting in acidification of surface or groundwater or impacts to ecological receptors (Drawdown expected to be less than seasonal variability)	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Ground movement associated with dewatering	Groundwater drawdown could lead to consolidation and settlement	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance Detailed analysis and design of dewatering system Careful dewatering sequencing during construction Monitoring of settlement and early intervention if needed	Minor Adverse	Unlikely	Low	No additional mitigation measures identified			
Ground movement associated with soil excavation	Ground disturbance may cause settlement and or collapse in surrounding soils	Construction	Detailed analysis and design of excavation and soil retaining systems Careful construction sequencing during excavation Monitoring of settlement and early intervention if needed	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Ground movement associated with soil loading	Groundwater drawdown could lead to consolidation and settlement soil loading	Construction	Further geotechnical study to inform consolidation and settlement Detailed analysis and design of excavation and soil retaining systems Careful construction sequencing during excavation Monitoring of settlement and early intervention if needed	Minor Adverse	Possible	Low	No additional mitigation measures identified			

Table 9-5 Geology and Soils - Summary of impacts, risks and mitigation measures (Continued)

Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Residual Assessment: Additional Mitigation	Significance	Likelihood	Residual Risk
Deep excavation causing unstable slopes	Failure of slopes during excavation with resulting environmental and or occupational health and safety risk	Construction	Slope stability analysis and design of retaining structures	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Ground movement associated with soil excavation	Ground disturbance may cause settlement and or collapse in surrounding soils	Construction	Detailed analysis and design of excavation and soil retaining systems Careful construction sequencing during excavation Monitoring of settlement and early intervention if needed	Minor Adverse	Possible	Low	No additional mitigation measures identified			
New pavement areas	Long term groundwater level change resulting in acidification from acid sulfate soils	Operation	Not applicable	Minor Adverse	Highly Unlikely	Very Low	No additional mitigation measures identified			
Effect of new Northern Main Drain and Southern Main Drain	Long term groundwater level change resulting in acidification from acid sulfate soils	Operation	Design: drain levels to be at or above Master Drainage Strategy 2017 concept design levels NRP impermeable area to be at or less than Preliminary Design	Minor Adverse	Highly Unlikely	Very Low	No additional mitigation measures identified			
Ground movement associated with insufficient excavation to remove unsuitable founding materials	Settlement of compressible soils (e.g. organics) due to insufficient excavation	Operation	Further geotechnical study to inform founding material requirements Inspection of soils exposed at base of excavations prior to construction Allowance for variability in quantity estimates Additional targeted geotechnical investigation to fill data gaps	Minor Adverse	Possible	Low	No additional mitigation measures identified			

Table 9-5 Geology and Soils - Summary of impacts, risks and mitigation measures (Continued)
Source: Perth Airport

9.5 Contaminated Sites Database

9.5.1 Methodology

The study area for the contaminated land investigation includes the NRP area as well as an area identified as having the potential to be impacted. Investigations were predominately targeted within the NRP area. The wider study area includes the areas captured in the desktop searches (licensed ground water bore search, DWER contaminated sites database, heritage records and other available databases). Figure 9-12 shows the study area for the contaminated land assessment.

The assessment was completed through a preliminary site investigation (including desktop review) and a detailed site investigation.

The purpose of the preliminary site investigation was to identify potential on-estate and off-estate contaminant sources that warranted further detailed inspection and included:

- a walkover across all accessible areas of the study area including operational properties within the estate,
- photography and completion of a photo-log for visual representation of the condition of the study area,
- inspections and interviews with the operators of individual properties within and adjacent to the NRP area that were considered to contain potential areas of environmental concern, and
- a desktop review.

The desktop review was undertaken to identify potential areas of environmental concern and contaminants of potential concern and included a review of:

- historical aerial photographs obtained from Landgate,
- heritage records, including records held by the State Department of Planning, Lands and Heritage (which consists of various former State Departments, including the Department of Aboriginal Affairs) and DWER.
- records of environmental incidents or former environmental licences as held by the DWER,
- historical tenant audit reports completed for leased properties within the estate on behalf of Perth Airport by previous environmental consultants,
- data of licensed bores present within a one kilometre radius of the estate as made available by the State Department of Water, and
- various geological, hydrogeological and topographical maps.

Based on the findings of the preliminary site investigation, a detailed site investigation was conducted in January 2017 which comprised:

- excavation of 13 soil bores, with samples collected at depths of 0.5 metre, one metre and 1.5 metres below ground level,
- surficial soil samples collected in areas of observed potential asbestos-containing material,
- groundwater sampling from eight existing groundwater wells, and
- surface water sampling from areas identified as significant water bodies, including Munday Swamp.

Various field quality assurance and control samples were collected, prepared and submitted for analysis at the densities required to meet the assessment requirements, including:

- Split duplicate (Inter-laboratory duplicate) – A field replica of a primary sample which is submitted to a secondary laboratory to independently assess the primary laboratory precision and/or sample heterogeneity.
- Blind duplicate (Intra-laboratory duplicate) – A field replica of a primary sample which is labelled in a manner which does not allow the primary laboratory to identify the corresponding primary sample. The blind duplicate is submitted to the primary laboratory to independently assess the primary laboratory precision and/or sample heterogeneity
- Rinsate – sample collected using laboratory supplied deionised water (certified as free of any contaminants) which is poured over decontaminated non-disposable sample equipment and collected in laboratory supplied bottles. Rinsate samples assess the effectiveness of the decontamination process.
- Trip spike - Laboratory supplied samples with known concentrations of volatile contaminants which accompany samples during field activities and transportation. This type of sample is used to provide a quantitative measure of volatile loss due to inadequate cooling of samples during handling and transport.
- Trip blank - Laboratory supplied samples certified as being free of volatile contaminants which accompany samples during field activities and transportation. This type of sample is used to provide a quantitative measure of cross contamination of volatiles.

Figure 9-13 and Figure 9-14 show the sampling locations.

In addition to the PSI and DSI completed within the NRP area, an All of Estate DSI (Senversa 2019) has been completed for the entire Perth Airport estate and includes surficial soil sampling and groundwater sampling within the NPR area. The All of Estate DSI underwent an independent review by a DWER Contaminated Sites Auditor. Data collected during the All of Estate DSI has been included below to supplement the existing data set.

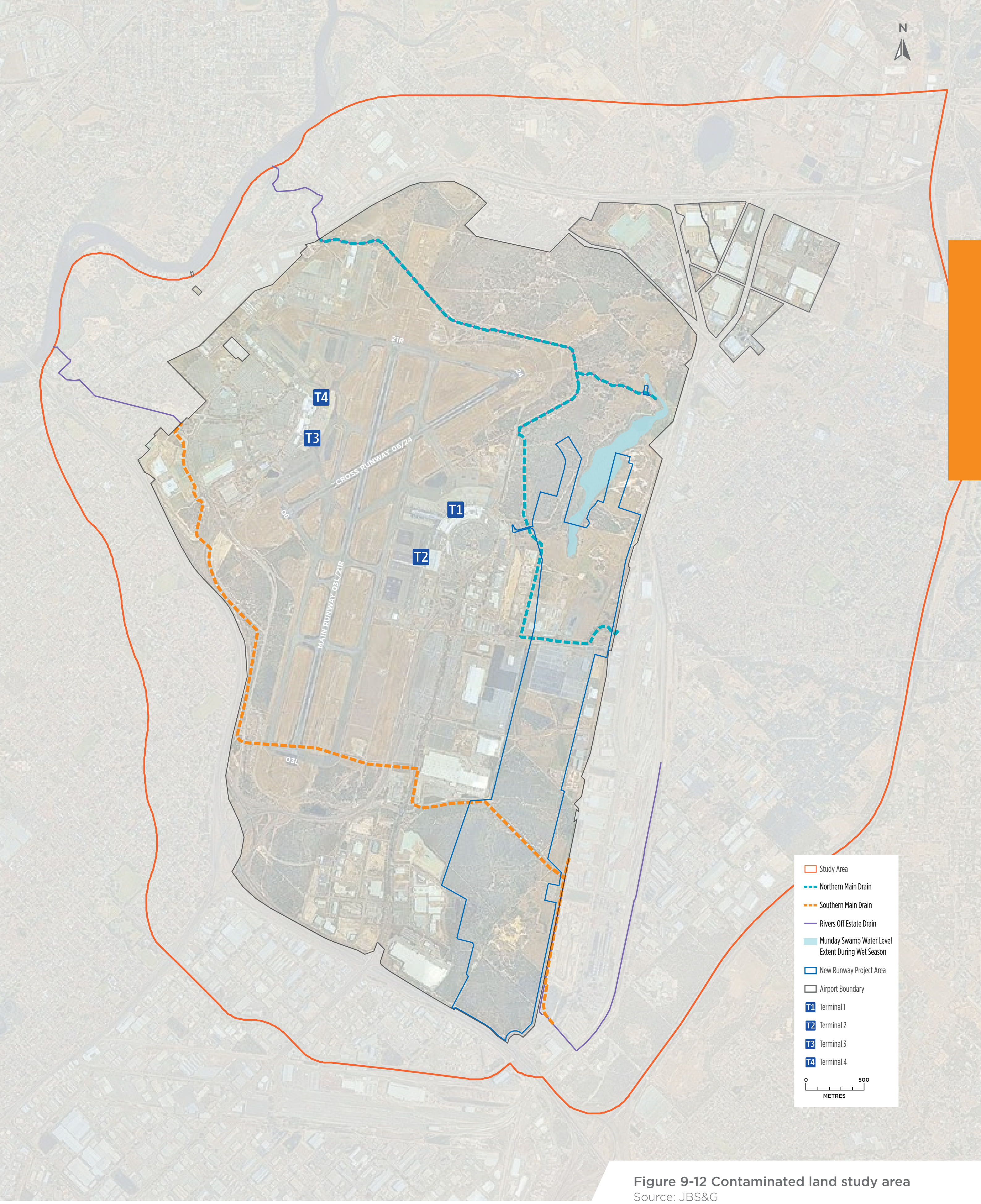


Figure 9-12 Contaminated land study area
Source: JBS&G

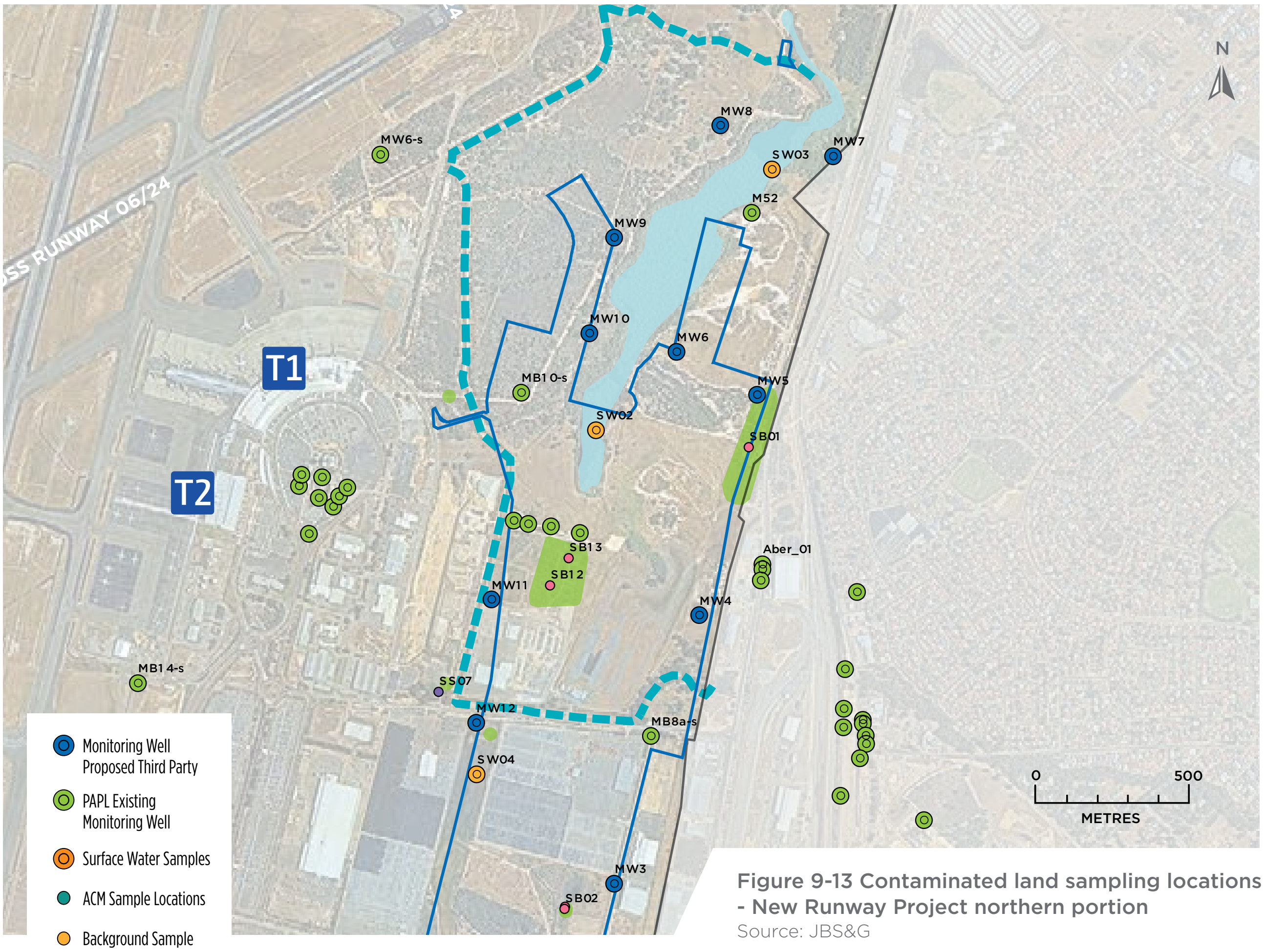


Figure 9-13 Contaminated land sampling locations - New Runway Project northern portion
Source: JBS&G

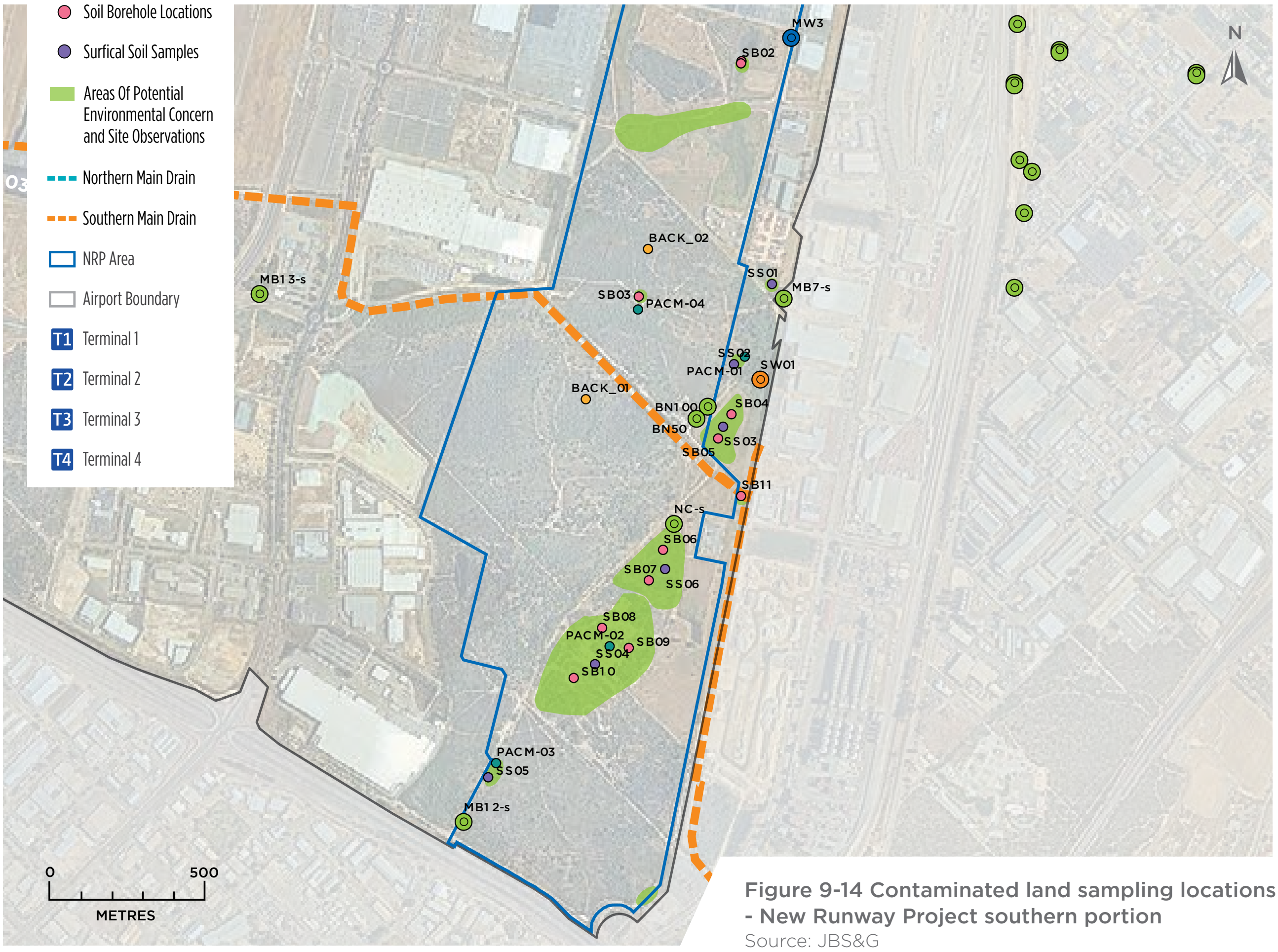


Figure 9-14 Contaminated land sampling locations - New Runway Project southern portion
Source: JBS&G

9.5.2 Existing Condition

An assessment of potentially contaminated soils was carried out. This included a preliminary site investigation and a detailed site investigation consisting of specific sampling and analysis programs in areas identified as potentially containing contaminated soil.

The study considered geological conditions as described in Section 9.4. Surface and groundwater interactions including hydrogeology were considered in the context of Section 10.

9.5.2.1 Perfluoroalkyl and Polyfluoroalkyl Substances

Per- and poly fluoroalkyl substances (PFAS) are a large group of compounds consisting of a fluorinated hydrophobic alkyl chain of varying length with a hydrophilic end group. Certain PFAS have been identified as contaminants, including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), of emerging concern in Australia and internationally. PFAS are very stable with a moderate mobility and are highly resistant to biological degradation, therefore they are persistent within the environment. In addition, PFAS are bio-accumulative and are noted to be ubiquitous in the food chain.

Aqueous film-forming foams containing PFAS have been used internationally in firefighting activities since the 1960s. The PFAS used in aqueous film-forming foams reduce the surface tension of the water and allow an aqueous film to spread over flammable liquid and suppress vapours during firefighting.

During their historical use and storage on the estate, it is possible that aqueous film-forming foams may have been released to the environment through firefighting activities as well as being used on hydrocarbon spills for fire prevention. Aqueous film-forming foams may have also been released through firefighting training activities and during the maintenance, cleaning and testing of firefighting equipment, as well as through spills and leaks from storage and transfer activities.

A number of investigations, including a human health and ecological risk assessment, as well as ongoing monitoring for PFAS in both groundwater and surface water, have been undertaken across the estate. Previous investigations have identified eight individual PFAS areas of potential environmental concern at the estate which are depicted on Figure 9-15 and include;

- Former Workshop and Tyre Store (Airport West),
- Former Fire Station (Airfield),
- Current ARFF Fire Station (Airfield),
- Area 1 (Airport North),
- Area A (Airport Central),
- Area B (Airport West),
- International Terminal Apron Fuel Spills (Airport Central), and
- Old Incinerator Building (Airport North).

All of the identified PFAS areas of potential environmental concern are located outside of, and down hydraulic gradient of, the NRP area. The highest concentrations of PFAS are predictably located within the vicinity of former fire stations and associated areas. Surface water run-off and interactions with groundwater have also resulted in the detection of PFAS within the existing Southern and Northern Main Drains on the estate. Concentrations of PFAS are higher in the Northern Main Drain in comparison to the Southern Main Drain. Based on the high mobility and resistance to degradation, it is recognised that PFAS detections in the wider airport estate may also be contributed to by off-estate sources.

As referenced in Section 9.3, the HEPA (2018) provides specific guidance to the assessment of PFAS. The HEPA states the following guiding principles of sound environmental regulation that have informed the development of the plan and continue to guide its implementation.

1. a focus on protection of the environment and, as a precaution, protection of human health
2. consideration of the principles established by the Intergovernmental Agreement on the Environment in all decision-making, including:

a. the precautionary principle. The precautionary principle states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by: careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and an assessment of the risk-weighted consequences of various options.

b. intergenerational equity. The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

c. conservation of biological diversity and ecological integrity. Conservation of biological diversity and ecological integrity should be a fundamental consideration.

d. improved valuation, pricing and incentive mechanisms. Environmental factors should be included in the valuation of assets and services; polluter pays, i.e. those who generate pollution and waste should bear the cost of containment, avoidance, or abatement; the users of goods and services should pay prices based on the full life cycle costs of providing good and services, including the use of natural resources and assets and the ultimate disposal of any wastes; and environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.

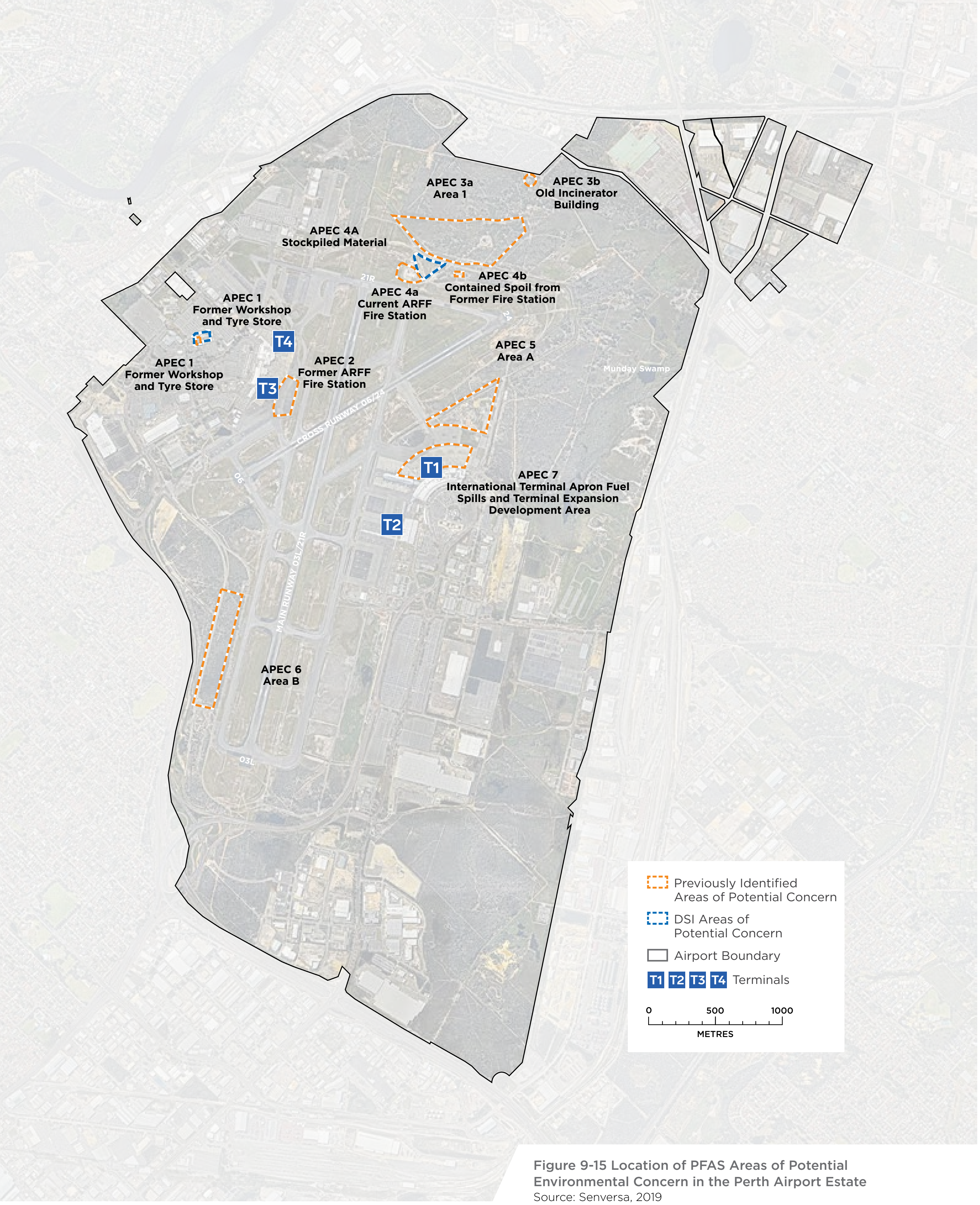


Figure 9-15 Location of PFAS Areas of Potential Environmental Concern in the Perth Airport Estate
Source: Senversa, 2019

3. regulatory actions and decisions are risk-based, informed by scientific evidence, focused on the identification of PFAS exposure pathways, and meet national and international obligations
4. quantitative PFAS assessment is to be based on appropriate analytical methods and standards, with the required quality assurance and control
5. consistency across jurisdictions, supported by the Plan, with consideration of accountability for pollution and management actions
6. coordinated and cooperative action on cross-boundary issues, including within catchments
7. consideration of legislative and policy frameworks across jurisdictions and at the national and international level for chemical and contaminated sites management
8. integration with existing national guidelines, including the National Water Quality Management Strategy, the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) and the National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998
9. where existing principles, guidelines, approaches or management options do not adequately foresee or address an identified environment risk, responses are to be guided by available scientific approaches, the precautionary principle and the understanding that action may be required to reduce risks
10. consideration of sustainability, including environmental, economic and social factors, when assessing the benefits and effects of management options, acknowledging the limited management options for PFAS currently available in Australia.

The plan (HEPA, 2018) recognises that environmental legislation in many jurisdictions includes obligations and duties to prevent environmental harm, nuisances and contamination. Table 9-6 includes the actions outlined in the HEPA (2018) that will enable the responsible person or organisation to demonstrate compliance with the obligations and duties, to which Perth Airport have provided comments on how they intend to comply with these during the NRP works.

PFAS NEPM (HEPA, 2018) Actions	Comment
Understanding the PFAS content of products and/or presence of PFAS contamination, for example, by determining the concentrations of PFAS present and/or the nature and location of PFAS sources	Perth Airport have completed a PSI and DSI to assess the nature and extent of PFAS within soil, groundwater and surface water at the site.
Understanding the environmental values that may be impacted by the contamination, both on- and off-site, such as determining the surface water and groundwater environments and determining what the water is used for. Important issues include any off-site movement, PFAS transformations and exposure pathways	Perth Airport have completed an impact assessment as part of the NRP MDP which includes the identification of environmentally sensitive areas.
Taking all reasonable and practicable measures to prevent or minimise potential environmental harm from PFAS-related activities and contamination, such as ensuring PFAS wastes, contaminated materials and products are effectively stored and/or remediated to prevent release, and having appropriate contingency plans to deal with leaks and spillage	Whilst the PSI and DSI indicate that PFAS source areas do not exist in the NRP area, mitigation measures proposed for the exposure of PFAS contaminants include the preparation of an Acid Sulphate Soils and Dewatering Management Plan, a Construction Environment Management Plan (CEMP) and an Operational Environment Management Plan.
Undertaking appropriate monitoring to check the effectiveness of management measures implemented and to assess the extent and impacts of any contamination	Perth Airport propose to assess PFAS levels in groundwater and surface water throughout construction.
Ensuring proper disposal of PFAS-contaminated waste, for example, by properly characterising waste and sending it to a facility licensed to accept it. Dilution is not acceptable for example in soil, compost or other products	Whilst the PSI and DSI indicate that PFAS source areas do not exist in the NRP area, it is recognised that the proposed CEMP will detail the appropriate storage, handling, transportation and disposal of waste.
Ensuring environmental regulators and any persons or organisations likely to be adversely affected by any releases are promptly advised of any incidents and contamination	Whilst the PSI and DSI indicate that PFAS source areas do not exist in the NRP area, it is recognised that the proposed CEMP will detail the incident reporting procedure which will include all relevant stakeholders.

Table 9-6 Actions to comply with environmental legislation obligations and duties
Source: PFAS NEMP (HEPA, 2018)

9.5.2.2 Contaminated Sites Database

To understand the soil conditions surrounding the NRP area, a search of the State Government Contaminated Sites Database was undertaken. The contaminated sites database records information on sites that are either:

- 'Contaminated – Remediation Required',
- 'Contaminated – Restricted Use', or
- 'Remediated for Restricted Use'.

Sites that are classified as Possibly Contaminated – Investigation Required under the *Contaminated Sites Act 2003* (WA) are not listed on the public database and have not been included within the assessment.

The following properties adjacent to, or within close proximity of the NRP area are included on the contaminated sites database, and shown in Figure 9-16, under one of the classifications listed above.

- 777 Abernethy Road, Forrestfield – Remediated for Restricted Use. The property is located immediately east of the southern section of the NRP area. The site was classified in 2013 as the groundwater beneath the site is contaminated with copper, zinc and total nitrogen. Asbestos containing material may remain in the soil in isolated areas of the site. The contaminated groundwater and soil was caused by the site's historical use as railway yard from 1968 to the late 1990s. The site is restricted to commercial or industrial use with open-space areas, and excludes sensitive uses such as childcare centres, kindergartens, pre-schools and primary schools.
- Lot 13575 on Deposited Plan 221057 – Abernethy Road, Forrestfield – Remediated for Restricted Use. The property is located immediately south-east of the southern section of the NRP area. The site was classified in 2013 as the groundwater beneath the site is contaminated with copper, zinc and total nitrogen. Asbestos-containing material may remain in the soil in isolated areas of the site. The contaminated groundwater and soil was caused by the site's historical use as railway yard from 1968 to the late 1990s. The site is restricted to commercial or industrial use with open space areas, and excludes sensitive uses such as childcare centres, kindergartens, pre-schools and primary schools.

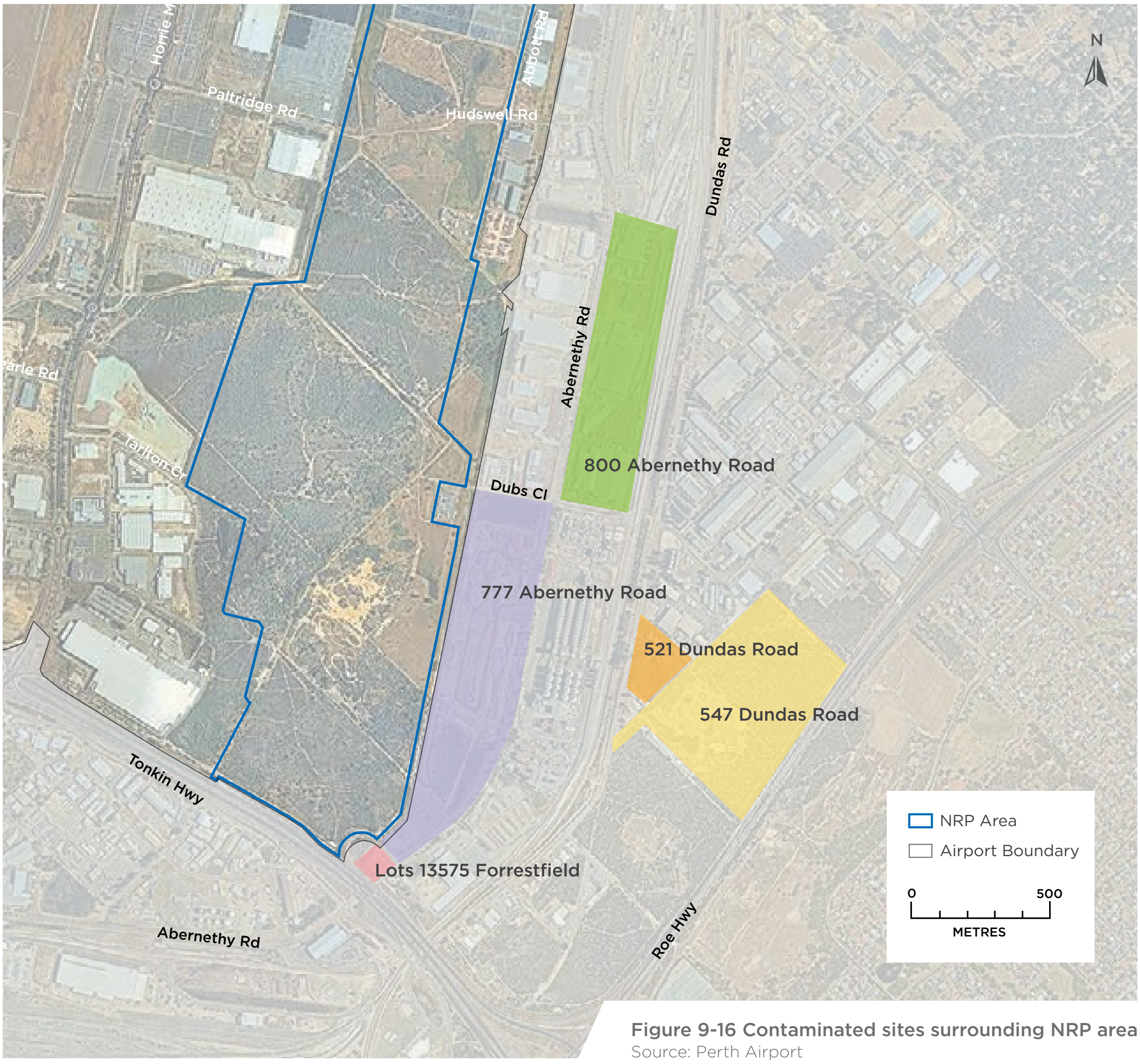


Figure 9-16 Contaminated sites surrounding NRP area
Source: Perth Airport

- 800 Abernethy Road, Forrestfield – Remediated for Restricted Use. The property is located approximately 300 metres to the east of the boundary of the central portion of the NRP area. The site was classified in 2014 due to petroleum hydrocarbons being present in the soils and groundwater contained beneath the railway infrastructure at the site. The contaminated groundwater and soil was caused by the site's historical use as a railway marshalling yard between 1968 to the late 1990s, and its ongoing use as a railway freight terminal. The site is restricted to commercial/industrial use with open-space areas, and excludes sensitive uses such as childcare centres, kindergartens, pre-schools and primary schools.
- 547 Dundas Road, Forrestfield – Contaminated – Remediation Required. The site is located approximately one kilometre to the east of the southern portion of the NRP area which is considered to be up-hydraulic gradient. The site is operated by the State Department of Fire and Emergency Services. A complex plume, comprising volatile organic compounds (including chlorinated solvents and petroleum hydrocarbons), metals and Per-and Poly-fluoro Alkyl Substances (PFAS) is present beneath the site and extends off-site to the west.
- 521 Dundas Road, Forrestfield – Contaminated – Remediation Required. The site is located approximately one kilometre to the east of the southern portion of the NRP area, which is considered to be up-hydraulic gradient. PFAS derived from fire-fighting foams are present in groundwater beneath the site, originating from the adjacent property 547 Dundas Road.

The State Department of Planning Lands and Heritage have advised that there are four properties classified as 'possibly contaminated -investigation required' under the Contaminated Sites Act 2003 (WA) which are located to the south of the NRP area, including:

- Lot 132 on Plan 31408, 3 Casella Place, Kewdale
- Lot 10592 on Plan 10093, 10592 Abernethy Road, Kewdale
- Lot 133 on Plan 31408, 5 Casella Place, Kewdale
- Lot 551 on Plan 27876, 543 Abernethy Road, Kewdale.

It is recognised that these properties are outside of the study area and the Airport Estate and are likely to be down or cross-hydraulic gradient of the NRP area.

9.5.2.3 Detailed Site Investigation

Site observations and analytical data for the soil samples indicate that contamination only exists within the NRP area at soil bore SB01 (Figure 9-13), where surface staining with hydrocarbon odours was observed. Table 9-7 outlines the reported concentrations that were exceeded in the sample.

The fly tipping (illegal dumping of waste) in the area around SB01 was cleared between the preliminary site investigation and the detailed site investigation, however, contaminated soils remain. Due to the presence of the Dampier to Bunbury gas pipeline in the area, it was not possible to extend the soil bore to assess the vertical extent of the contamination. The lateral extent of the contamination was observed to be approximately two to three square metres, and as such the impact is localised and small scale (associated with the previous fly tipping in the area) as opposed to a site-wide issue. Based on the exceeded screening criteria, the identified hydrocarbon and zinc concentrations could represent a risk to human and ecological receptors. However, any risks are likely to be negligible based on the observed extent of the contaminated soil.

Contaminate	Relevant Guideline	Limit Imposed	Sample Reading
Hydrocarbons	Airports (Environmental Protection) Regulations 1997	5,000 milligrams per kilogram	Total Recoverable Hydrocarbons C10-C36 fraction concentration of 32,460 milligrams per kilogram
	Ecological screening levels for commercial or industrial land use criteria	170 milligrams per kilogram	> C10-C16 fraction of 13,000 milligrams per kilogram
		1,700 milligrams per kilogram	>C16-C34 fraction 20,000 milligrams per kilogram
	Management limits	1,000 milligrams per kilogram	> C10-C16 fraction of 13,000 milligrams per kilogram
		3,500 milligrams per kilogram	>C16-C34 fraction 20,000 milligrams per kilogram
Xylene	Airports (Environmental Protection) Regulations 1997	25 milligrams per kilogram	28 milligrams per kilogram
Zinc	Ecological screening levels for commercial or industrial land use criteria	170 milligrams per kilogram	360 milligrams per kilogram

Table 9-7 Soil Bore (SB01) readings above criteria
Source: JBS&G

Fragments of asbestos-containing material were identified at three locations across the study area, however, asbestos fines (small particles) were not identified in the surficial soil samples collected.

Although not likely, it is recognised that asbestos containing material may exist within the NRP area where access could not be achieved during the preliminary or detailed site investigation works.

PFAS concentrations were reported below the laboratory limit of reporting (<0.005 mg/kg) and below the applicable screening criteria in all soil samples. Considering the absence of any PFAS detections in soils and the absence of any historical or anecdotal information to suggest otherwise, it is considered unlikely that the NRP area was utilised for firefighting training during the time of PFAS use at the airport.

The analytical data collected during the All of Estate DSI is consistent with the data collected in the NRP DSI, which reported the PFAS concentrations below the laboratory limit of reporting in all surficial soil samples.

Ground water testing reported concentrations of PFOS and PFHxA that were above the laboratory limit of reporting in all samples with the exception of one bore. Table 9-8 outlines the reported concentrations (µg/L) of PFAS (Perfluorohexanesulfonic acid (PFHxS), Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA)) for each of the groundwater sample locations against the applicable criteria.

Applicable screening criteria was only exceeded at one location (groundwater monitoring well BN100) located towards the eastern boundary (up-hydraulic gradient of the site). The concentration of PFOS in monitoring well BN100 was reported above the freshwater criteria (95 per cent species protection) of 0.13 µg/L, with a reported concentration of 0.14 µg/L.

Groundwater monitoring well BN100 is located adjacent to a stockpile of soil. Soil samples taken from the stockpile did not report any PFAS above the laboratory limit of reporting indicating that the source of the PFAS is not from the stockpiled soil. Considering that the groundwater PFAS concentrations are fairly consistent across the NRP investigation area, that the reported concentrations are orders of magnitude lower than PFAS concentrations recorded in the groundwater around known or suspected areas of AFFF use, and that no historical firefighting activities are known to have occurred in the area, it is reasonable to consider that levels of PFAS in groundwater are indicative of wider ground water quality which may be contributed to from sites outside of the estate.

Metals and nutrients were reported in groundwater across the area of investigation at concentrations that exceeded the ecological screening criteria and the Airport (Environment Protection) Regulations 1997. As the concentrations of metals and nutrients are comparable over such a large site area it is reasonable to assume that the reported concentrations are generally indicative of background conditions, which may be influenced by farming and industrial activities being undertaken up-hydraulic gradient of the site.

Groundwater samples were collected from existing groundwater monitoring wells within the NRP area as part of the All of Estate DSI (Senversa 2019). The analytical data reported concentrations of PFOS and/or PFHxA that were above the laboratory limit of reporting in all samples with the exception of one bore. Table 9-9 outlines the reported concentrations (µg/L) of PFHxS, PFOS and PFOA for each of the groundwater sample locations against the applicable criteria.

The analytical data collected as part of the All of Estate DSI is broadly consistent with the data collected during the NRP DSI. It is recognised that a few sample locations have reported exceedances of the drinking water criteria and the ecological freshwater species protection (95%). It is noted that all PFAS concentrations are below the adopted recreational criteria. The PFAS exceedances are located towards the south east corner of the

	PFHxS	PFOS	PFOA
PFAS NEMP (2018) - Health Based Guidance - Drinking Water	0.07	0.07	0.56
PFAS NEMP (2018) - Health Based Guidance - Recreational Water	0.7	0.7	5.6
National Health and Medical Research Council (2019) - Recreational Water	2	2	10
PFAS NEMP (2018) - Freshwater/interim marine 95% species protection		0.13	220
PFAS NEMP (2018) - Freshwater/interim marine 90% species protection		2	632
WA DWER PFAS (2016) - Drinking water		0.5	5
WA DWER PFAS (2016) - Non-potable and recreational uses		5	50
Monitoring Well ID			
ABER_01	<0.01	<0.01	<0.01
BN100	0.02	**0.14**	<0.01
M52	0.01	0.06	<0.01
MB10-S	0.02	0.01	<0.01
MB12-S	0.01	0.03	<0.01
MB13-S	0.03	0.03	<0.01
MB7-S	0.02	0.02	<0.01
NC-S	0.03	0.01	0.01

Table 9-8 PFAS concentrations in groundwater (µg/L)
Source: Senversa, 2019

NRP. Consistent with the conclusions made in the NRP DSI, due to the absence of any PFAS detections in soils in the NRP area, and absence of any known or suspected fire fighting activities within the NRP area, it is reasonable to consider that levels of PFAS in groundwater in the southern portion of the NRP area are derived from sites outside of the estate.

PFAS was detected in each of the surface water samples collected from the major water bodies. Table 9-10 outlines the reported concentrations (µg/L) of PFAS (PFOS, PFOA and PFHxS) for each of the surface water sample locations against the applicable criteria.

Applicable screening criteria was only exceeded at one location (sample location SW01) located on the eastern boundary (up-hydraulic gradient of the site), within close proximity to groundwater monitoring well BN100. The concentration of PFOS at SW01 was reported above the NEMP freshwater criteria (95 per cent species protection) of 0.13 µg/Land the NEMP recreational water use criteria of 0.7µg/L with a reported concentration of 0.73 µg/L. The concentration of PFHxS at SW01 was reported above the NEMP Ecological Freshwater Guideline of 0.13, with a reported concentration of 0.23 µg/L. Based on the location of the surface water body, it is anticipated that PFAS detections in SW01 are attributed to off-site sources. Recordable detections of PFAS at other surface water locations are relatively consistent, and in the absence of identified firefighting activities in the investigation area, may be representative of regional conditions rather than site derived, noting the close interaction between surface water and groundwater at the site.

Surface water run-off and interactions with groundwater have also resulted in the detection of PFAS within the existing Southern and Northern Main Drains on the estate. Concentrations of PFAS are higher in the Northern Main Drain in comparison to the Southern Main Drain.

Surface water samples reported comparable metals and nutrient concentrations to the groundwater samples and also exceed the adopted ecological and Airport (Environment Protection) Regulations 1997, again this indicates that contaminant concentrations may be representative of regional surface water quality issues.

	PFHxS	PFOS	PFOA
PFAS NEMP (2018) - Health Based Guidance - Drinking Water	**0.07**	**0.07**	**0.56**
PFAS NEMP (2018) - Health Based Guidance - Recreational Water	0.7	0.7	5.6
National Health and Medical Research Council (2019) - Recreational Water	2	2	10
PFAS NEMP (2018) - Freshwater/interim marine 95% species protection		0.13	220
PFAS NEMP (2018) - Freshwater/interim marine 90% species protection		2	632
WA DWER PFAS (2016) - Drinking water		0.5	5
WA DWER PFAS (2016) - Non-potable and rectreational uses		5	50
Monitoring Well ID			
MW0156	0.03	0.02	<0.01
MW0229	0.03	0.02	<0.01
MW0154	0.02	<0.01	<0.01
MW7D	<0.01	<0.01	<0.01
MW0113	0.02	**0.09**	<0.01
MW0115	0.03	0.03	<0.01
MW0181	**0.08**	<0.01	0.01
MW0235	0.02	**0.1**	<0.01
MW0123	**0.09**	**0.52**	<0.01
MW2024	**0.08**	0.02	<0.01

Table 9-9 PFAS concentrations in groundwater (µg/L)
Source: Senversa, 2019

	PFHxS	PFOS	PFOA
PFAS NEMP (2018) - Health Based Guidance - Recreational Water	0.7	0.7	5.6
National Health and Medical Research Council (2019) - Recreational Water	2	2	10
PFAS NEMP (2018) - Freshwater/interim marine 95% species protection		0.13	220
PFAS NEMP (2018) - Freshwater/interim marine 90% species protection		2	632
WA DWER PFAS (2016) - Non-potable and rectreational uses		5	50
Surface Water Location			
SW01	0.23	0.73	0.05
SW02	0.05	0.04	0.02
SW03	0.03	0.05	0.02
SW04	0.12	0.02	0.03

Table 9-10 PFAS concentrations in surface water (µg/L) (NRP DSI)

9.5.3 Contaminated Sites Database

Significance criteria have been used to assess the potential impacts that may arise from the NRP with respect to contamination. The significance criteria in Table 9-11 have been derived from the generic criteria provided in Section 8.

The various risks identified and mitigation strategies to reduce resulting impacts are discussed in the following sections and are summarised in Table 9-14.

Magnitude Description	Specialist Criteria
Major Adverse	Impacts that affect nationally important environmental resources or affect an area that is nationally important or have macro-economic consequences. Accepted contamination limit or standard is drastically exceeded causing an impact to a highly valued/sensitive resource/receptor, where natural functions or processes are altered to the extent they will permanently cease.
High Adverse	Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem. An accepted contamination limit or standard is exceeded causing an impact to an important or sensitive resource/receptor where natural functions and processes temporarily cease.
Moderate Adverse	Impacts that affect the NRP area or immediate surrounds. An accepted contamination limit or standard is exceeded causing a measurable impact to a resource or receptor, however, the affected environment is altered but natural functions and processes continue, albeit in a modified way.
Minor Adverse	Impacts that are limited to the NRP area. An accepted contamination limit or standard is marginally exceeded causing a localised impact to a resource or receptor in such a way that natural functions and processes are not affected.
Negligible	Impacts that are limited to the NRP area. Contamination is present but within accepted contamination limit or standard with no detectable impact to a resource/receptor.
Beneficial	The project results in remediation of areas that are currently contaminated.

Table 9-11 Significance criteria – Contaminated Sites Database
Source: JBS&G

9.5.3.1 Contaminated Media

As discussed in Section 9.5.2, a number of areas of environmental concern have been identified across the NRP area, which include: hydrocarbon contaminated soils, surface asbestos-containing material fragments, concentrations of metals, nutrients and PFAS in both surface and groundwater.

The potential for contaminants to migrate is a combination of:

- the nature of the contaminants (solid/liquid and mobility characteristics),
- the extent of the contaminants (isolated or widespread),
- the location of the contaminants (surface soils or at depth), and
- the site topography, geology, hydrology and hydrogeology.

The following factors influence the migration pathways relevant to the NRP:

- the NRP area has areas of vegetation and, as such, the potential for wind-blown dust from the site is considered to be negligible at present. Dust is potentially a pathway once construction and associated soil disturbance commences,
- there is the potential for hydrocarbons identified in soils at SB01 to leach downwards through the soil profile to impact groundwater,
- migration of contamination via groundwater movement is a plausible migration pathway,
- surface water channels may act as a migration pathway, both for surface water, and for surface expressions of groundwater at times of elevated groundwater levels, and
- asbestos containing material fragments identified are unlikely to become airborne but may be disturbed by site preparation and construction activities.

Based on the contaminants of potential concern identified in various media as discussed in Section 9.5.2, the potential exposure pathways for the site include:

- skin contact and ingestion of potentially contaminated soils,
- skin contact and ingestion of potentially contaminated groundwater via groundwater abstraction,
- skin contact and ingestion of potentially contaminated surface water via surface water bodies on and off site, and
- ingestion of potentially contaminated vegetation.

9.5.3.2 Receptors

The potential receptors to the possible contamination in the NRP area include:

- human receptors on site including current and future workers and others who access the NRP area, including Traditional Custodians,
- human receptors off-estate including current and future workers and occupiers of residential properties, and
- terrestrial, avian and aquatic fauna on estate and within the immediate site surrounds, specifically Munday Swamp and avian species listed under the EPBC Act.

Potential source-pathway-receptor linkages are summarised in Table 9-12 and discussed in Table 9-13. The NRP area will not be used for residential purposes in the future and therefore ingestion of vegetation from the NRP area is not considered to be a potential pathway for human receptors.

✓ Complete Pathway × Incomplete Pathway – Not Applicable	Human Receptors		Ecological Receptors					
	On-estate	Off-estate	On-estate			Off-estate		
	Land Users	Land Users	Terrestrial Fauna	Avian Fauna	Aquatic Fauna	Terrestrial Fauna	Avian Fauna	Aquatic Fauna
Exposure Pathway								
Soil – dermal contact, ingest	✓	×	✓	×	×	×	×	×
Groundwater – abstraction, skin contact, ingest	✓	✓	✓	✓	✓	✓	✓	✓
Surface water – skin contact, ingest	✓	✓	✓	✓	✓	✓	✓	✓
Vegetation – ingest	×	×	✓	✓	–	✓	✓	–

Table 9-12 Potential source-pathway receptor linkages
Source: JBS&G

Exposure Pathway	Receptor	Discussion
Contaminated Soils		
Dermal contact and ingestion of potentially contaminated soils. Plant root uptake	Human receptors on the NRP area including current and future workers, people illegally accessing the NRP area, and traditional owners	Contamination identified at SB01 is below the adopted human health-screening criteria for commercial/industrial land use. However, asbestos-containing material fragments have been identified at the NRP area and therefore the potential exists for exposure to asbestos fibres.
	Human receptors outside the NRP area including current and future workers and occupiers of residential properties	The potential exists for dust generated (including potentially contaminated dust) from the NRP area to affect areas outside of the NRP area, including surrounding residential areas. However, it is recognised that current vegetation cover at the NRP area will significantly limit the current dust generation. During the construction works, dust suppression and soil management practices will be implemented to limit the generation and mobilisation of any dust from the NRP area.
	Terrestrial, avian and aquatic fauna within the NRP area and within the surrounding NRP area	Soil contamination has been identified in excess of adopted ecological screening criteria and may present a risk (from dust generation) ecological receptors found inside and outside the NRP area. Based on the areas investigated, it is noted that exceedance of ecological criteria is limited to an area of stained soil in the vicinity of SB01 which is considered to be limited in horizontal extent. As such the contaminated soil that may pose a risk to ecological receptors is localised and limited in extent.

Table 9-13 Potential source-pathway-receptor discussion
Source: JBS&G

Exposure Pathway	Receptor	Discussion
Contaminated Groundwater		
Dermal contact and ingestion via abstraction. Plant root uptake	Human receptors on the NRP area including current and future workers, people illegally accessing the NRP area, and traditional owners	Exposure to contaminated groundwater could occur through excavation works and reticulation bores surfacing contaminated groundwater. Exposure for intrusive construction workers within the NRP area will be higher than general airport worker/operators or occupiers in the NRP area. However, with appropriate personal protective equipment, the potential for ingestion will be low and risks will be minimal. Groundwater is also considered to discharge to surface-water drains in response to seasonal variations.
	Human receptors outside the NRP area including current and future workers and occupiers of residential properties	Exposure to groundwater could occur through groundwater abstraction from licensed and registered (and un-registered) bores surrounding the NRP area. The groundwater could be used for many purposes including irrigation, washing or for drinking purposes. Abstraction for drinking water purposes is considered to be unlikely based on the provision of scheme water in the vicinity of the NRP area and the poor quality of groundwater. Groundwater is considered to flow north-west towards the Swan River. Groundwater is likely to discharge to the Swan River where recreational users of the river may be exposed to groundwater contamination, however there is significant dilution factor at the point of discharge.
	Terrestrial, avian and aquatic fauna within the NRP area and within the surrounding NRP area	Exposure of ecological receptors to contaminated groundwater could occur through reticulation and abstraction bores inside and outside the NRP area as well as groundwater discharge to surface-water bodies including the Swan River.
Contaminated Surface Water		
Skin contact and ingestion of potentially contaminated surface water. Plant root uptake	Human receptors on the NRP area including current and future workers, people illegally accessing the NRP area, and traditional owners	Occupiers of the NRP area may be exposed to contaminated surface water from the NRP area. Exposure for intrusive construction workers will be higher than general airport worker/operators in the NRP area or occupiers. However, with appropriate personal protective equipment, the potential for ingestion will be low and risks will be minimal.
	Human receptors outside the NRP area including current and future workers and occupiers of residential properties	The surface water drains leaving the NRP area are accessible to human receptors outside the NRP area, however, exposure is unlikely. There is potential for impacts to surface water entering the Swan River.
	Terrestrial, avian and aquatic fauna within the NRP area and within the surrounding NRP area	The potential exists for contaminated surface water to affect the flora and fauna in the NRP area and surrounds (including the Swan River and Munday Swamp) as well as the environmental value of ecological receptors. There are no livestock in the vicinity of the NRP area that may be affected by the consumption of contaminated surface water.

Table 9-13 Potential source-pathway-receptor discussion (Continued)

Exposure Pathway	Receptor	Discussion
Vegetation Ingestion		
Ingestion of potentially contaminated vegetation	Human receptors on the NRP area including current and future workers, people illegally accessing the NRP area, and traditional owners	The NRP area will not be used for residential purposes in the future and therefore ingestion of vegetation within the NRP area is not considered to be a potential pathway.
	Human receptors outside the NRP area including current and future workers and occupiers of residential properties	Groundwater may be extracted from licensed and registered (and un-registered) groundwater bores outside the NRP area for irrigation purposes. As such home-grown produce may be affected by contaminated groundwater.
	Terrestrial, avian and aquatic fauna within the NRP area and within the surrounding NRP area	Vegetation contaminated by groundwater and surface water inside and outside the NRP area has the potential to be ingested by terrestrial, avian and aquatic fauna.

Table 9-13 Potential source-pathway-receptor discussion (Continued)

Historical site activities have resulted in contamination at various locations across the NRP area, however much of this contamination is localised. Surface and groundwater contamination, however, appears to be more widespread and not limited to the NRP area. That is, the results obtained as part of this assessment are indicative of the quality of surface and groundwater that flows into and across the estate.

9.5.3.3 Early Works and Construction Phases

Any early works and construction activities associated with the NRP are likely to encounter and disturb the existing contamination hazards that have been identified as part of the preliminary site investigation and the detailed site investigation. The following potential impacts may be caused by the construction of the NRP:

- the possible exposure of hydrocarbon and other contaminated media, to surface water runoff, during site-preparation activities (site clearance, topsoil stripping and fill activities), which may affect surface water and/or groundwater quality and impact downstream ecological receptors, and
- the disturbance and release of friable asbestos materials during site-preparation activities, to the air or via dermal contact, which may impact current and or future workers.

Based on the findings of the contaminated land investigation and the NRP activities, the existing contamination hazards will require management prior to the construction phase. The following mitigation measures will be implemented:

- an Acid Sulfate Soils and Dewatering Management Plan (as part of the Construction Environmental Management Plan (CEMP)) will be prepared at the commencement of the project that includes procedures for the re-injection of groundwater to align with the proposed groundwater management strategies, the CEMP will be reviewed by the AEO prior to implementation,
- fly-tipped material identified during the detailed site investigation to be removed,
- the zinc and hydrocarbon contaminated soils at SB01 and wherever else encountered are to be excavated and removed to the extent practicable, noting this may be limited by the close proximity of natural gas infrastructure. Given the small area that is contaminated, partial remediation should still be adequate to reduce the risk to an acceptable level,
- a licensed asbestos-removal contractor will remove surface asbestos-containing material, identified during the detailed site investigation, to an approved landfill site,
- appropriate personal protective equipment to be worn by workers where necessary, and
- procedures for unexpected finds and conducting further testing will be built into the CEMP.

Undertaking these management measures and remediating the existing contaminants will result in a beneficial impact where contaminants are removed and appropriate risk minimisation occurs.

The risk to workers from exposure to contaminated ground or surface water will be managed using standard personal protective equipment (long-sleeve trousers and shirts, gloves and glasses) to limit any exposure to potentially contaminated groundwater or surface water.

The use of groundwater from the site to undertake dust suppression will be subject to a risk assessment prior to new runway works commencing.

It is also possible that workers will be exposed to contaminated surface water that contains PFAS which would present medium risk to workers. An Acid Sulfate Soils and Dewatering Management Plan will be prepared that includes procedures for the re-injection/infiltration of groundwater to align with the proposed groundwater management strategies. This requires further treatment which is discussed in Section 10.

Spills or leaks of fuel and oil could potentially occur during construction. These would be handled though standard spill-response measures as part of the Construction Environmental Management Plan and would likely have a limited and localised impact.

A summary of the potential impacts and statutory mitigation measures resulting from the early works and construction phase is shown in Table 9-14.

9.5.3.4 Operation and Maintenance

There is the potential risk that surface water and groundwater quality may be impacted by contamination spills and contamination runoff during the operational phase of the new runway. The release of substances (due to the storage and use of fuels, oils etc.) and the accumulation of contaminated surface runoff (from rubber particles from aircraft landing, organic compounds from aircraft emissions or heavy metals from aircraft components etc.) to surface water and groundwater may impact on downstream ecological receptors. These would likely be localised in nature.

The likelihood of spills will be minimised through appropriate statutory procedures for handling, transporting and using potentially contaminating substances including diesel, petrol, oils, greases, chemicals and herbicides. The consequence of a spill will be minimised by rapid spill-response measures and remediation of any affected area. The surface water drainage for the NRP provides for sediment and infiltration ponds to reduce the potential for contaminated surface water to enter Munday Swamp or other ecological receptors.

9.5.4 Mitigation

The risk assessment into potential contamination across the site noted that a majority of the impacting processes resulted in risks that were rated beneficial or low. However, the assessment identified two potential medium risks that require additional mitigation:

- the possibility of workforce and ecological receptor exposure to PFAS during construction, and
- the risk posed by spills of hazardous substances entering sensitive environments during construction.

Perth Airport has identified the need for further treatment of the risk posed, as described in the sections below.

9.5.4.1 Per- and Poly-Fluoroalkyl Substances Exposure

There is a possibility that workers could be exposed to water that contains PFAS during the construction phase of the NRP. Soil and spoil used in the construction of the NRP will have the concentrations of PFAS and leachability monitored against relevant guidelines in place at the time of construction.

PFAS levels in groundwater and surface water will also be monitored throughout construction. Water extraction, handling and placement will be considered to ensure there is no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water.

The placement of soil and spoil (including the re-use of soil and spoil) will be considered to ensure that no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water.

The risk to workers from exposure to contaminated ground or surface water can be managed using standard personal protective equipment (long sleeve trousers and shirts, gloves and glasses) to limit any exposure to potentially contaminated groundwater.

Perth Airport will also undertake appropriate monitoring and evaluation procedures, risk management practices and site management and remediation activities in line with the PFAS National Environment Management Plan and other relevant guidance documents. Perth Airport will also support ongoing innovation and research into how the management of PFAS can be improved.

Mitigation and management measures will include the development of a CEMP for assessing and managing contamination of soil and water by PFAS. This CEMP will be consistent with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM), the PFAS NEMP and the National Water Quality Management Strategy, including the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. The CEMP will be finalised before site works commence.

An Acid Sulfate Soil and Dewatering Management Plan will also be developed. The CEMP and the Acid Sulfate Soil and Dewatering Management Plan will be sent to the Airport Environment Officer (AEO) for review prior to the construction of the new runway. Results of testing, risk assessment and management activities will be reported to the AEO. Adherence to this strategy will reduce the identified risk from medium to low.

It is expected that the Acid Sulfate Soil and Dewatering Management Plan will include periodic monitoring of the groundwater and surface water, including assessment for PFAS, during construction to assess for changes in PFAS concentrations from groundwater abstraction. Dewater effluent will be managed in a manner that does not result in an unacceptable increase in contamination risk, an increase in off-site release risk or an increase in risk to groundwater and surface water. Based on the relatively minor concentrations of PFAS in groundwater compared to the wider Airport Estate and the absence of any identified PFAS source areas within the project area treatment of abstracted water for PFAS is not required during dewatering.

As stated in the DWER Interim Guideline on the Assessment and Management of PFAS, 'With respect to partitioning relationships between soil, sediment and water, leaching is highest around neutral pH and decreases in more acidic and alkaline conditions'. As such, the generation of any acidic conditions during the disturbance of acid sulphate soils is unlikely to increase the mobility of any present PFAS. Therefore, the PFAS mobilisation risk as a result of ASS generation are considered to be low.

9.5.4.2 Contamination Spills During Construction

Spills of hazardous substances and hydrocarbons during the construction phase of the NRP has been classified as a medium risk. In addition to ensuring that that hazardous substances are stored in line with guidelines in the CEMP, it's intended that low impact and low-toxicity chemicals are used where practicable during the construction phase. Physical spill containment measures will also be used through construction and emergency response and recovery measures will be identified and planned for in the event of an unplanned release. Enacting these treatments will reduce the risk to low.

9.5.4.3 Residual Impacts

If the recommended management measures are adopted, residual risk levels for the construction and operation of the NRP with respect to contamination have been assessed as low. The measures will remove the source of current soil contamination, ensure no additional risk is created, or reduce them to a level that will present minimal risk. Existing groundwater contamination will remain. Importantly, the NRP will not:

- add any new sources of contaminants to surface or ground water,
- exacerbate existing contamination issues, or
- comprise measures to remediate existing groundwater contamination.

9.5.5 Summary of Impacts

Table 9-14 presents a summary of the impacts assessed as part of the potential contamination assessment as well as standard and additional mitigation measures and associated risk rankings.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Existing hydrocarbon contamination hazards encountered	Impact on surface water and or groundwater quality and ecological receptors	Construction	Preparation and implementation of a contaminated Land Management Plan including: • additional investigation to delineate extent of contamination • remove and dispose of hydrocarbon contaminated soil as per statutory requirements.	Beneficial	Not applicable	Not applicable	No additional mitigation measures identified			
Disturbance of asbestos containing material fragments	Release of friable asbestos materials, which may impact current or future workers	Construction	Preparation and implementation of a contaminated Land Management Plan including: • additional investigation to delineate extent of contamination • removal and disposal of asbestos containing material by an approved removalist prior to site clearance activities as per statutory requirements	Beneficial	Not applicable	Not applicable	No additional mitigation measures identified			
Contaminated groundwater encountered during dewatering and groundwater management activities	Exposure of contaminated groundwater which may impact on construction workers and or ecological receptors	Construction	Preparation and implementation of an Acid Sulfate Soils and Dewatering Management Plan including: • re-injection/ infiltration of groundwater to align with proposed groundwater management strategies.	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Contaminated groundwater encountered during construction of main drains	Exposure of contaminated groundwater which may impact on construction workers and or ecological receptors	Construction	Preparation and implementation of an Acid Sulfate Soils and Dewatering Management Plan including: • re-injection/ infiltration of groundwater to align with proposed groundwater management strategies.	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			

Table 9-14 Potential contamination - Summary of impacts, risks and mitigation measures
Source: Perth Airport

Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Initial Assessment: Significance/ Consequence	Initial Assessment: Likelihood	Initial Assessment: Initial Risk	Residual Assessment: Additional Mitigation	Residual Assessment: Significance	Residual Assessment: Likelihood	Residual Assessment: Residual Risk
Contaminated groundwater encountered during dewatering and groundwater management activities	Exposure of PFAS contaminants to surface water runoff which may impact surface-water and or groundwater quality and construction workers or ecological receptors	Construction	Preparation and implementation of an Acid Sulfate Soils and Dewatering Management Plan including: • re-injection/ infiltration of groundwater to align with proposed groundwater management strategies	Moderate Adverse	Possible	Medium	PFAS evaluation and risk assessment of soil concentration and leachability, and of groundwater and surface water that may be impacted Consideration of soil placement to ensure no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water Consideration of water extraction, handling and placement to ensure no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water Conformance with the PFAS National Environmental Management Plan and other relevant guidance documents Ongoing monitoring of PFAS concentrations in groundwater and surface water throughout construction Reporting of evaluation, risk assessment, management activities and monitoring results to the Airport Environment Officer (AEO) Submission of the CEMP and ASSDMP to the AEO for review prior to commencement of bulk earthworks and dewatering activities	Moderate Adverse	Unlikely	Low

Table 9-14 Potential contamination - Summary of impacts, risks and mitigation measures (Continued)

			Initial Assessment				Residual Assessment			
Impacting Process	**Impact Detail**	**Project Phase**	**Standard Mitigation**	**Significance/ Consequence**	**Likelihood**	**Initial Risk**	**Additional Mitigation**	**Significance**	**Likelihood**	**Residual Risk**
Contamination spills (Early works and construction phase)	Storage and use of fuels, oils etc. resulting in the release of substances to soil, surface water or groundwater which may impact on ecological and social receptors	Construction	Preparation and implementation of a CEMP to include: • appropriate measures for the storage and use of hazardous substances as per statutory requirements • spill response procedures • regular maintenance of vehicles to prevent leaks or spills • monitoring of construction water quality-control measures	Moderate Adverse	Possible	Medium	Select low impact or low toxicity chemicals during construction Physical spill containment bunds/ barriers Pumping options to remove contaminated surface waters Incident register to be monitored to identify recurring problems which can then inform maintenance programs	Minor adverse	Possible	Low
Contamination spills (Operation and maintenance phase)	Storage and use of fuels, oils etc. resulting in the release of substances to soil, surface water or groundwater which may impact on ecological and social receptors	Operation	Preparation and implementation of an Operational Environmental Management Plan to include: • appropriate measures for the storage and use of hazardous substances as per statutory requirements • spill response procedures • regular maintenance of vehicles to prevent leaks or spills • monitoring of water quality control devices	Moderate Adverse	Highly unlikely	Low	No additional mitigation measures identified			
Contamination from surface water runoff (Operation and Maintenance Phase)	Contaminated runoff to surface water (from accumulation of contaminants on pavement surfaces) which may impact on ecological receptors	Operation	Design to incorporate operational water quality treatment for runoff from new pavement areas e.g. swales, infiltration basins. Operational Environmental Management Plan to include updates to existing operational procedures for managing surface contamination on pavement surfaces	Minor Adverse	Possible	Low	No additional mitigation measures identified			

Table 9-14 Potential contamination - Summary of impacts, risks and mitigation measures (Continued)

9.6 Conclusion

In summary, the studies undertaken by Perth Airport assessed the existing geological and contaminant conditions within the NRP area. Studies noted the existence of acid sulfate soils, and contaminants of potential concern that will require management and treatment during the construction phase of the NRP. However, with appropriate mitigation in place the risks identified can be managed.

10 Wetlands and Hydrology

This section describes the impacts on wetlands and hydrology resulting from the construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- How will the drainage systems will be designed to cater for expected rain events?
- What mitigation measures will be put in place during construction and operation of the new runway?

10.1 Introduction

This section describes the impacts of changes to stormwater infrastructure and groundwater levels as a result of the NRP, as well as wetland values supported by the current hydrological regime.

The NRP will impact the two major stormwater drains that run across the estate, with sections of the Northern Main Drain (NMD) and Southern Main Drain (SMD) required to be realigned. The NRP will have the following physical impacts:

- some areas of wetland with ecological values and areas currently used for stormwater storage will be filled,
- the existing overflow channel that allows stormwater to drain into Munday Swamp from the NMD during larger storm events, will be cut off due to the proposed taxiway layout, and
- Munday Swamp will receive additional surface water in larger storm events.

Potential impacts of the NRP were identified by comparing the existing hydrological situation on the airport estate with a future scenario of having the NRP infrastructure in place. This was undertaken by using specialised computer software programs to model the two situations and then comparing the results. Appropriate mitigation measures were then identified.

Additional information on clearing and construction of the new runway and associated infrastructure can be found in Section 6.

10.2 Key Findings

Key findings from investigations into wetlands across the NRP include:

- 19 priority wetlands were identified in and around the NRP, comprising sumplands and damplands of the Mungala consanguineous suite. In total, the boundaries of these wetlands cover 191.5 hectares, of which 97.6 hectares is within the NRP.
- The clearing of the NRP and construction of infrastructure will result in the unavoidable loss of 79.8 hectares across seven wetlands considered commensurate with Conservation category wetlands and 17.8 hectares of 12 wetlands considered commensurate with Resource Enhancement category wetlands.

Key findings from investigations into stormwater across the New Runway Project area include:

- Sections of the NMD and SMD are required to be realigned to facilitate the safe operation of the new runway and to provide adequate drainage capacity. The design of the drainage network will cater for one per cent annual exceedance probability (100 year) events and will include water flow through Munday Swamp.
- Flood modelling indicates that any flooding as a result of the proposed stormwater infrastructure system changes, will not result in an increased risk of harm or damage to property on, or off the airport estate.
- Changes to surface water and groundwater affecting Munday Swamp will be within the tolerance levels of the swamp's flora and fauna.
- For flows larger than the one exceedance per year storm event, there will be an increased volume of water flowing into Munday Swamp. Potential scouring of the Munday Swamp base and the banks by the water draining through the swamp will be managed by the design of the proposed pollution capturing basins, an infiltration basin and measures to control the velocity of water flow. These measures will be designed to reduce the velocity of the water before it enters Munday Swamp.
- Construction activities that result in a risk of mobilising sediment, acid sulfate soils and other contaminants into Munday Swamp will be managed through the design process and via the implementation of a Construction Environmental Management Plan (CEMP). Where the same risks are expected post construction, they will be addressed in the detailed design work.

10.3 Policy Context and Legislative Framework

Water resources management is currently managed under six separate acts in Western Australia by the State Department of Water and Environmental Regulation. The *Rights in Water and Irrigation Act 1914* (RIWI Act) establishes the legislative framework for managing and allocating water resources in Western Australia and is most relevant to activities on Perth Airport. Being on Commonwealth land, activities on the estate are exempt from licensing under the RIWI Act.

State Planning Policy 2.9 – Water Resources, is the overarching sector policy and State Planning Policy 2 - Environment and Natural Resources, provides clarification and additional guidance to decision-makers when considering water resources in land-use planning strategies. The objectives of these policies are to:

- protect, conserve and enhance water resources that are identified as having significant economic, social, cultural and/or environmental values,
- assist in ensuring the availability of suitable water resources to maintain essential requirements for human and all other biological life with attention to maintaining or improving the quality and quantity of water resources, and
- promote and assist in the management and sustainable use of water resources.

Where applicable, guidance is taken from the state planning policy when designing and managing the hydrology on the airport estate.

The environmental impacts from changes to hydrology on Commonwealth land are covered by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

At a Commonwealth level, wetlands can be recognised as being of international importance (Ramsar wetlands) or national importance. There are no wetlands of international importance at Perth Airport. Nationally important wetlands are listed in the Directory of Important Wetlands in Australia, an online inventory first published in 1993, which acts as a knowledge base and tool for wetland managers. Although Ramsar wetlands are specifically protected under the EPBC Act as a matter of national environmental significance (MNES), nationally important wetlands do not have any specific level of statutory protection. There are 120 wetlands in Western Australia recognised in the Directory; of those, eight occur on Commonwealth land and one occurs at Perth Airport; the 'Perth Airport Woodland Swamps'. The Commonwealth mapping and description of the Perth Airport listing refers to 23 hectares of remnant woodland areas to the east and south of the main runway, covering Munday Swamp, Runway Swamp and Link Road Swamp (Department of the Environment and Energy 2019). However, the State mapping associated with the Directory listing has recently been updated, with a broader interpretation of the extent of wetlands associated with the listing. Current Department of Biodiversity, Conservation and Attractions (DBCA) mapping includes approximately 455 hectares of the Airport Estate as part of the Directory listing.

Additional legislation relating directly to Munday Swamp is the State *Aboriginal Heritage Act 1972* (AH Act), which lists the swamp as an Aboriginal Site. A Section 18 submission to conduct various site works including work required to manage stormwater impacts to Munday Swamp was submitted in June 2017 and subsequently approved by the State Government in May 2018. This is described in Section 16.

10.4 Methodology

10.4.1 Wetland mapping and evaluation

In Western Australia the term 'wetland' is used to refer to areas that are permanently, seasonally or intermittently waterlogged or inundated with water (DBCA 2019a). Wetlands are not always naturally occurring, some can be artificially created, and the water occupying wetlands can be either fresh or salty, and flowing or still (DBCA 2019a).

The wetlands found within Western Australia have been mapped at varying scales. Perth Airport is located on the Swan Coastal Plain (SCP), where detailed mapping has been undertaken at a scale of 1:25,000 (DBCA 2019a). The Geomorphic Wetlands Swan Coastal Plain (GWSCP) dataset is accepted by Western Australian planning and regulatory bodies (e.g. Environment Protection Authority (EPA)) as the primary dataset for wetlands within the region. This mapping was originally compiled by Hill et al. (1996) and is modified by the DBCA (as the current dataset custodian) as new information becomes available.

Each wetland within the GWSCP dataset has been evaluated and assigned a management category that provides guidance on how these wetlands should be managed and protected (Table 10-1). The three management categories used are Conservation (CCW), Resource Enhancement (REW) and Multiple use.

Management Category	Description	Management objectives
Conservation (CCW)	Wetlands which support a high level of attributes and functions.	Highest priority wetlands. Objective: to preserve and protect the existing conservation values of the wetlands. No development or clearing is deemed appropriate. Any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Objective: manage, restore and protect towards improving their conservation value. Have the potential to be restored to Conservation category by restoring wetland function, structure and biodiversity.
Multiple use	Wetlands with few remaining important attributes and functions.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

Table 10-1 Management categories and objectives for wetlands on the SCP
Source: Table adapted from DBCA 2017a.

The GWSCP dataset includes large portions of the airport estate mapped variously as CCW (228 ha), REW (265 ha) and Multiple use (651 ha) management category wetlands. However, mapping for the airport is somewhat outdated, with many of these areas now cleared and occupied by airport infrastructure. In response to this within the NRP additional work has been undertaken to validate the current GWSCP mapping and evaluation categories as a basis for assessing potential impacts to wetlands. There is no current guidance for SCP wetland identification and delineation methodology, however DBCA provides advice that determination of presence/absence or mapping of wetland boundaries should consider hydrology, hydric soils and wetland vegetation (DBCA 2017b).

Geomorphic boundaries of the wetlands intersecting the NRP project boundary have been confirmed through interrogation of historical aerial imagery, vegetation mapping, surface contours and information on hydrology. Wetland vegetation has been recently mapped across the airport site. Information on current wetland hydrology available to support the mapping and evaluation exercise included:

- Mapping of flood inundation areas for modelled rainfall events of varying magnitude.
- Mapping of seasonal high groundwater levels for the regional superficial aquifer.
- Various bore logs suggesting absence of potential perching layers.

Inundated or waterlogged landform units completely devoid of native vegetation were assumed to represent Multiple use wetlands and further work was not undertaken to refine geomorphic boundaries of these wetlands. Multiple use wetlands are not considered priority wetlands as they are highly modified and retain few or no important attributes or functions (DBCA 2017a). As such, impacts to these wetlands are generally not considered in impact assessments in Western Australia as they are not defined as significant ecosystems (EPA 2018). On this basis no further work was considered necessary to refine the boundaries of wetlands with a Multiple use classification and these wetlands have not been included in the impact assessment analysis undertaken for the NRP. In the context of Significant Impact Guideline 1.2, Multiple use wetlands are not likely to be sensitive or vulnerable to impacts and are not rare, endemic, unusual, important or otherwise valuable. This approach is therefore consistent with Commonwealth guidance on assessing impacts to the environment on Commonwealth land.

DBCA have published *A methodology for the evaluation of wetlands on the Swan Coastal Plain, Western Australia* which provides guidance on assigning an appropriate management category to a wetland. This methodology has been used to determine an appropriate management category (i.e. CCW or REW) for the wetlands within the NRP. The evaluation of wetlands is based primarily on their attributes and functions, independent of decisions regarding protection and management of the wetlands (DBCA 2017a).

To inform assessment of potential indirect impacts to wetlands outside of the NRP boundary, the current GWSCP dataset has been adopted as the basis for identification of wetland values. In recognition of the previously extensive nature of the Perth Airport wetland systems and given the extent of previous development within wetland areas, this dataset has been clipped to current wetland vegetation extent to provide a more accurate indication of wetland areas with remaining ecological attributes and functions (i.e. consistent with an REW or CCW). Wetland boundaries can extend beyond remaining wetland vegetation, however this approach was considered the most appropriate in the absence of updated wetland mapping across the entire airport estate. Where the DBCA dataset indicated Multiple use wetland areas but vegetation mapping suggests the presence of wetland vegetation units in Degraded or better condition, these areas have conservatively been displayed as REW areas. This mapping of wetlands within the Perth Airport boundary but outside the NRP should be considered indicative only.

10.4.2 Munday Swamp

Munday Swamp is a CCW located on the northern boundary of the NRP. In response to its recognition as a high value wetland in 2017 surveys and studies were undertaken to define wetland characteristics of Munday Swamp, with a focus on wetland vegetation, flora and fauna. This provided a description of key ecological values of the wetland and the processes supporting these values. This information was combined with bathymetry and modelling of the current extent and duration of inundation in order to inform impact assessment.

10.4.3 Stormwater Terminology

The terms "average recurrence interval" and "average return period" have historically been used to describe the frequency of storm events. They are not technically correct and have created confusion among decision makers and the public for inferring that once an event has occurred, for example a 1-in-100-year storm, that this magnitude of event will not occur again for that specified period. Events can, and do, occur in clusters. Flood events generally are random occurrences and the period between exceedances of a specific nominated event is usually random.

The 2016 edition of Australian Rainfall and Runoff (ARR), which is used by the stormwater industry to provide information relevant to design flood estimation (an extract is provided in Figure 10-1), has addressed this issue by recommending that the term "annual exceedance probability" (AEP) be used. This is defined as the probability of an event being equalled or exceeded within a year. For example, a 10 per cent annual exceedance probability indicates that the event has a 10 per cent chance of occurring at least once per year and similarly a 1 per cent annual exceedance probability indicates that the rainfall event has a 1 per cent chance of occurring at least once a year. The smaller the percentage annual exceedance probability nominated, the larger the storm will be, as it is likely to occur less often. This is the opposite to the terminology that has historically been used. For example, the largest storm event that Perth Airport designs for is the 1 per cent annual exceedance probability which historically has been referred to as the 1-in-100-year average return period.

An exception to this terminology is for storm events that are likely to occur at least once per year. The terminology for these is "Events per Year" (EY). For example, a 1 EY storm is likely to occur at least once per year. This MDP will use the terms "annual exceedance probability" (AEP) and "Events per Year" (EY) as recommended by the ARR document. The ARR document is a national guideline that can be used for the estimation of design flood characteristics in Australia and is published and supported by the Australian federal government.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.221	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			PMP	
			PMPDF	

Figure 10-1 Australian rainfall and runoff preferred terminology
Navy border indicates preferred terminology while shading is acceptable depending on use
Source: Australian Rainfall and Runoff (2016)

10.4.4 Stormwater Design Criteria

The concept for Perth Airport's stormwater design criteria relating to airside infrastructure is to protect all runways and taxiways from a 1 per cent annual exceedance probability storm event. Implementing that concept across the estate means that flood water on the airport estate would only be a limiting factor for aircraft movements in extreme rainfall events.

Stormwater flood modelling has shown that the existing NMD and SMD network floods during a 10 per cent annual exceedance probability storm event. To protect the new and the existing runways and taxiways, an upgrade of the main drainage networks is required across the estate, however the NRP will only form part of that upgrade. The main drain infrastructure will be developed to provide the capacity to cater for rainfall runoff from the estate and to meet inflows and peak storage requirements from upstream sources, to the same values that existed in 1997 when management of the airport was privatised. This will help to ensure that Perth Airport does not increase the risk of flooding downstream of the estate boundary due to any aeronautical or non-aeronautical developments being undertaken. This is consistent with the commitments described in the Perth Airport Master Plan 2014, and Perth Airport Master Plan 2020.

Most of the new infrastructure will be in the form of larger open channels and new stormwater storage areas. The storage areas will temporarily store water until the downstream network has capacity to drain the stored water. The channels and the detention areas will all have the capacity to handle a 1 per cent annual exceedance probability storm event based on 1997 external peak inflow rates, as well as the runoff from existing and planned developments on the estate as described in the Perth Airport Master Plan 2014, and Perth Airport Master Plan 2020.

The level of the base of the NMD and SMD at the upstream and downstream boundaries only allow for the drains to have relatively flat gradients within the estate. The original alignments of the NMD and SMD were created in the low areas of the estate, but the new alignments will require some construction to occur 'uphill' from the low areas resulting in depths to the bottom of the drains from the surface being greater within the estate than at the airport boundaries. Therefore, there will be sections of the drains that are deeper and wider than needed for conveying the stormwater, but advantage is taken of this by using the channels as in-line storage during larger storm events. Where possible, this will be achieved by controlling flows at culverts under road crossings so that water on the upstream side is higher than on the downstream side. In the absence of a road crossing at a suitable location, a weir will be built.

10.4.5 Water Quality

Perth Airport monitors water quality in the NMD and SMD at their upstream and downstream boundaries. The stormwater contains the expected pollutants from an urban and former farmland catchment. There is no specific surface water pollution issue in the NRP area that Perth Airport is currently required to manage apart from the standard stormwater industry issues dealt with as part of Water Sensitive Urban Design. Per- and poly-fluoroalkyl substances (PFAS) are discussed in in Section 9.

The concept for the design of the main drains on the estate is to construct the drains as open channels and vegetate them, to create Living Streams. The aim is to provide a healthy ecosystem for microbes to perform bioremediation and biotransformation of environmental pollutants such as hydrocarbons (e.g. oil), nutrients, and various metals.

10.4.6 Stormwater Assessment for the New Runway Project

Stormwater assessment for the airport estate has been undertaken as part of the Perth Airport Master Drainage Strategy 2017 update (MDS). Three of the scenarios assessed for the MDS are relevant for the NRP. They are:

- 'Existing' situation scenario (developments and surface levels) on the airport estate (as at February 2016),
- NRP scenario ('Existing' situation with NRP infrastructure constructed), and
- 'Ultimate' scenario (developments and surface levels based on future planned land uses for both aeronautical, with NRP infrastructure, and non-aeronautical).

Specialised computer software programs were used to create a model of each scenario. The output information includes flow rates, flow depths, areas of surface flooding, flood depths, water velocities and at some locations on the airport estate, the time of inundation has also been provided.

The modelling results of the first two scenarios were used to assess the impacts of the NRP, and the last scenario was used to check that the NRP design would not negatively impact on future concept plans for aeronautical and non-aeronautical developments across the estate.

10.4.7 Stormwater Computer Modelling

The process used for computer modelling of stormwater on the airport estate was to divide the estate into approximately 350 catchments and calculate the stormwater generated by the rain falling on those catchments. This was undertaken with a computer software program called XP-RAFTS. The information output from that computer program was used as input to another computer program called TUFLOW. This computer program then calculated flow rates, velocities and depths within open channels and pipes. The TUFLOW program divides the estate into a four-metre grid to determine where overland flow inundation may occur if flow exceeds the drainage network capacity.

Calculating the amount of rain falling on the catchments using specialised computer software programs is normally undertaken using industry standard rainfall patterns. The Master Drainage Strategy (MDS) models utilise a specifically created rainfall pattern that is based on, and consistent with industry standard patterns.

10.4.8 Standard Rainfall Patterns

The modelling process described in the 'Stormwater Computer Modelling' section is standard stormwater industry practice, however there are various specialised computer programs available to undertake stormwater modelling other than the ones used for the MDS. Computer programs that calculate rainfall runoff from catchments use hypothetical rainfall data. Hypothetical rainfall is a pattern of rain related to time, and mimics actual rainfall to a degree, by having the intensity increasing quickly and then trailing off slowly. Hypothetical rainfall patterns can be calculated for any location in Australia based on information in the ARR guidelines and are created using historical Bureau of Meteorology rainfall data.

Normally a range of rainfall patterns are used that differ in the length of time that the rain is falling. The computer programs run a series of standard industry rainfall durations ranging from five minutes up to 72 hours and the duration that produces the largest flow rate, or volume of water, is referred to as the design (or critical) storm. The design storm, when assessing maximum flow rates for determining pipe or open channel sizes for example, will normally be different than the design storm used when assessing the stormwater storage elements such as detention basins. This is because peak intensity of the rainfall is important for the former, while total volume generated by the storm is important for the latter.

10.4.9 Master Drainage Strategy Rainfall Pattern

The MDS uses a single rainfall pattern per recurrence period instead of a range of standard patterns. Preliminary modelling work on the MDS used several standard rainfall pattern durations (ranging from 15 minutes through to six hours). Results from these preliminary model runs indicated that the critical duration for flooding in the study area was associated with storms of around two to four hours duration, which is consistent with urban catchments, and that the volume of the broader rainfall weather system that this storm falls within is also important. This catchment behaviour can be attributed to the generally 'flat' grades within the study area in combination with hydraulic controls provided throughout the system (An example of a hydraulic control is a pipe under a road that can restrict flow and store water in the drain upstream of the pipe. The size of the pipe then controls the flow rate).

Based on the preliminary modelling results, the total rainfall volume was generally found to be a significant factor governing the extent and duration of flooding as well as the peak intensity of the rainfall pattern being used. The degree of flooding in the study area is therefore largely driven by the available flood storage as well as the capacity of the flow paths.

An analysis of historical rainfall records from the Bureau of Meteorology rain gauge at Perth Airport, in conjunction with a review of the preliminary model results, indicated that a rainfall burst duration of three or four hours was critical in terms of peak water levels in the detention storages on the airport estate. Since the total rainfall volume is of significance, an embedded design storm approach was taken, where a shorter duration standard rainfall pattern was embedded (added) into a longer standard rainfall pattern and used for the MDS modelling.

The final design storm considered appropriate for the assessment was created by embedding a standard three-hour rainfall pattern into a standard 12-hour rainfall pattern beginning at the four-hour point. This embedded rainfall pattern has been used for all recurrence events that have been modelled for the MDS. These are the one event per year and the 10, 2 and 1 per cent annual exceedance probability storms.

This embedded design storm combines the critical peak flow duration for the catchment with additional volume considerations relevant for the numerous flood detention storages throughout the airport estate.

10.4.10 Groundwater

Groundwater modelling was undertaken specifically for the new runway project to assess impacts caused by infrastructure changes. The modelling was undertaken using a specialised computer software program called Visual MODFLOW. The models set up were:

- NMD and SMD Model, and
- Pavement Model

The modelled area is 4.5 kilometres wide (approximately east-west) and 6.0 kilometres long (approximately north-south). The modelled area was aligned approximately with the prevailing groundwater flow direction which is generally north-west. The modelling extent was set to ensure that the model boundaries would be at distances outside the influence of groundwater changes that might occur due to the NRP. As part of the model set up, more detailed information was set up to focus on specific areas of interest such as the Northern Main Drain and Southern Main Drain.

10.5 Existing Condition

10.5.1 Wetlands

10.5.1.1 Regional context

The SCP lies within the South West Botanical Province of Western Australia, one of the 34 Global Biodiversity Hotspots (Conservation International 2007). It has previously been suggested that the origin and features of wetlands on the SCP are globally unique and distinct and are not represented elsewhere (Semeniuk and Semeniuk 2001).

Historically there has been significant loss of wetlands on the SCP. The wetlands are subject to a high level of anthropogenic activities, and this is a major contributor to the degradation and loss of these wetlands (Hill et al 1996b). Not only is degradation to wetlands influenced by human induced land use activities such as urban development and agriculture, wetlands are also impacted by climate change (DBCA 2017). Higher than average temperatures, a drying environment and reduced average winter rainfall and runoff are detrimentally impacting the wetlands of the south-west (EPA 2007). EPA (2004) have estimated that approximately 80 per cent of wetlands on the SCP have been lost, and of the remainder, only 15 per cent are of high ecological value (CCWs). Multiple use category wetlands make up approximately 72 per cent of wetlands on the SCP (DBCA 2019a).

Remaining wetlands within the Perth Airport estate have also been subject to disturbance over time and changes to hydrology which have impacted wetland values. Major drainage lines have been constructed, redirected and upgraded to manage surface water flows and shallow groundwater tables affecting development of the site; as well as to convey stormwater from large urban catchments upstream of the airport estate through to the Swan River.

Wetlands on the SCP vary in a number of characteristics including size, shape and hydrology as a result of their physical setting and development processes (DBCA 2017). Semeniuk (1988) proposed a system of grouping wetlands on the SCP with common features such as geomorphic setting and origin, labelling these similar wetlands 'consanguineous'. On the SCP there are 62 recognised consanguineous wetland suites.

The Perth Airport lies within the 'Mungala' consanguineous suite. DBCA (2017a) has reported that the Mungala suite covers approximately 26,000 hectares of wetlands. Of that, the wetlands within the Perth Airport cover approximately 1,143 hectares. The Mungala suite wetlands occur within the transition between the Bassendean Dunes and Pinjarra Plain landform units, above a complex of sands, clays, silcrete and laterite (Semeniuk and Semeniuk 2001). Wetlands lie along depressions at the distributary ends of the creeks or adjacent to intermittent disconnected drainage channels (Hill et al 1996). Within the Mungala consanguineous suite 12.6 per cent of wetlands are assigned to the CCW management category (DBCA 2017a).

10.5.1.2 New Runway Project Wetland Boundaries

The NRP boundary includes 257.5 hectares mapped as wetland in the current GWSCP dataset, 88 per cent of the total NRP area. Of this 68.1 hectares is mapped as a CCW and 49.4 hectares as REW, with the remainder mapped as Multiple use wetland (Figure 10-2).

As a result of the remapping process described in Section 10.4.1, undertaken for the purpose of assessing impacts of the NRP, 19 potential REW or CCWs were identified in and around the NRP, in addition to Munday Swamp. In total, the boundaries of these wetlands cover 191.5 hectares, of which 97.6 hectares is within the NRP (Figure 10-3). Table 10-2 provides a summary of each of these wetlands. Although wetlands 2, 8 and 14 do not intersect the NRP they have been included because they directly adjoin other wetland areas that do intersect the boundary.

Further information on the values and attributes of these wetlands is provided in the following sections.

Figure 10-2 Geomorphic Wetlands on Perth Airport estate
Source: ELA 2019

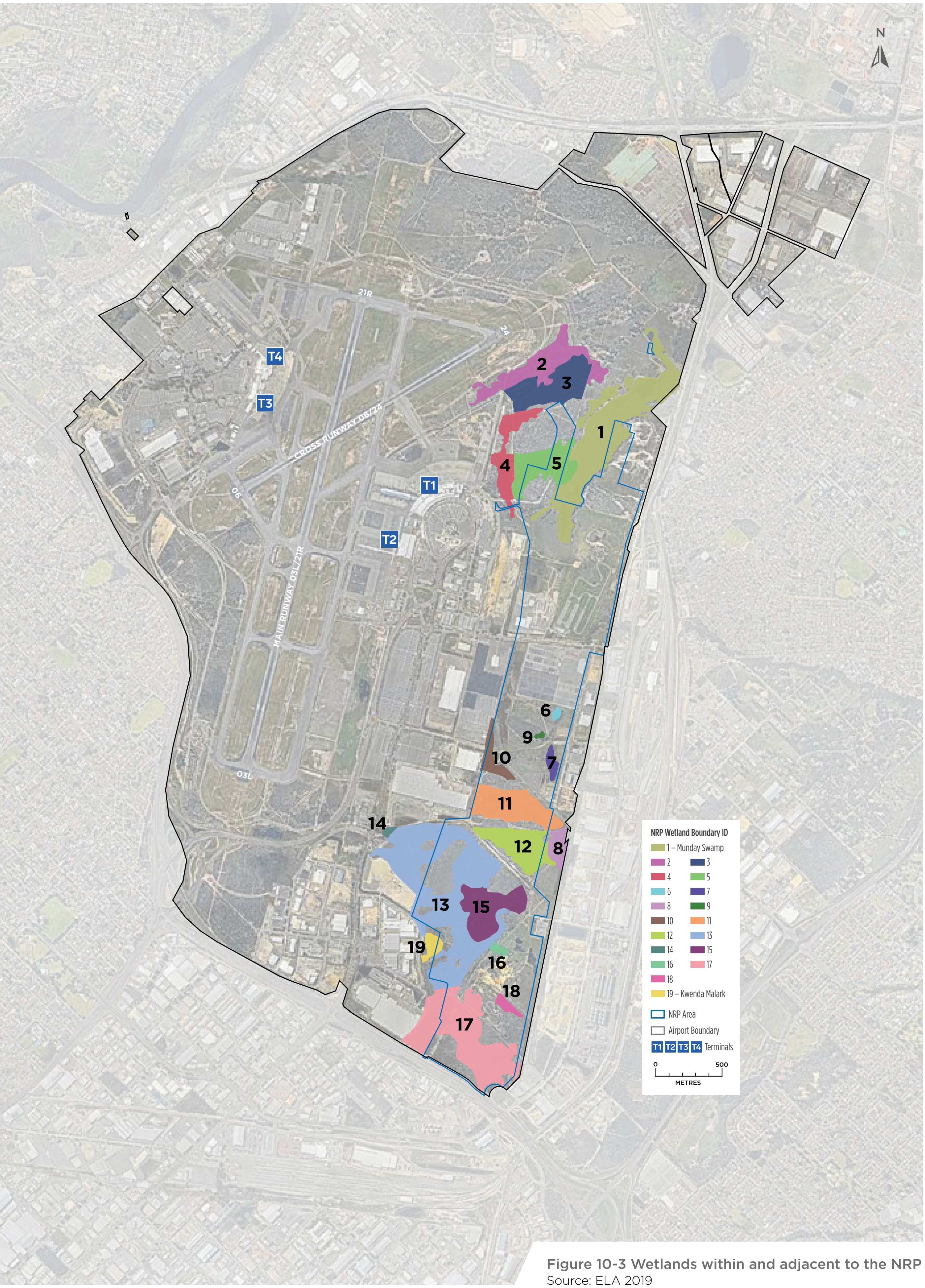


Figure 10-3 Wetlands within and adjacent to the NRP
Source: ELA 2019

ID	Type*	Total area (ha)	Historical status	Current status	Proposed category
1	Lake	33.1	Munday Swamp is described in Section 10.5.2		CCW
2	Dampland	12.9	Part of a system of more extensive inter-connected wetlands.		REW
3	Dampland	12.4	Part of a system of more extensive inter-connected wetlands.	Remaining vegetated portions with varying vegetation condition dissected at multiple locations by the Northern Main Drain.	CCW
4	Sumpland	7.7	Part of a system of more extensive inter-connected wetlands.		REW
5	Dampland	10.8	Part of a system of more extensive inter-connected wetlands.	Large portions have been cleared and hydrological connections with wetlands to the south have been disrupted by construction and upgrades of the NMD. This portion represents wetland vegetation remaining in largely Excellent condition directly adjoining Munday Swamp.	CCW
6, 7, 8	Sumpland	0.5; 1.4; 2.9	Located along a former long linear wetland/ natural drainage line running north-south.	Linear wetland/ drainage line has been dissected by infrastructure forming distinct degraded sumplands.	REW
9, 10	Dampland	0.3; 3.2	Previously comprised part of an extensive sumpland system linking to wetland 11.	Small remnants of dampland vegetation. Now surrounded by extensive cleared areas to the east and infrastructure to the west.	REW
11	Sumpland	12.0	Very eastern end of a previously extensive sumpland which had been identified as a highly ranked sumpland (No 73 in Hill et al 1996).	Now bounded by infrastructure to the west.	CCW
12	Sumpland	10.0	Part of the same geomorphological unit as Wetland 13.	Now hydrologically disconnected from Wetland 13 by the Southern Main Drain.	CCW
13	Sumpland	43.2	Extensive area previously mapped as distinct sumpland and dampland basins (No 80, 113, 126 in Hill et al 1996); recognised as regionally significant high value wetland areas in various studies and reports.	Sumpland and dampland vegetation units grade into one another without separation and as such have been remapped as one extensive wetland.	CCW
14	Sumpland	0.5	Part of the same geomorphological unit as Wetland 13.	A small area of lower quality vegetation separated by a road.	REW
15, 16	Dampland	10.8; 0.8	Part of the same geomorphological unit as Wetland 13.	Mapped as a separate wetland for evaluation due to the degraded nature of vegetation.	REW
17	Sumpland or Dampland	26.0	Recognised as a regionally significant high value wetland in various studies and reports (Hill et al 1996).	Geomorphic unit still largely intact.	CCW
18	Dampland	1.2	Previously a more extensive dampland.	Small remnant of dampland vegetation surrounded by clearing and other disturbance.	REW
19	Artificial Lake	1.8	Former sand quarry.	Kwenda Marlark Wetland – an artificial wetland created to receive stormwater runoff, rehabilitated over the past 10 years including an annual planting program.	REW

Table 10-2 Wetlands intersecting the NRP
Source: ELA 2019

10.5.1.3 Geomorphology and wetland processes

Geomorphology of the NRP wetlands have been significantly altered through filling of whole wetlands and parts thereof, and the introduction and rerouting of major open drainage structures, such as the Northern Main Drain and Southern Main Drain.

Wetland hydrological processes have been inferred through vegetation mapping combined with an estate-wide groundwater and surface water models. A study in 2015 investigated the presence/absence of claypans/layers which may underlay the surficial sands in the various wetland areas around the Airport estate. A number of sites within the NRP were assessed which did not provide any indication of confining layers within 1.5 m of the surface. It is therefore assumed that wetlands within the NRP are a reflection of the regional superficial groundwater table rather than perched systems.

Analysis of long-term monitoring well data shows a steep decline in groundwater levels across the Belmont area in the late 1950's and 1960's due to the installation of drains, followed by generally steady groundwater levels between the 1960's and today. The drains (such as the Northern and Southern Main Drains) generally constrain the maximum groundwater level. The groundwater regime of wetlands within the NRP have therefore likely experienced significant historical drying from the 1950's and is now controlled by the inverts of and proximity to the Northern and Southern Main Drains (as well as a number of other minor drains).

All wetlands were assessed as occurring within basin landforms and vegetation unit mapping has been used to ascribe a type to the wetlands (seasonally inundated sumpland or seasonally waterlogged dampland), apart from wetland 19 which is a constructed wetland and wetland 1, Munday Swamp (described further in Section 10.5.2).

Whilst much of wetland 13 has previously been mapped as dampland, close inspection of topography, vegetation mapping and aerial imagery suggests that these areas are a continuation of basin formations hosting sumpland vegetation to the north and as such have been mapped as part of this sumpland.

10.5.1.4 Wetland vegetation and habitat

The wetlands within the NRP form part of a mosaic of wetland and bushland areas covering the eastern and south eastern side of the airport estate. At a regional scale, Perth Airport remnants have previously been included in mapping of draft regional ecological linkages (Del Marco et al 2004). At a local scale, the NRP is fragmented by cleared areas, tracks and constructed drains.

Vegetation within the NRP wetlands varies from Degraded to Excellent, with the majority of vegetation in Very Good or Excellent condition (70 per cent). This suggests that current hydrological regimes, albeit modified are largely sufficient to support the floristic diversity of the wetlands. It is possible that vegetation assemblages have altered over time to reflect a drier hydrological regime and some previous wetland areas may still be transitioning to reflect more terrestrial ecosystems. Though much of the NRP was used as farmland until the Commonwealth purchased it in the 1980's, it appears from current vegetation condition mapping that wetland vegetation in the south of the NRP either remained relatively intact (likely due to restricted seasonal access) or has recovered well due to the inherently robust nature of wetland systems.

The vegetation of the NRP wetlands is representative of the Southern River complex (Webb et al. 2016), of which only 14 per cent remains in the Perth Metropolitan Region (DBCA 2019b). Within this region, only 0.75 per cent of this complex is within lands secure for conservation (DBCA 2019b). Wetland 11 supports an occurrence of a State listed threatened ecological community: Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (Vulnerable). No other threatened or priority ecological communities have been mapped within the NRP wetlands.

Two Commonwealth and State listed flora species are known to occur within the NRP wetlands; *Conospermum undulatum* (Vulnerable) and *Macarthuria keigheryi* (Endangered). Ten State Priority species were recorded in the NRP wetlands. Table 10-3 outlines the wetland/s each of the significant flora species was recorded in. No significant flora were recorded in wetlands 2, 6, 7, 8, 9, 14 or 16.

Flora species	Conservation status	Wetland number
Conospermum undulatum	T	11, 12, 17
Macarthuria keigheryi	T	12, 13, 17
Johnsonia pubescens subsp. *cygnorum*	P2	17
Byblis gigantea	P3	17
Jacksonia gracillima	P3	3, 5, 11, 13, 19
Platysace ramosissima	P3	12
Myriophyllum echinatum	P3	5
Schoenus benthamii	P3	11, 17, 19
Schoenus pennisetis	P3	3, 5, 11
Ornduffia submersa	P4	11, 12, 13
Stylidium longitubum	P4	4, 13
Verticordia lindleyi subsp. *lindleyi*	P4	3, 5, 10, 11, 12, 13, 15, 17, 18

Table 10-3 Significant flora species recorded within NRP wetlands
Source: ELA 2019

The NRP wetlands also provide habitat for a number of fauna species. Damp heaths provide dense cover for birds, including a suite of birds that are otherwise in decline in the Perth region. The Splendid Fairy-wren and White-browed Scrubwren are considered to survive poorly in the Perth area by Davis et al. (2012) but remain common at the Airport Estate (Bamford Consulting Ecologist, 2019). Damp heaths also provide cover for the State listed Priority species Quenda (Isoodon fuscivente*r*) and the persistence of these species may depend upon this sort of shelter. The seasonally damp soils are also the most likely habitat within the NRP to support short range endemic invertebrates. Invertebrate assemblages in general are poorly documented and as such undescribed species could occur (Bamford Consulting Ecologist, 2019).

Inundated areas support seasonal breeding by frogs. A rich frog assemblage has been noted at the airport, including some species that are usually absent or very uncommon on the SCP. The Hooting Frog and Lea's Froglet are unusual records for the Swan Coastal Plain in the Perth area. Munday Swamp has also been shown to support a distinct assemblage of aquatic invertebrates, with one south-west endemic species (freshwater isopod *Paramphisopus palustris*) recorded in 2017 and others previously recorded. The Kwenda Malark wetland was also found to have a generally similar functional composition to natural wetlands (WRM 2017).

Long-necked tortoises are also abundant in wetlands around the airport estate including Munday Swamp. Munday Swamp supports a high fauna diversity and provides connection to downstream drains via a drainage network which ultimately connects to the Swan River, facilitating a fauna corridor. Drains provide a network along which fauna such as long-necked tortoises, aquatic invertebrates and fauna associated with riparian vegetation can move through the landscape. Mosquitofish have been noted as very abundant in these drains and may be having an effect on aquatic fauna (Bamford Consulting Ecologist, 2019).

The species Rakali is present in the area but probably restricted to permanent wetlands along Abernethy Road (e.g. Ollie Worrell Reserve), with seasonal dispersal into Munday Swamp and along the northern main drain (Bamford et al. 2017). Drains may provide connectivity for Rakali between the Abernethy Road wetlands and the Swan River.

Seasonally inundated areas within wetlands 4, 8, 11, 12, 13, 14, and 17 support *Banksia littoralis*, a key food source for the Commonwealth-listed species, Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), which forages throughout the estate. The Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*, Commonwealth listed), also present in the NRP, may also use occasional Marri trees within the NRP wetland areas as a food source.

The fauna of Perth Airport in general is typical of the eastern Swan Coastal Plain, however due to extensive clearing in the area surrounding the airport there are few, if any examples of comparable faunal assemblage nearby (Bamford Consulting Ecologist, 2019). Refer to section 12 for further detail on the fauna values of the NRP area.

10.5.1.5 Wetland cultural, scientific and educational values

The land on which Perth Airport is situated forms part of the traditional network of communication routes, meeting places and camping sites of the Noongar people. To date, a number of archaeological and ethnographic sites have been identified on the airport estate. Munday Swamp is considered one of the more important wetlands on the SCP, in part for its cultural heritage values (as detailed in the listing advice for the Directory of Important Wetlands). The registered ethnographic site (3719) is classified as a ceremonial, mythological, hunting and camp ground and noted for its plant resource values. The Site is also listed as an artefact scatter, indicating that archaeological material has been recorded. More information is presented in Section 16.5.2. Perth Airport has committed to maintain continued access to Traditional Custodians to Munday Swamp for traditional activities including hunting for turtles.

A number of 'Other Heritage Places', some of which may overlap with wetland areas, are detailed in section 16.5.2.

Scientific and educational value of the NRP is limited as it is located within airport land where access is restricted. The constructed Kwenda Malark wetland is accessible to the public and is used for community conservation education purposes including an annual Night Stalk and school tree planting program.

10.5.1.6 NRP wetland evaluation

According to DBCA mapping, all 19 wetlands in and around the NRP meet at least one preliminary criteria under the DBCA Methodology for the evaluation of wetlands on the Swan Coastal Plain, Western Australia, which automatically assigns them to the CCW category, being inclusion on the Directory of Important Wetlands in Australia.

Wetlands 1, 3, 5, 11, 12, 13 and 17 are dominated by vegetation in good or better condition and have been identified as regionally significant vegetation in Bush Forever (site 386). Of these, wetlands 11, 12, 13 and 17 also support confirmed occurrences of a listed Threatened flora species (either *Conospermum undulatum* or *Macarthuria keigherii*) and wetland 11 supports an occurrence of a State listed threatened ecological community: Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (Vulnerable).

Secondary evaluation was considered appropriate for the smaller or degraded wetland areas 2, 4, 6-10, 14-16, 18 and 19, to confirm whether these areas are commensurate with CCW status. As the result of this process, it was considered that these wetlands are more consistent with REW management category, meaning these are wetlands which may have been partially modified but still support substantial ecological attributes and functions. Figure 10-4 shows the remapped wetland boundaries and proposed evaluation.

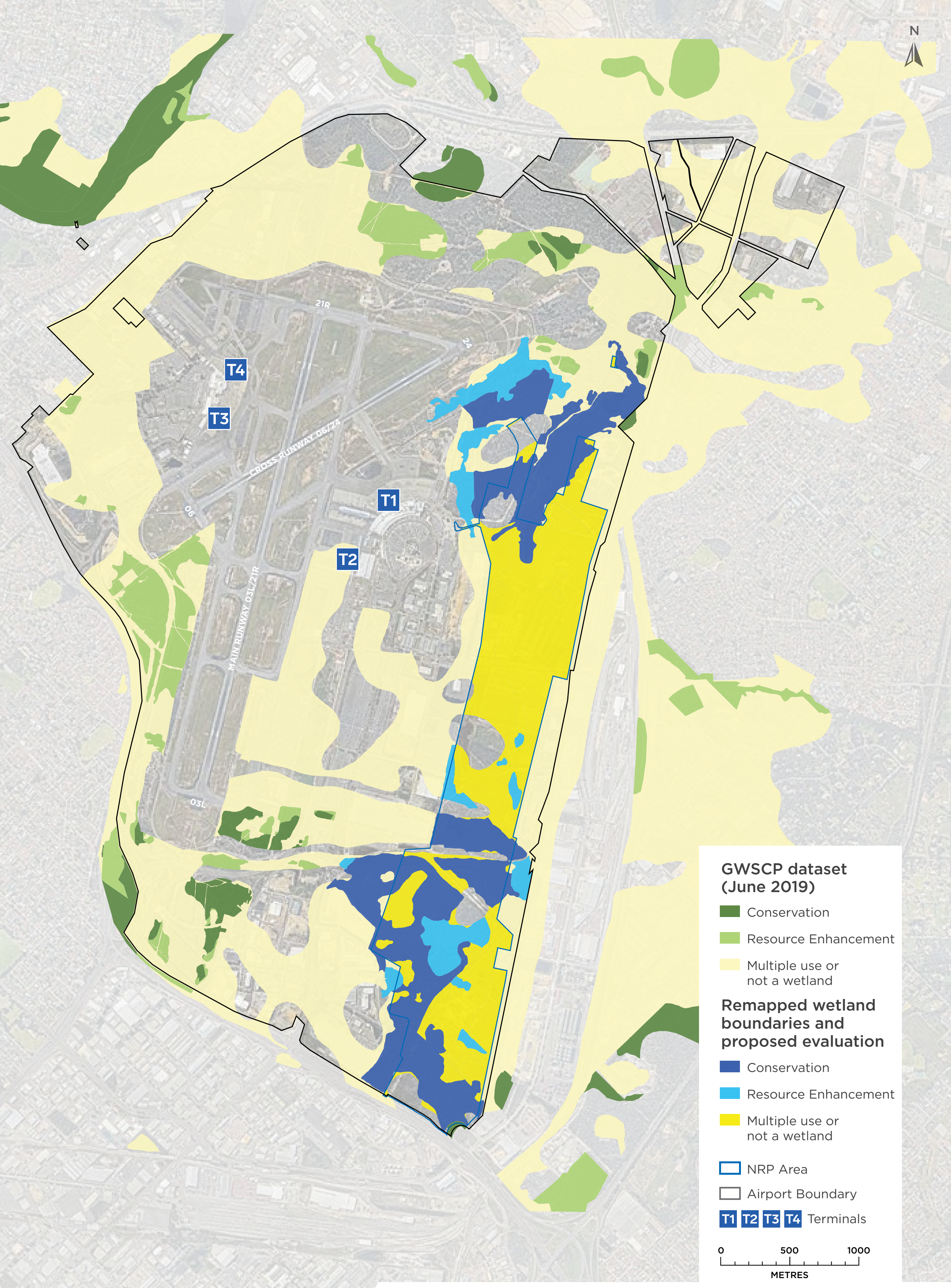


Figure 10-4 Remapped Wetlands within and adjacent to the NRP
Source: ELA 2019

10.5.2 Munday Swamp

Due to its recognition as a significant wetland and Perth Airport's commitment to its conservation and management, specific work has been undertaken to understand the attributes of and hydrological processes supporting Munday Swamp.

Munday Swamp is a freshwater wetland with surface and groundwater inflows. It falls within a larger area that is mapped as a lake (permanently inundated basin) by the DBCA. The swamp and its current inflows are shown in Figure 10-7.

The surface water within the swamp is predominantly an expression of the groundwater that generally flows from east to west across the swamp area. With the current cycle of decreasing rainfall, most of the swamp now dries out over summer with areas of permanent water shrinking to deeper pools in the central area and exposed areas of mud.

Aerial photographic records show a drying trend over the past 20 years. This may be related to the declining rainfall experienced in the south-west of Western Australia attributable to the climate shift which has occurred since 1974.

Based on a 1953 aerial photograph, the swamp has historically had direct inflows from the east as indicated in Figure 10-9. The photograph indicates that both a natural creek flow and an excavated channel existed, and both were draining into the open water area in the north-east part of the swamp. It is assumed that the catchment for the excavated channel is now similar to the catchment for the Water Corporation's High Wycombe branch drain: and similarly, the natural creek catchment is now the catchment of the Water Corporation's Macao Road branch drain.

Munday Swamp also receives inflow from the NMD catchment when there is rainfall slightly larger than a one event per year storm. This inflow discharges into the west side of the swamp to the open water area at the southern end. Aerial photographs show that the location of the flow path between the swamp and the NMD has remained largely unaltered over the years. This is based on comparing aerial photographs and ground-level data which show this flow path is effectively the same as it was when the airport was established in 1944, despite some localised surface changes over the years and the formalisation of the NMD channel.

Between 1968 and 1970, the Metropolitan Water Supply, Sewerage and Drainage Board (now Water Corporation) proclaimed the High Wycombe and the Macao Road branch drains as declared main drains and assumed control of their management. The flows now join prior to draining under the Midland to Kwinana freight railway line and then flow into the estate and down to Munday Swamp. Part of the natural creek can still be seen on the estate, and it is used as a high-flow overflow path for the Macao Road branch drain. The old excavated drain that entered the swamp is close to where the combined flows do so today. These branch drain alignments and the overflow path are shown in Figure 10-7.

Based on historical aerial photographs, the swamp outlet appears to have been formalised in the form of an excavated channel within the swamp leading up to the outlet location from the south-east as well as the installation of culverts during the construction of a gravel track.

10.5.3 Stormwater Infrastructure

Perth Airport is located on the Swan Coastal Plain and sits within two of the 30 major stormwater catchments of the Swan and Canning rivers system. The NMD and the SMD are two open-channel main drains that traverse through the estate, draining two of those 30 catchments. The NMD catchment (2,367 hectares) and the SMD catchment (2,633 hectares) both extend from the top of the Darling Scarp down to the Swan River. The airport estate sits as close as 450 metres from the river and makes up 43 per cent of the total NMD catchment and 39 per cent of the total SMD catchment. The stormwater catchments are shown in Figure 10-6, with Figure 10-7 providing details of the existing drains in relation to the NRP.

Upstream of the estate, the NMD catchment consists primarily of residential areas, while the SMD catchment is primarily residential but with an industrial area just outside the estate to the east. Downstream of the estate, the areas for both catchments are a mix of residential, commercial and light industry. The estate consists of aviation land uses plus commercial and light industrial.

Both the Perth Airport Master Plan 2014 and Perth Airport Master Plan 2020 state that a Living Stream is planned for the SMD, to provide water-quality and water-storage improvements on the estate. This will also be the concept for the NMD. The NMD and SMD open channels will mimic the characteristics of natural streams with suitable tree canopy, understorey and in-stream vegetation. Local provenance vegetation is planned to be used where suitable. Water quality improvement is achieved by aquatic vegetation and natural biological processes helping to oxygenate the water and removing nutrients plus non-nutrient contaminants. The development of Living Streams within the estate supports the natural surface-water management and control of peak flows, as well as improving water-quality prior to discharge of the stormwater off the estate. They also improve the general amenity of the area. Figure 10-5 is an example of what the existing sections of the SMD that have been constructed as a Living Stream to date will look like at maturity. The NMD will be constructed to the same design or similar.

Figure 10-5 Southern Main Drain living stream design cross sections
Source: Syrinx Environmental (2014)

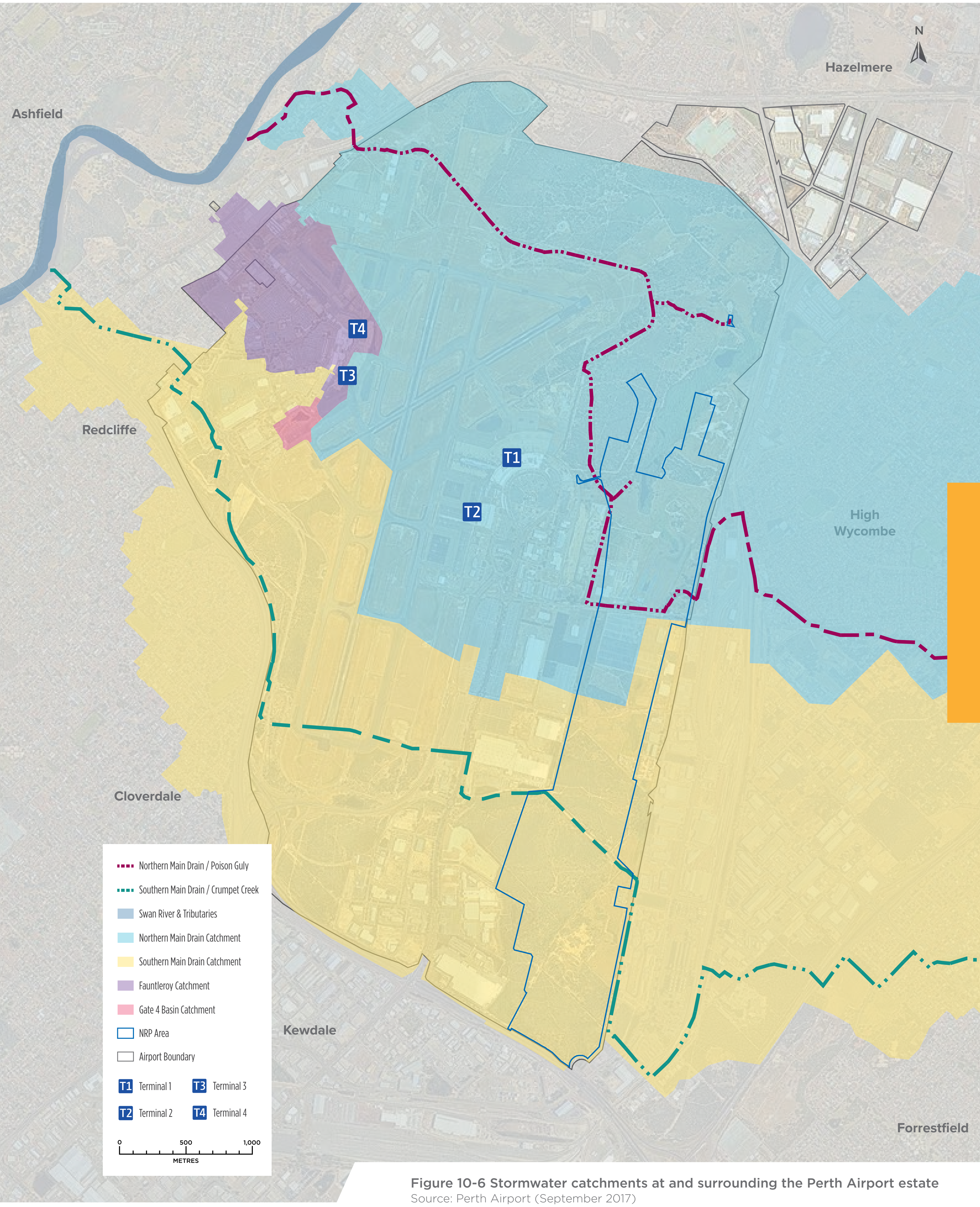


Figure 10-6 Stormwater catchments at and surrounding the Perth Airport estate
Source: Perth Airport (September 2017)

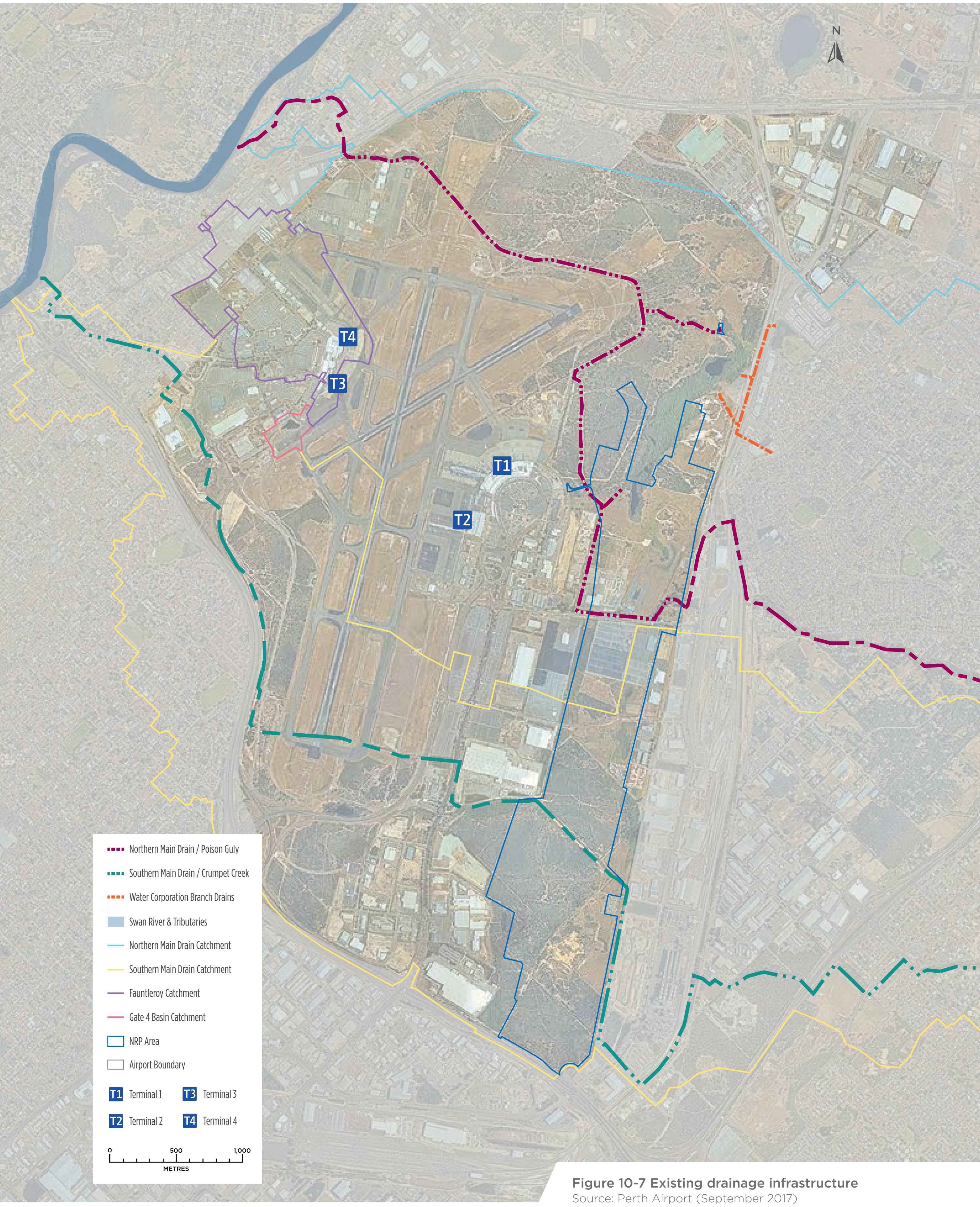


Figure 10-7 Existing drainage infrastructure

Source: Perth Airport (September 2017)

10.5.4 Stormwater Management

The Water Corporation is responsible for managing Perth's main arterial stormwater drainage network, and local governments manage the local networks within their jurisdiction. Prior to Perth Airport Pty Ltd taking over management of the airport in 1997, the Water Corporation administered parts of the NMD and SMD within the estate. Perth Airport now manages these drains within the estate, along with all other stormwater infrastructure.

Perth Airport liaises with the Water Corporation and surrounding local governments about long-term planning and proposed changes to the NMD and SMD.

10.5.5 Northern Main Drain

The NMD is required to be realigned for the NRP. The NMD drains one of the 30 major stormwater catchments of the Swan Canning rivers system and has a catchment upstream of the estate of 1,326 hectares. Stormwater modelling has shown that the NMD will receive a peak inflow of 8.2 cubic metres per second for the 1 per cent annual exceedance probability.

The NMD is currently an open channel through the estate with several non-public road crossings over it. Within the estate, it drains most of the Airfield Precinct, the northern half of Airport Central and all of Airport North. Much of the existing alignment on the estate was created by excavating between natural low-lying areas. The excavation work was undertaken in two stages with the initial work undertaken in 1945 and the latter stage in 2003.

Figure 10-8 shows a 1944 aerial image taken prior to any NMD work being undertaken compared to a circa 1946 aerial image taken after the initial NMD works were completed.

The second stage of NMD was undertaken in 2003 as part of works to realign the drain along Grogan Road. From Grogan Road, the alignment to the north was modified through the low-lying areas to connect to the first stage.

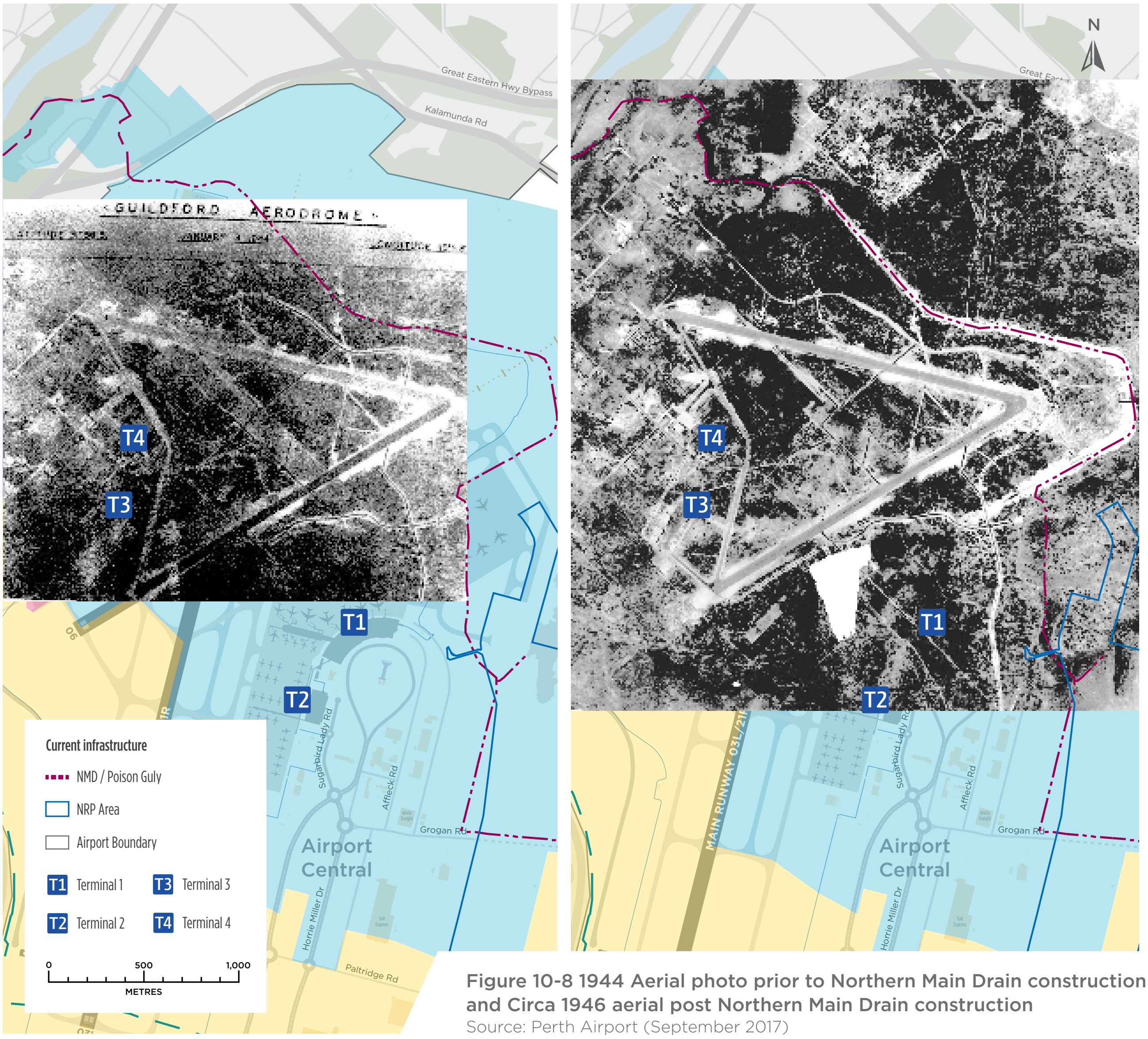


Figure 10-8 1944 Aerial photo prior to Northern Main Drain construction and Circa 1946 aerial post Northern Main Drain construction
Source: Perth Airport (September 2017)

10.5.6 Southern Main Drain

The SMD is also required to be realigned as part of the NRP. The SMD drains one of the 30 major stormwater catchments of the Swan Canning rivers system and has a catchment upstream of the estate of 1,531 hectares. Stormwater modelling has shown that the SMD will receive a peak inflow of 10.9 cubic metres per second for the 1 per cent annual exceedance probability.

A 1974 historical aerial photograph shows that at the south end of the new runway, Crumpet Creek (the name of the SMD upstream of the estate) flowed into low-lying areas of what was then farmland to the south east of the existing main runway (03/21); this is shown in Figure 10-10. Following an expansion of the airport by the Commonwealth that began in 1979 to secure land for the new runway, those areas are now part of the airport estate.

To alleviate flooding within the estate and provide a drainage outlet for the Shire of Kalamunda (now City of Kalamunda), the Shire of Belmont (now City of Belmont), the Commonwealth, and the then Metropolitan Water Supply, Sewerage and Drainage Board (now Water Corporation) agreed to construct the SMD through the estate. Construction commenced in 1966 and was completed in 1971. As the need has arisen, sections have been piped to accommodate runway and taxiway extensions as well as new roads.

10.5.7 Existing Groundwater Levels

The 'NMD and SMD Model' was used to determine the groundwater levels across the modelled area with the Northern Main Drain and Southern Main Drain on their existing alignments. Two scenarios were modelled:

- Existing Seasonal High Groundwater Level, and
- Existing Seasonal Low Groundwater Level.

The scenarios above provided a baseline for assessing the impacts of changes to the NMD and SMD as well as the runway and taxiway pavements.

In some locations along the existing alignments of the NMD and SMD the inverts are below the groundwater level, depending on the time of year. The inverts are generally close to the groundwater level, therefore as the seasons change the drains will provide recharge to the groundwater, and at other times drain the groundwater.

Figure 10-9 Circa 1953 aerial with Munday Swamp inflows
Source: Perth Airport

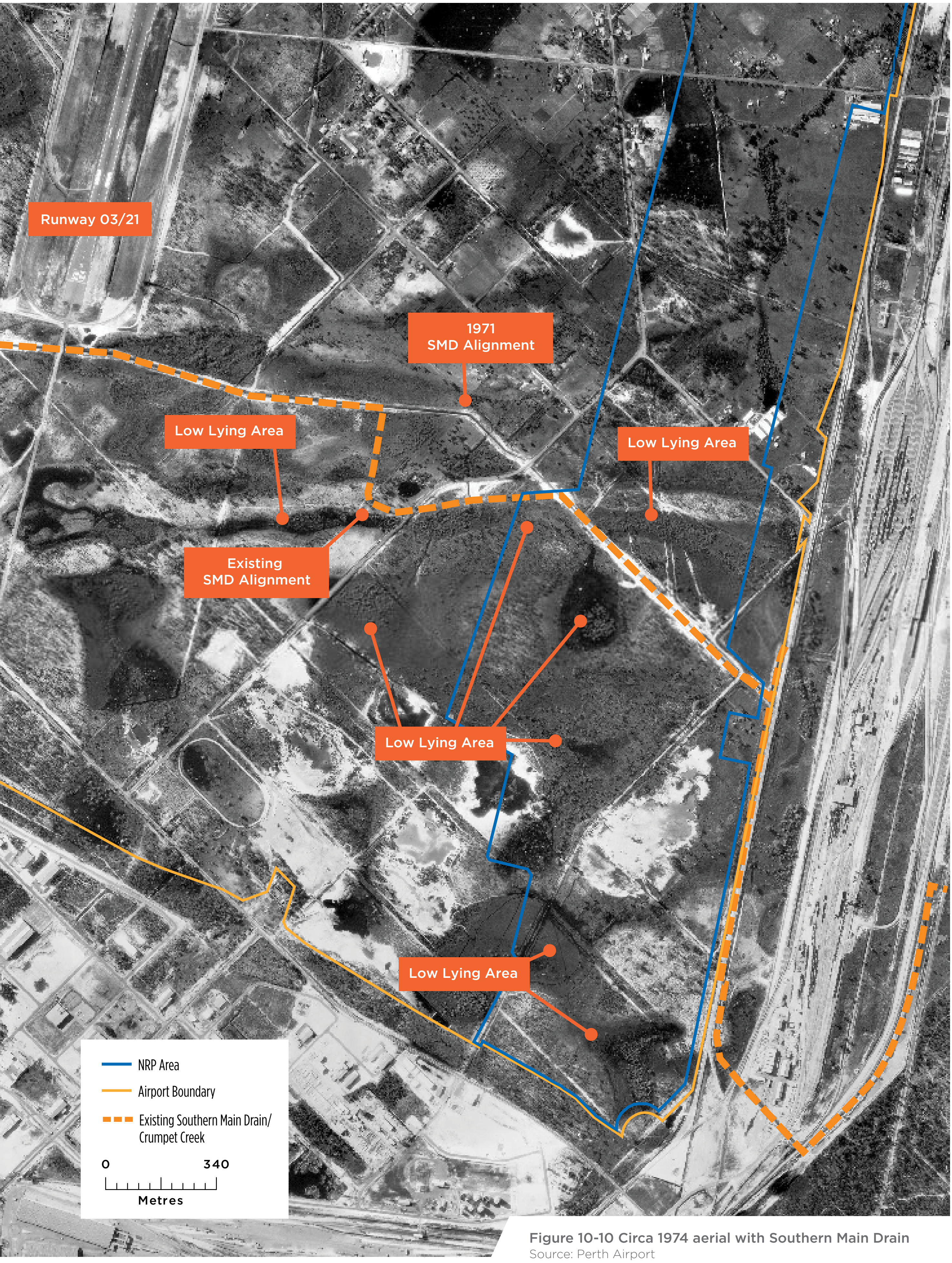


Figure 10-10 Circa 1974 aerial with Southern Main Drain
Source: Perth Airport

10.6 Concept Design

A concept design for stormwater infrastructure has been completed as part of the Master Drainage Strategy 2017 update and includes the NRP's concept design work. Detailed design will be completed prior to construction.

10.6.1 Airside Considerations

There are several issues identified with having large open drains within the airside area:

- **Wildlife** - Groundwater discharge in the main drain catchments means that flows occur for approximately 10 or 11 months of the year. This creates an environment favourable to birds and other wildlife, which may increase the risk of damage to aircraft and subsequent harm to human life through a bird strike event,
- **Security** - To ensure a secure airfield environment, security needs to be considered where the drains cross the airside boundary. This is normally in the form of metal screens. Screens collect debris from relatively small flows and need to be cleaned regularly to maintain the flow capacity,
- **Maintenance** - The flows provide nutrients for weed growth and can carry silt and debris, which require maintenance to have them removed. Having contractor personnel and vehicles airside requires operational as well as security processes, and can increase the operational occupational health and safety risks associated with people who do not regularly work in an aviation environment, and
- **Aircraft Operations** - Based on the limited opportunities for a NMD alignment airside, the drain would need to be located between the two taxiways near the south end of Munday Swamp. Due to space limitations in the area, maintenance is likely to require closure of a taxiway which may disrupt aircraft operations.

Given these constraints, the concept design has located the main drains outside the airside area. The NMD will be realigned to drain stormwater around the NRP area and the SMD will be piped under the airside area on a new alignment. They will both require stormwater storages as part of the works which are also located outside of the airside area.

10.6.2 Airside Drains

The stormwater system for the new runway and taxiway network will require pipes under the taxiways to connect to local drains in the open (grassed) areas within the airside area.

Approximately half of the NRP area drains north with the majority of that flowing to the west of Munday Swamp into the existing NMD. The balance of the northern half of the NRP area will flow into the new NMD alignment. The southern half of the NRP area will all drain to the new SMD alignment.

10.6.3 Northern Main Drain

10.6.3.1 Open Channel

The proposed NMD realignment (shown in Figure 10-11) will consist of the drain being diverted north along the eastern airside boundary into an infiltration storage as shown in Figure 10-12. This segment will be a combination of pipes and open channel. The existing inflow point will be retained. Creating a new inflow point would require the Dampier-Bunbury Natural Gas Pipeline to be lowered, which is an expensive option and not required for stormwater purposes.

The storage will be sized to contain the one event per year storm, with any larger flow volumes draining into Munday Swamp. Advice from the Traditional Custodians has indicated that Poison Gully historically drained directly into Munday Swamp. The new alignment will restore water flow, with the design incorporating ecological protection of the swamp for these flows.

10.6.3.2 Infiltration Storage

Protection of Munday Swamp from pollutants has been a key component of the design process. The design includes infiltration storage and pollution-removal elements, which will be constructed upstream of Munday Swamp. This proactive management measure is to provide ecological protection for the swamp as part of the NMD realignment works. A preliminary concept layout is shown in Figure 10-12 where Zone 1 is a gross pollutant basin, Zone 2 is a contaminant basin and Zone 3 is an infiltration storage basin. The size of the basin areas will be confirmed during the detailed design phase.

Stormwater from the NMD will drain into a gross pollutant-removal area (Zone 1) which will reduce the velocity of the water and capture pollutants such as litter and leaves, as well as larger sediments including gravel and sand. After this stage, the water will drain into a contaminant basin (Zone 2) that will capture weed seeds and propagules (the part of a plant that can give rise to a new plant, such as buds, suckers or spores) and smaller sediments (silts). The smaller sediments can have particulate metals and nutrients attached to them, therefore some of those pollutant types will be captured in this area. The water then drains into the infiltration storage basin (Zone 3) where any insoluble pollutants that have not been captured yet will be retained. The storage will be constructed in Bassendean Sand which has good infiltration properties. The basin will be planted out with suitable vegetation considering the wetting periods, airport wildlife management, and an ability to capture soluble pollutants such as nitrogen and phosphorus.

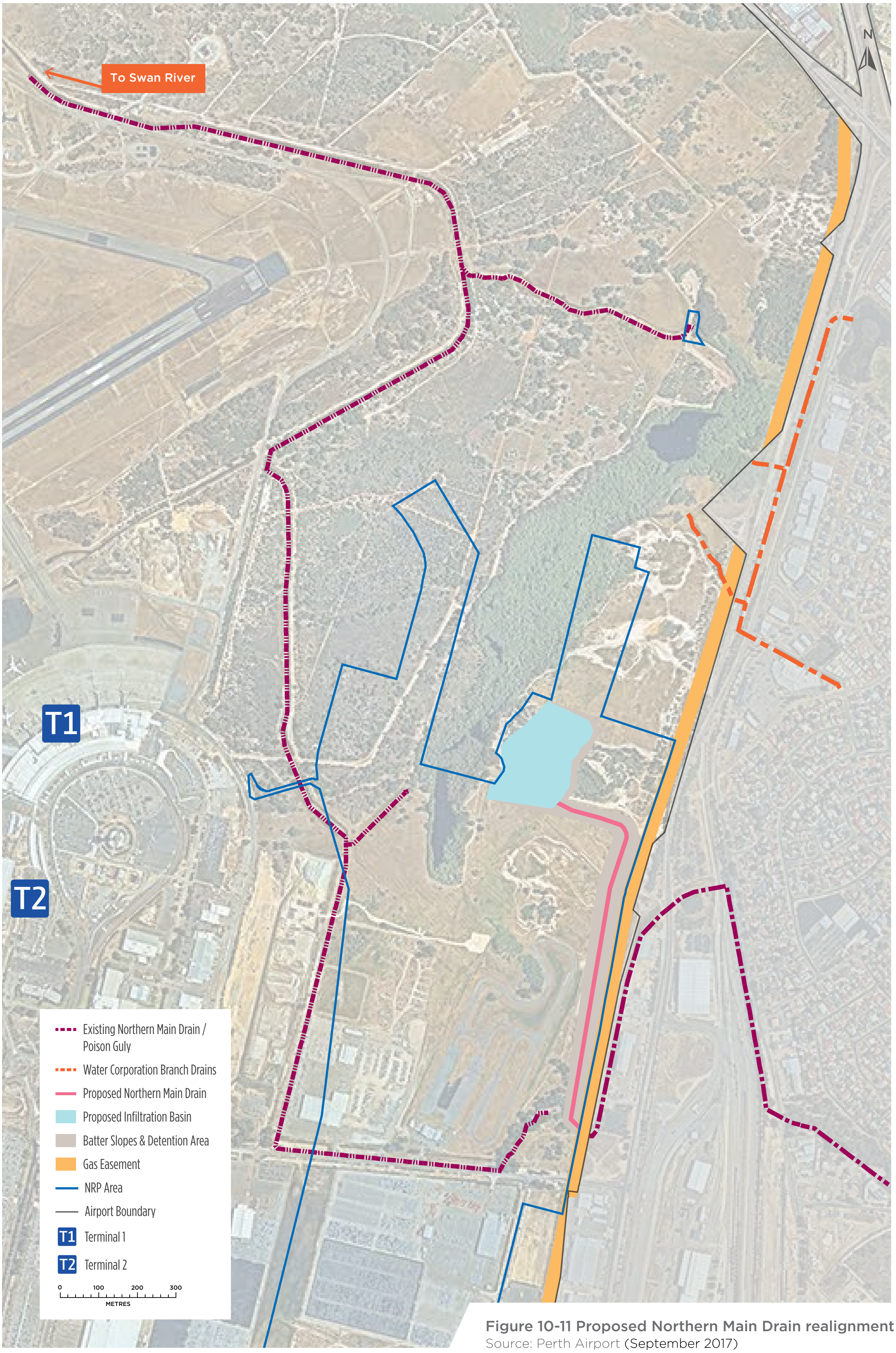


Figure 10-11 Proposed Northern Main Drain realignment
Source: Perth Airport (September 2017)

The two upstream pollution removal areas will undergo detailed design based on standard industry water sensitive urban design guidelines. The infiltration storage basin will be designed to detain and infiltrate all flows up to approximately the one exceedance per year storm event draining into it. Any flow volumes that are not detained in the basin will overflow to the west across the existing surface and drain into Munday Swamp. That existing surface will be bioengineered with vegetation and hard landscape elements, such as hardwood logs to provide erosion control which will protect the sandy surface as well as reduce the velocity of the water. The energy reduction will slow down the flow velocity of the water and help to protect the swamp bank that it drains over.

For the concept design, the development of the stormwater model used for this project included the basin having an infiltration capacity set to 5.0 metres per day (Five cubic metres (volume) per day infiltrating into each square metre of area).

The rate of 5.0 metres per day was used for the Bassendean Sand soil which generally comprises the top one to two metres below the surface where the basin is proposed to be located.

Further work will be undertaken during the detailed design phase to determine accurate infiltration rates based on assessment of the soil at the location. This will provide information to determine the actual area required for the infiltration storage basin.

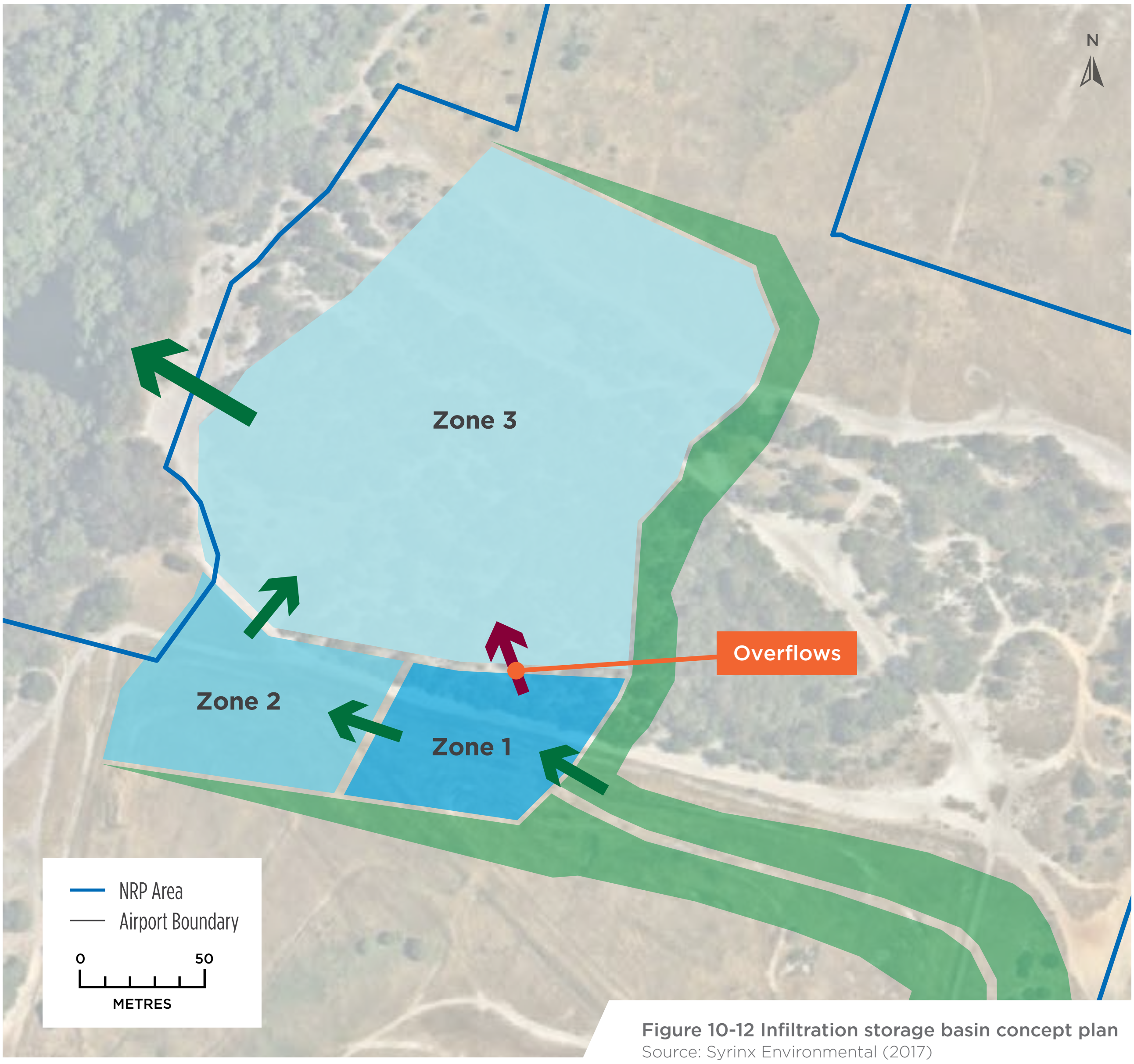


Figure 10-12 Infiltration storage basin concept plan
Source: Syrinx Environmental (2017)

Determining the criteria for design of the infiltration storage basin size was based on trying to replicate the existing seasonal pattern of water depth and inundation times; which are quantities important to preserving the conditions for the existing flora and fauna within Munday Swamp. Figure 10-13 is a flood map of the one event per year storm for the existing situation model from the MDS 2017 update, showing that stormwater from the NMD does not reach the swamp. Figure 10-14 is a flood map from the same model for the ten per cent annual exceedance probability event showing that stormwater does flow into the swamp. Interrogating the top water levels and the natural surface levels more closely indicates that the storm event that would generate flows that would begin overflowing into the swamp, is just above the one exceedance per year. Based on this, the one event per year storm was set as the design criteria for the basin size for detaining the volume of stormwater draining into the basin from the NMD.

This coincides with the State Department of Water and Environmental Regulation approach to managing stormwater. The Department recommends that the first 15 millimetres of runoff generated from constructed impervious surfaces should be retained at-source as much as practical to provide ecological protection downstream of the runoff source. A storm of 15 millimetres rainfall will generally cleanse impervious surfaces of substances such as oils, dust, soluble materials and transport them into a downstream stormwater network if they are not collected at-source.

Sixteen millimetres of rainfall in Perth is close to a one event per year design storm for a duration of one hour in the Perth area.

A trial and error exercise was undertaken with the NRP infrastructure stormwater model to determine if the storage area would fit into the land constrained by the NRP to the south, Munday Swamp to the west, the high-pressure gas pipeline easement to the east and Aboriginal Heritage Registered Site 3888 to the north. While the site chosen is within Aboriginal Heritage Registered Site 3719 most of the land nominated for the infiltration area has previously been disturbed by revegetation work. The modelling indicated that a basin size of three to four hectares in area is required. The land available is approximately 9.3 hectares, therefore any error in underestimating the size during the concept design is likely to be able to be accommodated in the detailed design. This applies to the gross pollutant and contaminant basins as well.

An emergency access road will need to traverse the area on a north-south alignment. The least impact will be a crossing over the NMD at the inlet to the treatment train infrastructure. If the emergency access road needs to impact any of the sediment, contamination or infiltration basins, then they can be designed to suit the requirements of the road.

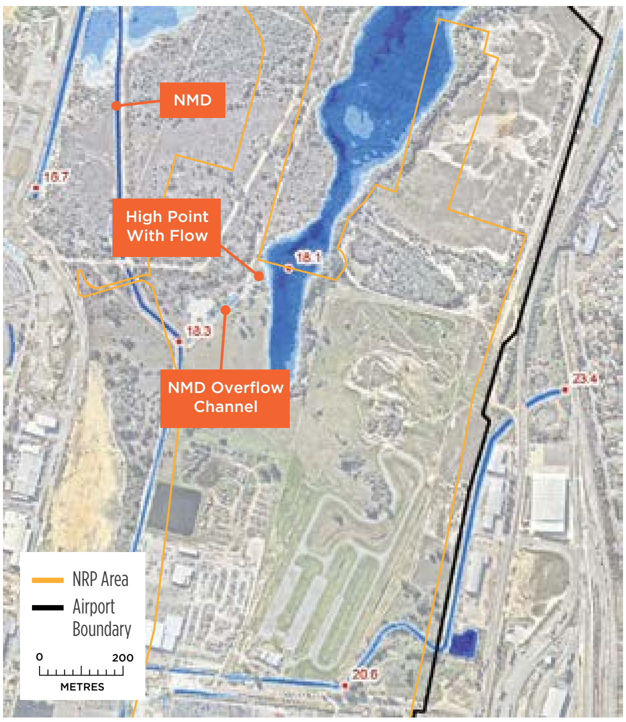


Figure 10-13 Existing flood map of northern portion of New Runway Project area, one event per year
Source: Perth Airport Master Drainage Strategy (2017)

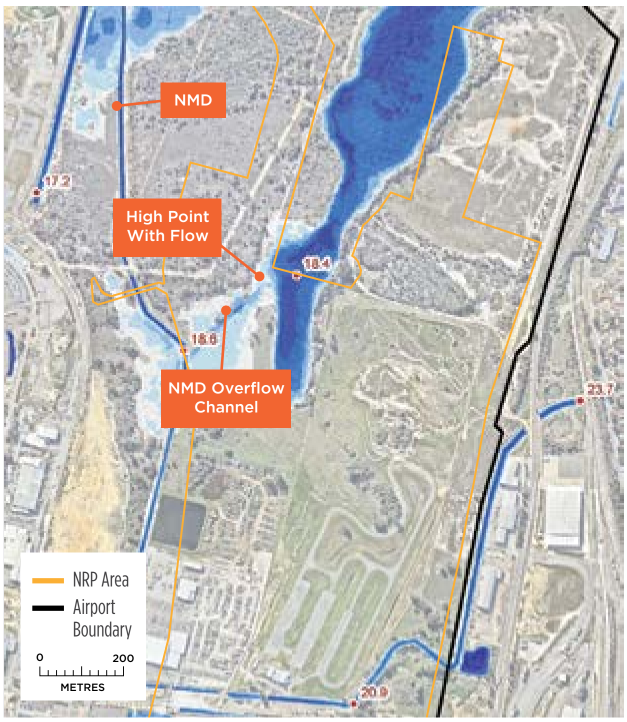


Figure 10-14 Existing flood map of northern portion of New Runway Project area, ten per cent annual exceedance probability
Source: Perth Airport Master Drainage Strategy (2017)

10.6.3.3 Munday Swamp Outlet

The existing Munday Swamp outlet will be upgraded to an engineered structure at the location shown in Figure 10-11. This will control the peak water levels and maintain the frequency and duration of inundation within the swamp to be similar to that which currently occurs. Maintaining the existing hydrological regime is important so that species that have limited tolerance to prolonged inundation or soil saturation due to root oxygen deprivation and lack of adaptive mechanisms are not negatively affected.

The structure will include pipes for low to medium flow events which will have an outlet level the same as it is currently. For larger flows the concept is for the outlet to operate as a weir with water flowing over the top of the structure as well as through the pipes. A concept design with three 750-millimetre diameter pipes with a 55-metre-long high flow weir has been included in the relevant computer models. The water depths and time of inundation within the swamp have been analysed and have determined that the expected flood duration is within the tolerance of the wetland and its associated flora and fauna. It was therefore considered that there are no significant risks to the vegetation.

The pattern of water level changes during large events and extreme events do lead to adjustments in areas around the swamp and by definition, are important ecological change events. The key impacts are likely to be of a temporary nature to certain fauna groups vulnerable to the rapid rise and fall conditions if it occurred during their breeding cycles.

The outlet will drain into the existing open channel that connects to the existing NMD. Currently, there is no specific issue with erosion downstream due to the outlet discharge, but detailed design will assess the need for energy reduction elements on the downstream side of the structure to protect the downstream channel from erosion.

10.6.4 Southern Main Drain

The proposed realignment of the SMD is shown in Figure 10-15.

10.6.4.1 East Channel

It is intended that the new SMD alignment from the eastern boundary of the estate will traverse south along the airside fence and then drain into a detention basin as shown in Figure 10-15. This segment will be an open channel except where road crossings are required. It will be constructed as a Living Stream and vegetated with suitable species for the location.

Stormwater modelling has shown that the section of the SMD outside the estate that runs parallel to the estate boundary starts to flood over its western bank (on the airport side) in various locations during the 10 per cent annual exceedance probability event. These flood waters that currently drain into low lying areas will drain into the new detention basin. The existing inflow point will be retained. As with the NMD, creating a new inflow point would require the lowering of the Dampier Bunbury Gas Pipeline and this is not required for stormwater purposes.

10.6.4.2 Detention Storage

Prior to the management of the airport being leased in 1997, land within the estate was used for the detention of stormwater due to stormwater infrastructure limitations downstream of the estate. Perth Airport now administers this legacy of detaining those stormwater volumes generated upstream, based on the 1997 inflows. As part of that legacy, a detention basin is required to be constructed to protect assets downstream and replace the loss of existing storage that the southern end of the NRP will fill in.

The basin will operate by having a single pipe outlet that is sized to constrain flows so that the basin will fill up in larger storm events. The basin size will cater for the one per cent annual exceedance probability storm event, and have a top water level that is below the limit set by the Water Corporation for flood protection of the land upstream of the estate.

The basin area will be vegetated with suitable species for the location.

10.6.4.3 West Channel

Stormwater from the piped basin outlet will drain under the airside area and discharge into a new section of open channel, and ultimately into a new drain connecting to the existing pipes beneath Horrie Miller Drive. The open channel will be used for storage during large storm events. It will be constructed as a Living Stream and vegetated with suitable species for the location. The exact alignment of this channel will be determined during the detailed design phase for the development of the land to the west of the NRP area, separate to the NRP design.

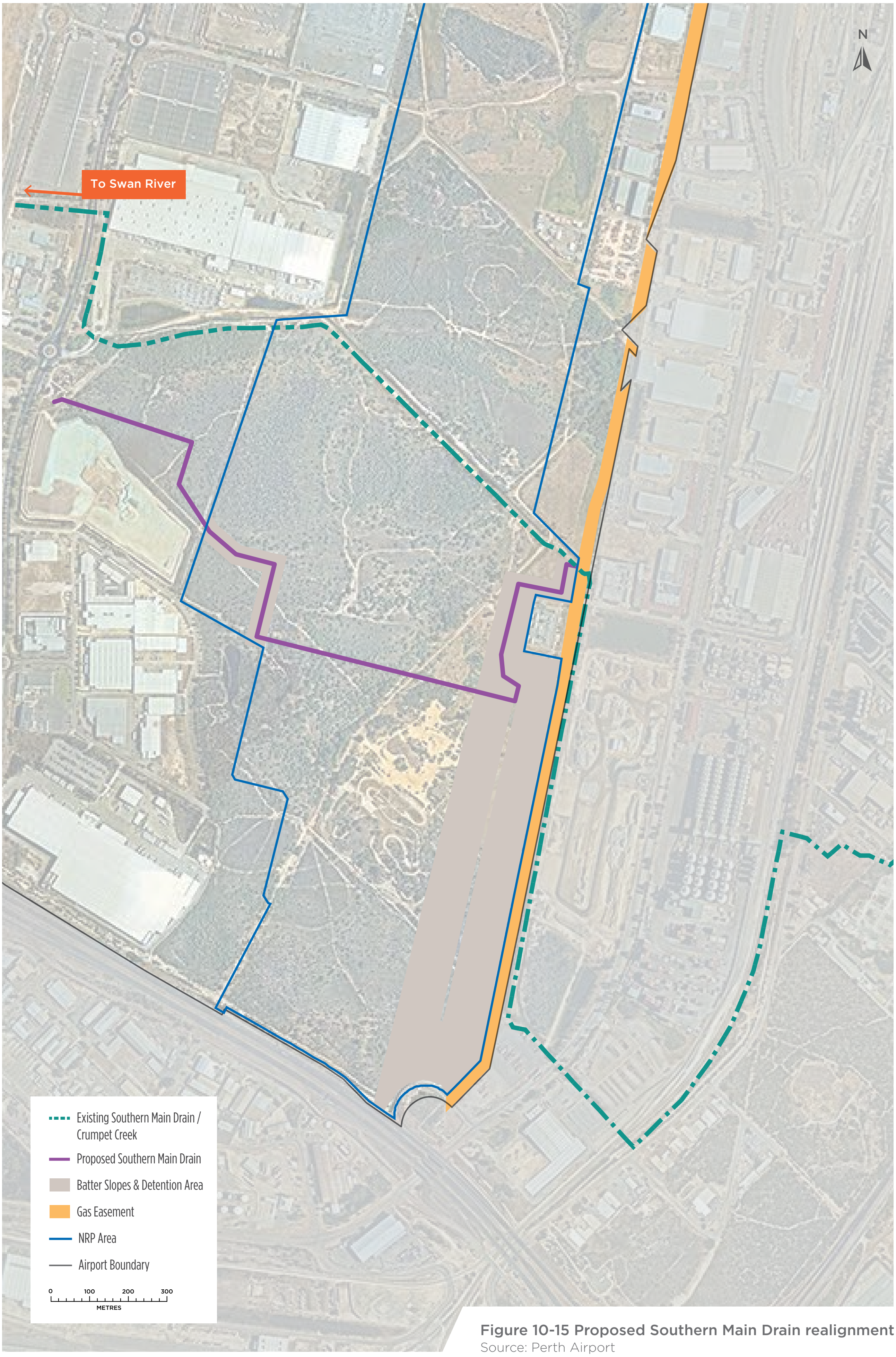


Figure 10-15 Proposed Southern Main Drain realignment
Source: Perth Airport

10.6.5 Climate Change

As part of the Master Drainage Strategy modelling, the airport estate's stormwater network was subjected to a sensitivity analysis. This simulated potential climate change impact. This was undertaken on the ultimate scenario model by changing the inflows of the upstream drains by minus ten per cent, plus ten per cent, plus 20 per cent and plus 30 per cent and also using similar scenario for the rainfall across the airport estate. The 1 per cent annual exceedance probability storm event was the only storm event assessed.

Comparing the plus 30 per cent scenario with the baseline (ultimate scenario) there were no new areas of flooding on the estate. Top water levels along the NMD were generally between 100 millimetres and 250 millimetres higher which is within normal minimum freeboard (depth between water and infrastructure to account for anomalies in data and design) of 300 millimetres. The water level at the downstream estate boundary did not increase.

For the SMD the changes in water level were less than 100 millimetres. At the downstream boundary there was no change to the water level.

For the plus ten per cent scenario the water levels for the NRP NMD infrastructure were between zero and 40 millimetres higher. This is likely to increase the inundation time in Munday Swamp by a few hours. The top water level in the SMD detention basin upstream of the new runway would increase by 30 millimetres but still be 170 millimetres below the Water Corporation calculated flood level.

For the plus 20 per cent and the plus 30 per cent scenarios the top water levels of the NRP NMD infrastructure would increase 80 millimetres and 130 millimetres respectively. The levels in Munday Swamp would increase by 80 millimetres and 100 millimetres respectively. The top water level in the SMD basin would be 60 millimetres and 90 millimetres respectively and still below the Water Corporation calculated flood level.

For the minus ten per cent scenario, the water level in Munday Swamp would be 50 millimetres lower than the baseline.

During detailed design the latest information on climate change will be assessed and the results of the current work being undertaken will help inform any changes to the concept design at that time. The current climate change information for rainfall in south western Australia is for increased storm intensities. Any increase in the size of the three basins is expected to be able to be accommodated in the land adjacent to the infiltration storage basin.

10.7 Impact Assessment

The NRP will result in changes to the hydrological regime within the estate. This section characterises the changes which are expected or modelled to happen, and assesses the impacts to existing built and natural infrastructure from these changes.

10.7.1 Significance Criteria

The significance criteria have been adapted to reflect discipline-specific considerations, as outlined in Table 10-4, the risk characterisation and impact assessment process is consistent with the stages outlined in Section 8.

Magnitude Description	Specialist Criteria
Major Adverse	Risk of flooding that can result in major injury or loss of human life.
	Risk of flooding that can result in major damage to public and private infrastructure both on and off the airport estate.
	Repairs to damaged infrastructure that can take several months to repair and impacts businesses and people during that time. Residential and business buildings are unusable until repairs taking several months are undertaken. Road pavements may be washed away preventing access along or across the affected road impacting commuters and access to businesses and residents.
	Environmental impacts tend to be permanent, irreversible or otherwise long term and can occur over large scale areas both on and off the airport estate. Permanent changes in hydrological regimes that are not within tolerances of affected flora and may cause a change in rare or protected flora types growing and impacting the amount of vegetation species and the fauna relying on vegetation species that may be lost.
	Uncontrolled disturbance of high level acid sulfate soils, or uncontrolled and widespread erosion, resulting in contamination of groundwater and receiving environments and long term adverse impacts to matters of national or international significance.
	Impacts to a wetland recognised as being of international (Ramsar listed) or national significance resulting in permanent and substantial loss of the values underpinning this significance.

Magnitude Description	Specialist Criteria
High Adverse	Risk of flooding that can result in minor damage to public and private infrastructure both on and off the airport estate. Repairs to damaged infrastructure are likely to take less than a month to repair and impacts businesses and people during that time. Residential and business buildings are still usable but have suffered aesthetic or minor damage resulting in short term discomfort or changes to operations. Risk of flooding that may stop or severely delay aeronautical operations. Runways, taxiways or airside roads may be flooded to the extent of preventing movements along them. Ground services and airport operations staff are prevented from accessing areas of the airport estate preventing them from carrying out their duties. Environmental impacts tend to be permanent or irreversible or otherwise long to medium term, and can occur over large or medium-scale areas, including outside the estate. Permanent changes in hydrology regime causing environmental changes that are not within tolerances of affected flora or fauna. Disturbance of high-level acid sulfate soils, resulting in deterioration of groundwater quality and that of the receiving environment and adverse medium to long-term effects on sites of state or national significance if unmanaged. A permanent or medium to long term deterioration in the ecological values or supporting processes of a wetland recognised as being of international or national significance. Impacts to wetlands considered commensurate with Conservation category such that they are no longer consistent with this management category or loss of extensive areas of wetlands commensurate with Resource Enhancement category.
Moderate Adverse	Risk of flooding that can result in minimal damage to public and private infrastructure both on and off the airport estate. Damage is limited to damaged verges, gardens and deposit of debris on roads and properties. Risk of flooding that may delay aeronautical operations. Runways, taxiways or airside roads may be limited in the number available for use, ground services staff may be delayed beyond normal operational times or airport operations staff experience difficulties in carrying out their work. Environmental impacts can range from long term to short term in duration, can occur over medium-scale areas or otherwise represent a significant impact at the local scale. Disturbance of acid sulfate soil, resulting in short term degradation of groundwater quality and/or local receiving environment. Appropriate measures can mitigate most adverse effects. Impacts to wetlands considered commensurate with Conservation category which result in a measurable decrease in the functional area of the wetland or loss of moderate scale areas of wetlands commensurate with Resource Enhancement category.
Minor Adverse	Flooding is limited to road reserves and may cause minor disruption to pedestrians and reduced vehicle speeds for the duration of the flooding both on and off the airport estate. Risk of flooding that may cause minor delays to aeronautical operations due to difficulties experienced by ground services staff who may be delayed beyond normal operational times or airport operations staff experiencing difficulties in carrying out their work. Environmental impacts tend to be short term or temporary. Disturbance of low-level acid sulfate soil, resulting in the generation of periodic or continual low yield acid runoff consistent with seasonal variations. Unlikely to significantly impact waters within the receiving environment. Loss of small areas of wetlands commensurate with Resource Enhancement category or further deterioration of the ecological values of these wetlands. Changes to wetland supporting hydrological regimes which do not result in impacts to defining attributes or values. Short term or temporary impacts to wetland values.
Negligible	Flooding is limited to areas designed to be flooded or areas where there will be no adverse impacts during larger storms on the airport estate. Environmental impacts would be beneath levels of detection, impacts that are consistent with seasonal variations, within the normal bounds of variation, or impacts that are within the margin of forecasting error.
Beneficial	Changes to existing situation that will lower the risk of flooding both on and off the estate. Environmental impact that provides an enhancement or provides increased protection.

Table 10-4 Significance criteria - wetlands and hydrology

Source: Perth Airport

10.7.2 Direct Loss of Wetlands

Based on the wetland boundary remapping and evaluations, direct impacts to wetlands as a result of the NRP relate to a loss of 79.8 hectares across seven wetlands considered commensurate with CCWs and 17.8 hectares of 12 wetlands considered commensurate with REWs. Although the scale of direct loss of wetland within the NRP project area is moderate, the impact represents a complete (i.e. high intensity, permanent and irreversible) loss of wetland within the project area. Considering the historical loss of wetlands on the Swan Coastal Plain, the interconnected nature of the NRP wetlands within an extensive mosaic of wetland and bushland vegetation that is part of a fragmented ecological linkage with the Swan River, the direct impacts of the NRP on wetlands have been assessed at a level of High Adverse significance in accordance with the specialist criteria defined in Table 10.4.

The NRP is considered to represent the development of infrastructure critical to the continued successful operation of the airport. As detailed design of the runway progessess, minimisation of impacts to wetlands will be considered and implemented as far possible.

10.7.2.1 Direct Impacts to Munday Swamp

The NRP project has been designed to avoid alteration of the geomorphic boundary of Munday Swamp where possible (see section 16.6.1 and 16.6.2 for more details), through the exclusion of the majority of this wetland from the NRP boundary. Where possible, impacts will be further minimised during detailed design. Where direct impacts do occur, specific mitigation and management is proposed.

Direct impacts to Munday Swamp include back filling of up to 4 hectares of the southern extent (including up to 2 hectares of the inundated zone with the remainder comprising riparian zone) and clearing or pruning of up to a further 2.4 hectares of wetland and riparian vegetation on its eastern boundary for installation of high-intensity approach lighting. Overall this will result in a reduction in the area of natural high-functioning wetland if no further opportunities for avoidance are able to be identified through the detailed design process.

Hydrological assessments have shown that the loss of volume due to the introduction of fill to the southern end of Munday Swamp will not impact the conveyance or detention storage capacity of the airport's stormwater network. There will be a loss of area for infiltration of surface flows into the groundwater at that location but this is offset by the infiltration basin which is to be part of the NMD realignment. Without appropriate controls however, this action could cause localised changes to groundwater throughflow and potentially significant changes to groundwater chemistry pending the type of fill used, which could alter the composition of aquatic biota. Based on the significance criteria in Table 10-4 this is considered to be of High Adverse significance.

The loss of wetland vegetation on the eastern side of Munday Swamp including pruning or removal of *Melaleuca rhaphiophylla* canopy is likely to cause permanent alteration to the form and structure of this area and could introduce risks associated with weed and dieback spread to the broader wetland from vehicle movements. Identification and on-going management of weed and dieback risk is discussed further in Section 11. Increased sun exposure and evaporation could speed up drying of semi-permanent small pools and lead to decreased water quality, potentially impacting on aquatic fauna. Some fauna are likely to be further impacted by the increased exposure to artificial light, which can impact vision of nocturnal animals, insects and fish, affect breeding cycles of frogs, and affect insect orientation. This could result in the loss of some fauna to the wetland. Based on the significance criteria in Table 10-4 this is considered to be of High Adverse significance. Specific mitigation has been identified to promote pruning in preference to clearing, and minimise the final areas of disturbance through the detailed design process, minimising the likelihood of flow-on impact to fauna.

10.7.3 Northern Main Drain

Changes to the NMD infrastructure will not increase the peak flows being discharged from the estate. In both the Perth Airport Master Plan 2014 and Master Plan 2020, Perth Airport has stated that it will provide stormwater infrastructure that has the capacity to meet the peak inflows and peak storage requirements from upstream sources as at 1997 values, as well as provide relevant peak stormwater storage requirements for all new development within the airport estate since 1997. Subject to the suitable management of inflows to 1997 flowing into the estate, Perth Airport will control outflows out of the estate and into external infrastructure, water courses and ultimately into the Swan River to the same peak rates as per 1997.

10.7.3.1 Open Channel

An open channel along the new alignment will have the capacity to convey the one per cent annual exceedance probability event flow. Flood modelling indicates that there will not be any flooding associated with this concept within, and external to the estate.

Having a section or sections of this piped has not been modelled. Modelling will be undertaken as part of detailed design if pipes are required. The open channel will be constructed as a Living Stream and vegetated with suitable species for the location.

10.7.3.2 Infiltration Storage

The basin will have the capacity to contain approximately the one exceedance per year storm event volume. It will be designed to allow storm events larger than that to drain over the western edge and into Munday Swamp. The existing terrain prevents overflow from any other edge.

10.7.3.3 Munday Swamp Hydrology

For flows larger than the one exceedance per year storm event there will be an increased volume of water flowing into Munday Swamp. This creates a risk of impacting vegetation in the Riparian and Fringing Woodland. However, if the pattern of flooding was consistent, a new distribution of vegetation would eventually form. Upland Woodland vegetation is extensive but Fringing Woodland is a narrow transition zone in which fauna populations would be vulnerable to change.

Some wetland fauna species may be at risk because they have a life cycle that is linked to natural cycles of flooding (e.g. frogs). An extended period of flooding may increase the impact of Mosquito fish which may already be adversely impacting aquatic invertebrates and frogs. However, there are some species such as waterbirds and some frogs that might benefit from extended flooding.

An assessment on the impacts to the flora, fauna and soils due to the flow from large storms draining into the swamp was undertaken by assessing the NRP scenario stormwater model outputs in the form of top water levels for various storms, water level versus time for the 10 per cent and one per cent AEP storm, a simplistic water balance model and water velocities.

The impact to the top water levels within Munday Swamp for the one exceedance per year storm event as well as the 10 per cent, two per cent and the 1 per cent annual exceedance probability storm events is shown in Table 10-5.

In terms of vegetation impacts, the peak water levels are immaterial to the wetland species present in the swamp since these species are adapted to flood waters and can tolerate inundation for periods. The key consideration is the period of inundation. Figure 10-16 is a graph of water level versus time and shows the period of inundation of a point in the swamp (labelled L16 in the MDS stormwater model) for a model run time of 10 days. The modelling does not take into account infiltration within the swamp or evaporation over this period.

The graph shows that the storm flow water will drain to a 'full' level close to 75 hours after the storm flow begins for both the 1 per cent and the 10 per cent storms modelled. Comparing the levels at the 24 hour and 75hour periods there is an approximate difference of 100 millimetres for the 10 per cent storm and approximately 230 millimetres for the 1 per cent storm. These are considered marginal changes to the flora and fauna of the swamp and hence the main flood waters will pass through the swamp rapidly.

Evaporation and rainfall data were assessed in a simplistic water balance model to determine how long it would take for water to recede to empty at a typical swamp bottom base invert level of 17.5 metres. The deepest locations in the swamp are as low as 17.0 metres but the water in some of the deepest locations has been found to be 300 millimetres deep during the dryer part of the year, therefore that is what has been used for the water balance model. The results are shown in Figure 10-17.

Storm Event	One EY	Ten per cent AEP	Two per cent AEP	One per cent AEP
Existing peak water levels (metres AHD)	18.13	18.37	18.56	18.61
NRP peak water levels (metres AHD)	18.10	18.30	18.52	18.61
Impact - change in peak water level (metres)	-0.03	-0.07	-0.04	Nil

Table 10-5 Munday Swamp peak water levels
Source: Perth Airport Master Drainage Strategy 2017

Note: AEP - annual exceedance probability. AHD - Australian height datum. EY - Events per Year

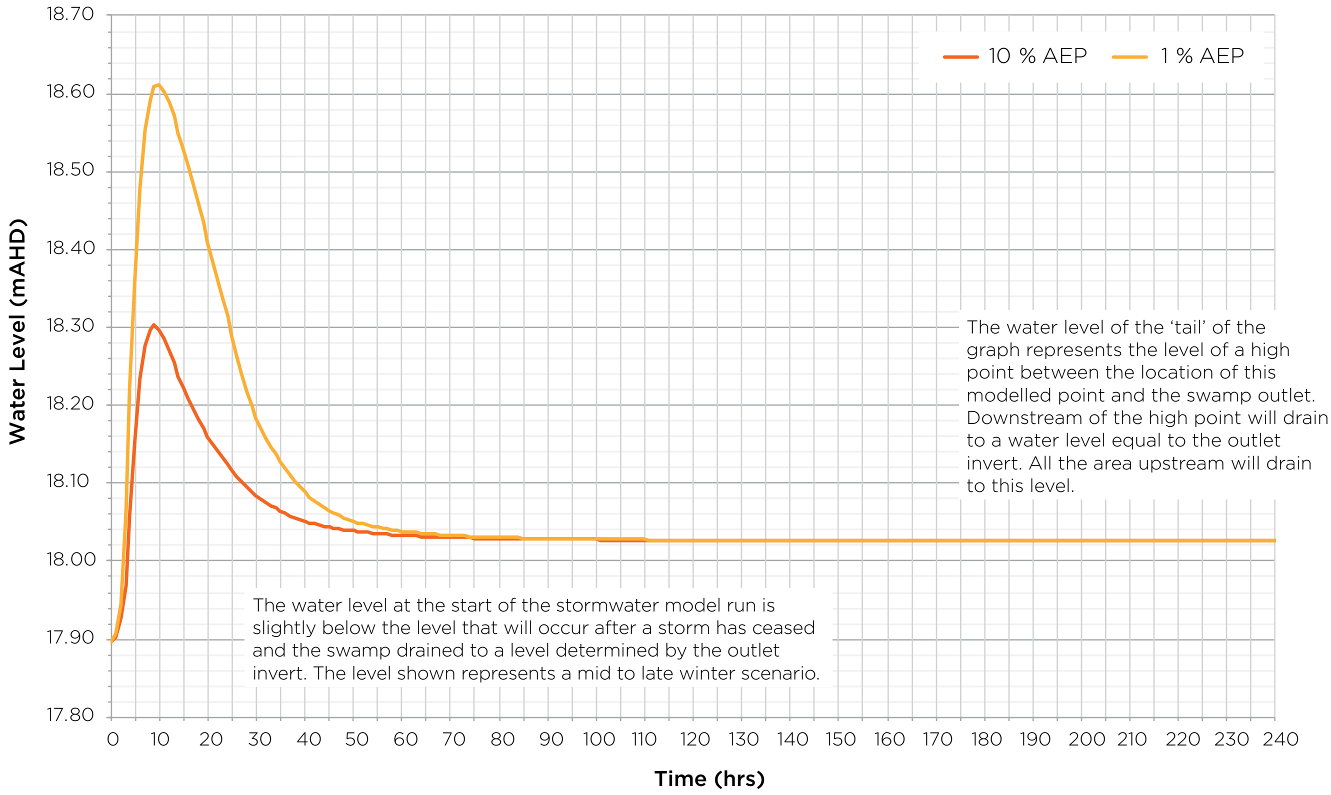


Figure 10-16 Typical inundation times in Munday Swamp
Source: Perth Airport Master Drainage Strategy (2017)

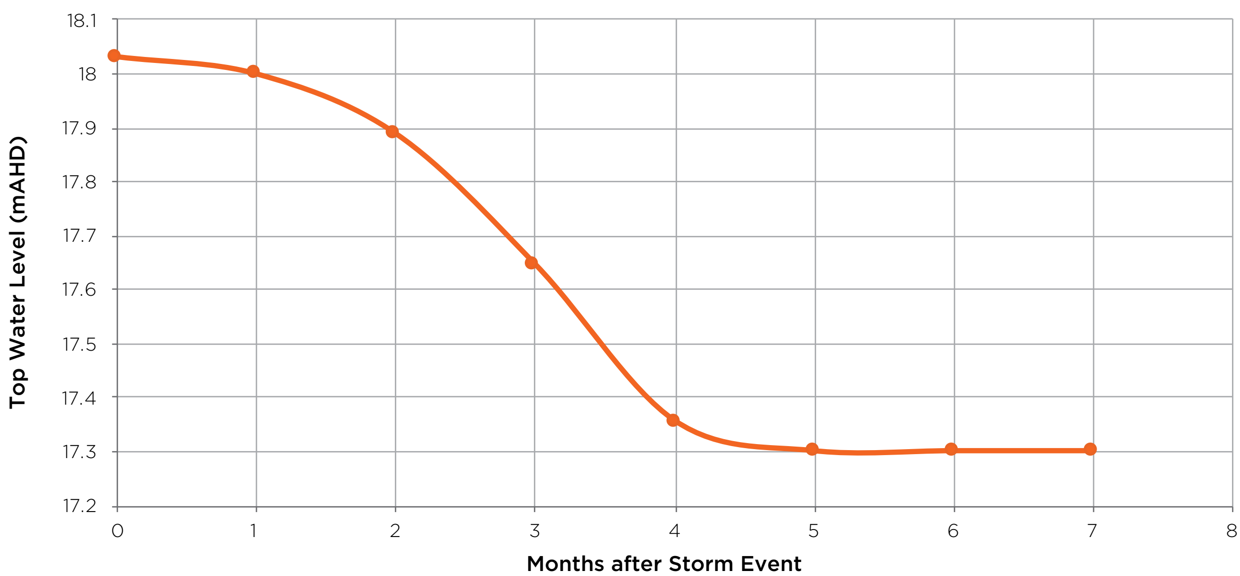


Figure 10-17 Chart of Munday Swamp water level (losses to evaporation after storm event)
Source: Syrinx Environmental (January 2018)

Assuming a storm event larger than a one exceedance per year occurs mid-winter and there is not another large event over the spring – summer period, the swamp would typically drawdown in a few months, and maintain its normal hydroperiod. As such, the expected flood durations are within the tolerance of Munday Swamp's environment and its associated flora and fauna, and therefore there is not a significant risk to the vegetation.

The pattern of water level changes during large and extreme events do lead to adjustments in isolated areas, and by definition are important ecological change events. The key impacts are likely to be of a temporary nature to certain fauna groups vulnerable to a rapid rise and fall in water levels during their breeding cycles.

Detailed design of the swamp outlet is important to help ensure the flow through the swamp is close to that as modelled. The NRP infrastructure stormwater model has a larger capacity outlet than the one that currently exists. The assessments have shown that the environment within the swamp is not overly sensitive to water levels providing the majority of water recedes within the one to two-day period, which will be accommodated through the outlet design.

The runway design criteria relating to operational clearances for the NRP will require a portion of the most southern section of the swamp to be filled in with one metre to two metres of fill. An assessment of the surface water, groundwater, vegetation and habitat was undertaken to determine the impact of this.

The loss of up to 12 per cent of the storage area has been included in the NRP scenario stormwater model. All the stormwater modelling results detailed in this document have taken into account the area being filled in.

There is likely to be minor localised changes to the groundwater flows but the extent and nature of these will depend upon the type of fill material used. The nature of the fill is likely to alter the natural peaty-clay acidic groundwater chemistry to an alkaline sandy hydrochemistry if the material is sourced from elsewhere on the airport estate. This in turn can alter the type and composition of aquatic biota. The type of fill needs to be carefully considered to minimise any negative impacts. The loss of perimeter vegetation will reduce the area of high functioning wetland available to fauna.

10.7.3.4 Munday Swamp Velocities

An assessment was undertaken to determine if the volume of water that will be flowing through the swamp from large rainfall events is likely to cause erosion either within the swamp or the overland flow area in between the infiltration basin and the swamp. The swamp and the overland flow area become part of the conveyance network when large event flows are draining through the system, and therefore the assessment was undertaken based on the science of flows in natural streams.

Erosion of soil material on the base and sides of a stream will occur when the velocity of the water flowing across those surfaces overcomes the surface-soil material resistance.

The concept design is to keep flow velocities down to 0.3 metres per second, or less, as this speed is the maximum allowable velocity for 'extremely erodible soils' in open non-vegetated channels. Generally, extremely erodible soils consist of soil particles 0.2 millimetres in diameter and smaller. This particle size represents fine sand, (coarse sand can be up to ten times that size,) plus silts and clays found in natural conditions.

A surface inspection of the swamp found various soil types within the swamp. There are peats (partially decayed vegetation) in the central section, clayey peats in the larger open areas and clayey silty sands in the southern and northernmost sections. The overland flow area has a surface soil type of Bassendean Sand.

Particles of peat vary in size based on the degree of degradation, and may be found bound or entwined, which provides resistance to movement. Clay in the form of separate particles falls within the extremely erodible soils class but are normally found in a bound state as a compacted layer, and therefore its resistance to movement can be a lot higher than in the loose particle form. The sand of the overland flow area as well as that in the swamp has a higher allowable erodible velocity, which is generally in the range of 0.40 to 0.46 metres per second.

Flow velocities in streams and flood plains are determined, in part, by resistance created by items within the flow path such as grass, trees, rocks, overhanging branches, fallen logs etc. The swamp is highly vegetated for most of its area and so provides a certain amount of flow resistance. The overland flow area currently does not provide much flow resistance because it consists mainly of loose sand with minimal weeds and not many trees. To better manage the control of flow velocities in this area, the concept design includes bioengineering with vegetation and hard landscaping such as seen in Figure 10-18. The figure is a modified photo of part of the actual overflow area. The trees in the top left and centre are existing vegetation, with most of the foreground trees, ground vegetation and hardwood logs being an example of what can be installed to control flow velocities and manage erosion.

Theoretically, velocities are at a maximum in the middle of a stream on the top surface of the water since this location is open to the atmosphere and unconfined. The slowest velocities are normally at the base and the sides, due to friction created by water dragging along those immoveable or partially immovable surfaces. Roughness also affects velocity. Computer modelling software uses simplifications and assumptions to estimate velocity.

The computer modelling results as shown in Figure 10-19 and Figure 10-20 are presented in a colour-graded form showing maximum velocities of the stormwater flow for 1 per cent annual exceedance probability storm events as well as the extent of flooding for such an event. Figure 10-19 displays such a storm event with the current stormwater infrastructure, and Figure 10-20 shows the situation for the NRP and other future works.

The computer software model used to calculate velocities through the swamp provides the results data in three-dimensional 'blocks' consisting of a two metre by two metre (water surface) area from the top of the water to the base of the swamp.

While the computer software provides data in two metre by two metre blocks, the surface level data input into the software was created based on a ten metre by ten metre grid with surface level data in between being extrapolated, and subject to a variable amount of error depending on the actual site topography.

Figure 10-20 shows that the overland flow area is mostly at 0.2 metres per second or less with some small patches higher than the concept design velocity of 0.3 metres per second. From the overland flow area, the water then drains down the swamp edge-slope which can be seen by the generally higher velocities in the figure. Most of the velocities on the slope are at the concept design velocity of 0.3 metres per second or less, with some areas higher.

The modelling has shown where the highest velocities are going to occur and what the flow velocities will be in those locations. The velocities that are above the concept design value are slow enough to be managed by increasing the flow resistance with local provenance vegetation if detailed design still indicates that is needed.

The flow velocities draining through the swamp are considered to pose little impact to fauna and vegetation.

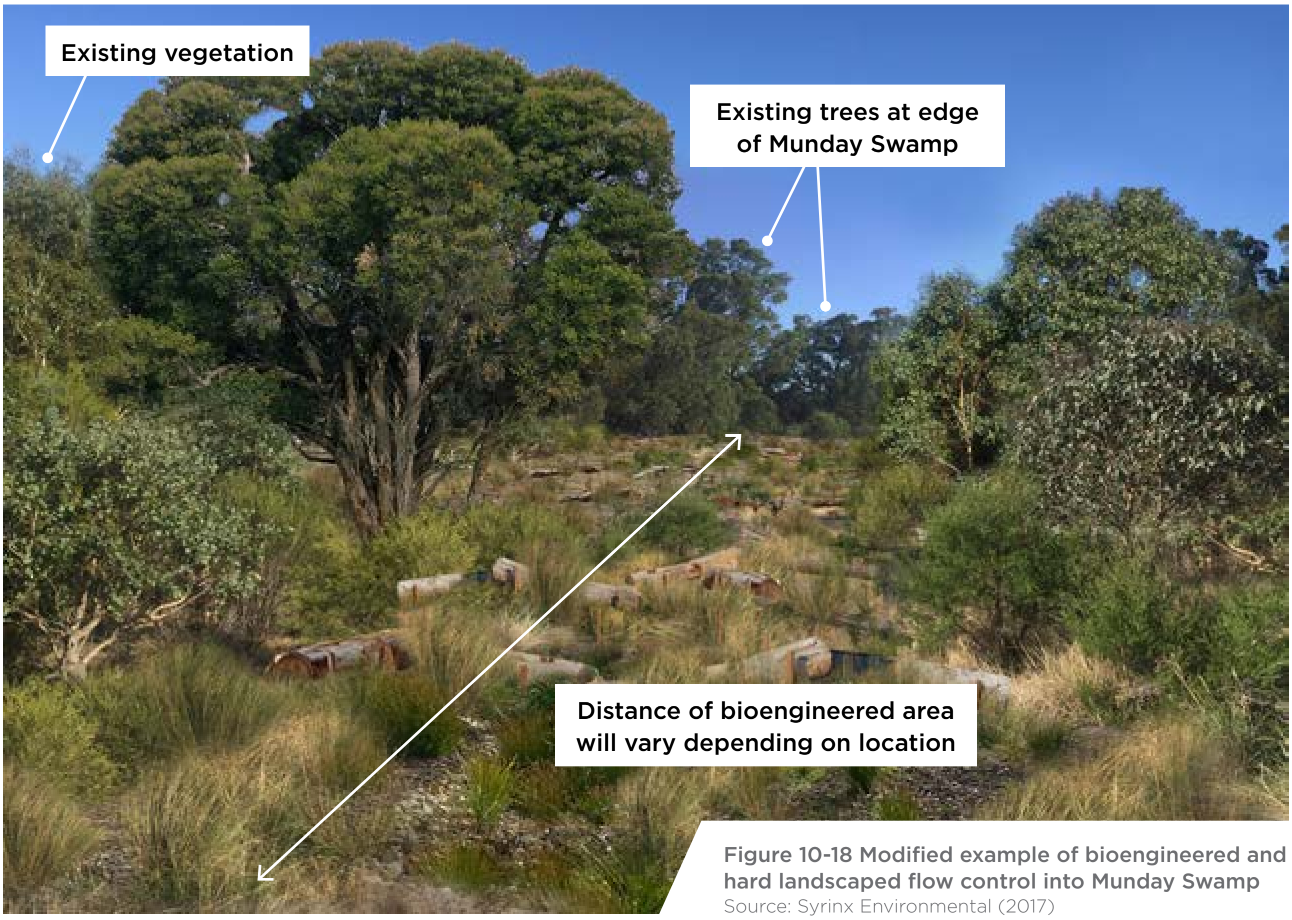


Figure 10-18 Modified example of bioengineered and hard landscaped flow control into Munday Swamp
Source: Syrinx Environmental (2017)

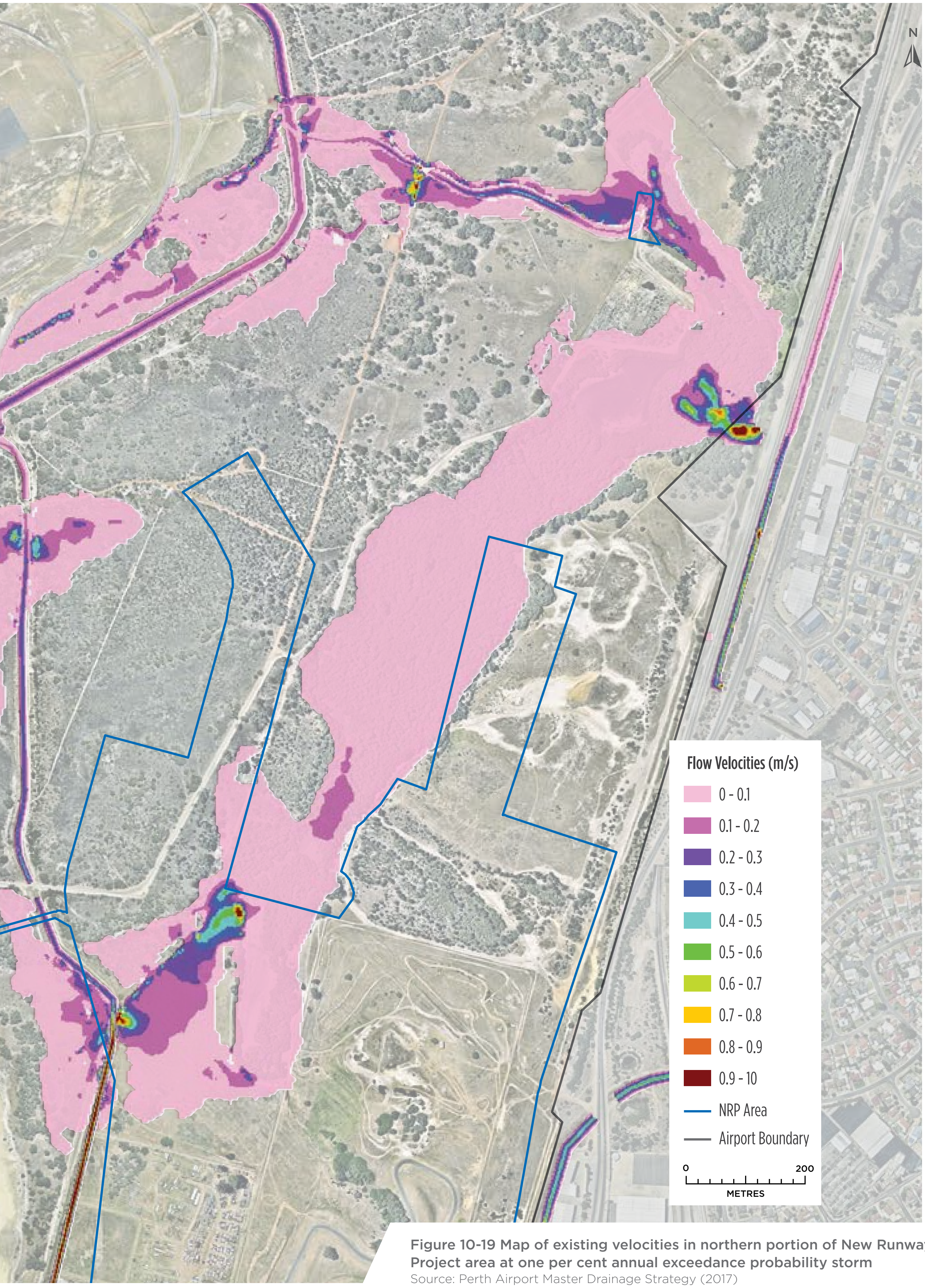


Figure 10-19 Map of existing velocities in northern portion of New Runway Project area at one per cent annual exceedance probability storm
Source: Perth Airport Master Drainage Strategy (2017)

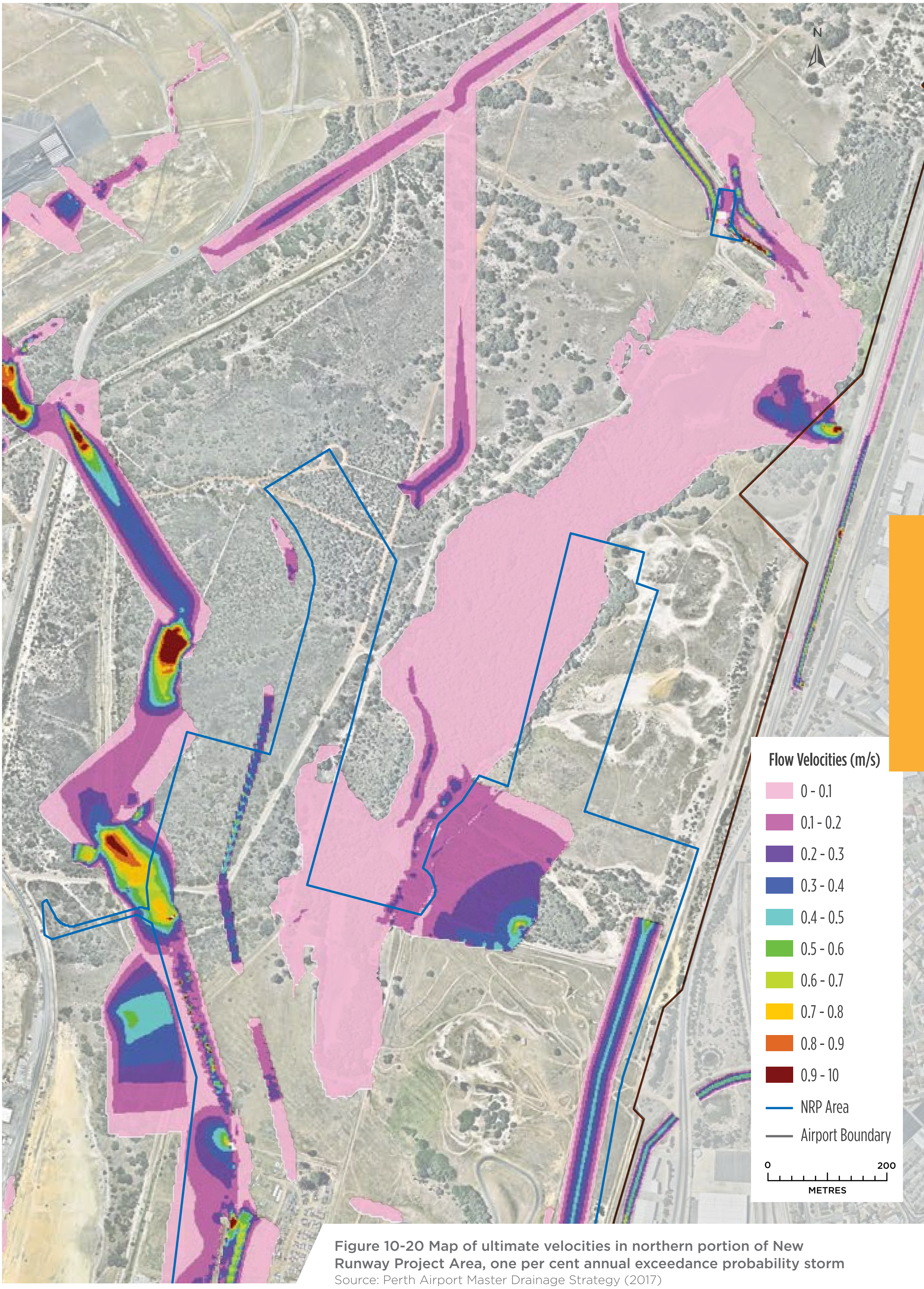


Figure 10-20 Map of ultimate velocities in northern portion of New Runway Project Area, one per cent annual exceedance probability storm
Source: Perth Airport Master Drainage Strategy (2017)

10.7.3.5 Munday Swamp Outlet

The new outlet structure will be built outside the tree line of the swamp. The existing fence and gravel access road will become redundant and pose no impediment to design or construction.

The existing outlet channel between the existing NMD and the swamp outlet currently overflows its banks in storm events larger than a one exceedance per year. The area of flooding will increase due to the larger volumes of water that will drain through the swamp. However, currently there is no infrastructure that will be affected, and there will not be any new infrastructure installed as part of the NRP that will be affected.

10.7.3.6 Downstream of the New Runway Project - Flooding

The existing NMD and the Munday Swamp outlet channel converge just upstream of the pipe under the cross runway (06/24) emergency access road. This point in the stormwater network is one of the flow restrictions mentioned previously and holds back water and provides an even flow output when running full. Modelling indicates that there is currently no flooding over this road in the 1 per cent annual exceedance probability storm event.

The NMD peak flows are generated upstream of the estate and arrive after the peak flows generated on the estate have drained off the estate. The realigned NMD will have the upstream flows draining into the infiltration basin storage which will capture most of that flow volume thereby reducing the total flows reaching the emergency access road culvert. Therefore, the NRP infrastructure will not cause an increase in the flood level upstream of the cross runway (06/24) emergency access road culvert. The water level will be lower than the current situation.

Storm Event	One EY	Ten per cent AEP	Two per cent AEP	One per cent AEP
Existing Peak Water Levels (metres AHD)	22.93	23.17	23.31	23.39
NRP Peak Water Levels (metres AHD)	22.85	23.07	23.23	23.30
Impact - Change in Peak Water Level (metres)	-0.08	-0.10	-0.08	-0.09

Table 10-6 Water level changes in the Northern Main Drain at the Perth Airport estate boundary
Source: Perth Airport Master Drainage Strategy 2017

Note: AEP - annual exceedance probability. AHD - Australian height datum

Storm Event	One EY	Ten per cent AEP	Two per cent AEP	One per cent AEP
Existing Peak Water Levels (metres AHD)	23.34	23.65	23.83	23.92
NRP Peak Water Levels (metres AHD)	23.33	23.63	23.80	23.90
Impact - Change in Peak Water Level (metres)	-0.01	-0.02	-0.03	-0.02

Table 10-7 Water level changes in the Northern Main Drain at Abernethy Road
Source: Perth Airport Master Drainage Strategy 2017

Note: AEP - annual exceedance probability. AHD - Australian height datum

10.7.3.7 Downstream of the New Runway Project – Water Quality

Due to the NMD flow draining through the treatment train upstream of Munday Swamp, the large majority of pollutants will be stripped from the flow at that point. This will provide a positive benefit to the water quality in the NMD downstream of Munday Swamp and into the Swan River.

10.7.3.8 High Wycombe and Macao Road Branch Drains

The invert levels of the High Wycombe and the Macao Road branch drains are 0.09 metres above Munday Swamp's 1 per cent annual exceedance probability top water level. This means that there will not be any downstream conditions affecting flow in these drains. There will also be no impact to these drains or the land abutting them.

10.7.3.9 Poison Gully

The larger capacity open channels of the NMD on the estate influence peak-water levels upstream of the estate by lowering them. This is due to the size of the new open channel being designed to convey larger flows. This influence extends upstream to the edge of the flood model at Abernethy Road.

Table 10-6 and Table 10-7 show the water levels at the estate boundary and Abernethy Road.

The modelling data in Table 10-6 and Table 10-7 is based on a full-length open channel down to the infiltration basin just upstream of Munday Swamp. If piped sections are required, then this would be modelled as part of detailed design. Any piped sections will have an overflow path designed above, or past the piped sections so there will not be a detrimental impact upstream.

10.7.4 Southern Main Drain

10.7.4.1 East Channel

The size of the section of SMD on the estate will be based on the limitation of the upstream external section. The 1 per cent annual exceedance probability storm event modelling has shown that flooding of the external channel is still limited to the western bank overflowing but this water will drain into the basin. Flood modelling indicates there will be no flooding within the estate with this concept.

10.7.4.2 Detention Storage Basin

This basin will be designed to cater for the 1 per cent annual exceedance probability storm event. Flood modelling has shown that the top water level is 210 millimetres below the Water Corporation limit.

10.7.4.3 West Channel

This channel will be designed to cater for the 1 per cent annual exceedance probability storm event. Flood modelling of this concept indicates that there will not be any flooding within the estate.

10.7.4.4 Downstream of the NRP

The new open channel between the NRP and Horrie Miller Drive will be constructed to contain the 1 per cent annual exceedance probability storm event. The design of this section of open channel and the NRP stormwater infrastructure is based on the peak flow rate in the existing pipes under Horrie Miller Drive being controlled to a rate based on the capacity of the downstream infrastructure.

Downstream of Horrie Miller Drive a new section of SMD will be constructed to meet up with the existing SMD where it reaches the western airport boundary after flowing under the existing 03/21 runway. The proposed concept is for the alignment to drain through or past another wetland that is part of the larger area listed on the Commonwealth Department of Agriculture, Water and the Environment's Directory of Important Wetlands in Australia. This wetland is known as Runway Swamp. This swamp is similar to Munday Swamp due to it being a freshwater wetland with surface and groundwater inflows. The surface water is predominantly an expression of groundwater. Assessment of the swamp has yet to be undertaken but will be part of the design process. The works for this section of the SMD will be subject to a separate approvals process and will need to be constructed and operating prior to the NRP works diverting water into it.

Stormwater modelling has shown that changes to the SMD infrastructure as part of the NRP and the future concept realignment through Runway Swamp will not increase the peak flows being discharged from the estate. In the Perth Airport Master Plan 2014, Perth Airport has stated that it will provide stormwater infrastructure that has the capacity to meet the peak inflows and peak storage requirements from upstream sources as at 1997 values, as well as provide relevant peak stormwater storage requirements for all new development within the airport estate since 1997. Subject to the suitable management of inflows to 1997 flowing into the estate, Perth Airport will control outflows out of the estate and into external infrastructure, water courses and ultimately into the Swan River to the same peak rates as per 1997.

10.7.4.5 Crumpet Creek

The larger-capacity open channel of the SMD and the detention basin upstream of the new runway influence peak water levels upstream of the estate by raising them. However, the increased top water level heights are still lower than the Water Corporation limit of 21.50 metres Australian height datum (AHD) for the detention basin. This section of channel upstream to Abernethy Road is directly influenced by the water level in the basin.

A section of the SMD between the estate and Abernethy Road has stormwater storage as part of the network. There is some undeveloped land to the north of the storage areas and modelling has shown that the land at its current level will partially flood in the 1 per cent annual exceedance probability storm event. It is expected that any development of the land to the north of the detention/retention area will manage this partial flooding because the 1 per cent annual exceedance probability design flood level is a standard planning consideration for the City of Kalamunda. This would be expected to be addressed in any development application lodged to, and then checked by the City.

Due to the small amount of stormwater volume that encroaches the land, any loss of storage area on the land north of the detention/retention area will not raise the 1 per cent annual exceedance probability top water level up to the Water Corporation's limit. Table 10-8 and Table 10-9 show the water levels at the estate boundary and Abernethy Road.

The modelling data in Table 10-8 and Table 10-9 is based on a full-length open channel down to the detention basin. If piped sections are required, this would be modelled as part of the detailed design. Any increased flooding due to the piped sections will have an overflow path directly into the basin so there will not be any increased impact upstream.

Storm Event	One EY	Ten per cent AEP	Two per cent AEP	One per cent AEP
Existing Peak Water Levels (metres AHD)	20.36	20.61	20.65	20.66
NRP Peak Water Levels (metres AHD)	20.75	21.06	21.23	21.29
Impact - Change in Peak Water Level (metres)	0.39	0.45	0.58	0.63

Table 10-8 Water level changes in the Southern Main Drain at the Perth Airport estate boundary
Source: Perth Airport Master Drainage Strategy 2017

Note: AEP - annual exceedance probability. AHD - Australian height datum

Storm Event	One EY	Ten per cent AEP	Two per cent AEP	One per cent AEP
Existing Peak Water Levels (metres AHD)	20.59	20.94	21.12	21.19
NRP Peak Water Levels (metres AHD)	20.75	21.07	21.25	21.33
Impact - Change in Peak Water Level (metres)	0.16	0.13	0.13	0.14

Table 10-9 Water level changes in the Southern Main Drain at Abernethy Road
Source: Perth Airport Master Drainage Strategy 2017

Note: AEP - annual exceedance probability. AHD - Australian height datum

10.7.5 Groundwater

Scenarios that were modelled as part of the impacts assessment were:

- Post NMD and SMD changes,
- Post NRP Pavement construction,
- Post NRP Seasonal High Groundwater Level, and
- Post NRP Seasonal Low Groundwater Level

The modelling results for the seasonal low situation indicate that there will be minimal to zero changes across the NRP area and beyond. The largest impacts are for the seasonal high situation.

The predicted seasonal high groundwater levels for the changes due to the NMD and SMD realignments will provide a localised lowering of the groundwater on the new alignments of up to 0.4 metres at the drains, with the affect decreasing as the distance from the drains increases. There is a localised increase of up to 0.4 metres where the superseded drain alignments will be filled in and similarly this effect declines as the distance from the old drains increases.

The new runway and taxiway pavements will reduce the proportion of sandy soils that rainfall currently infiltrates in to. Rainfall runoff from the new pavements will flow into surface drains and the proportion that does not infiltrate within the drains will be removed from the area draining ultimately into the NMD or the SMD. The reduction in groundwater recharge is expected to result in a long term and permanent decline in groundwater levels. For the seasonal high situation, the large majority of the NRP area will see a lowering of approximately 0.1 metres with a maximum of just over 0.2 metres approximately midway along the runway. Since the changes produce a lowering of the seasonal high levels, the changes are within existing seasonal changes which are generally between 1.0 and 1.8 metres between the wet and dry seasons.

Since the modelled long term seasonal low levels show minimal change and the season high levels will not be higher than existing groundwater levels, the structures within the 'NRP impact zone' will not be impacted.

The long-term change to seasonal high groundwater levels at Munday Swamp will be approximately 150 millimetres. Whilst there will be effects to vegetation and fauna within the swamp, these are likely to be within the tolerance limits of most species, albeit some localised changes to species composition is probable. The surface stormwater inflow is a major control factor, that in effect, compensates for the predicted changes to the groundwater levels.

10.7.6 Water Quality

Perth Airport have been monitoring surface water and groundwater since being granted the lease in 1997. Results are submitted to the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications. The monitoring program covers the estate and is a risk based approach with higher risk areas/locations with 'high' readings being monitored more often than other areas.

The majority of drainage excavation will be in sandy soils which are prone to erosion unless stabilised by vegetation, rock lining or engineering structures. This issue will be highlighted in the detailed design process. Potential impacts to surface water quality are described in Section 9.

Dewatering of in-situ acid sulfate soils during construction and subsequent acidification of soil and groundwater is a potential impact where groundwater level drawdown is greater than typical seasonal variability (i.e. greater than between 0.6 metre to 1.6 metres depending on site location). Oxidation of acid sulfate soils can lead to the release of acidity and lowering of groundwater pH. Acidified groundwater can dissolve metals that are otherwise stable in the soil matrix, and results in elevated metal concentrations in groundwater. Acidic groundwater containing elevated metals poses a significant risk for downgradient groundwater dependent ecosystems, vegetation and groundwater users (i.e. garden and irrigation wells).

Reduction of water quality from erosion and sedimentation of surface water channels during construction is also a potential impact, because of vegetation clearing, excavation and earthworks which may create destabilised surfaces and banks. The decreased infiltration levels would also lead to increased surface and stormwater flows into surrounding areas. The potential for contamination of surface and groundwater from chemical or fuel spills is temporarily increased due to construction activities. Surface water runoff has the potential to mobilise contaminated water beyond the estate boundary.

The new drainage system constructed as part of the new runway project is likely to intercept potentially contaminated soils and waters (including the highly recalcitrant emerging contaminants, PFOS/PFAS) when creating the new drainage system. Acid sulfate soils can also be expected due to the known presence of coffee rock as well as peats and clays.

These impacts are considered to be able to be effectively managed following appropriate baseline investigations, the preparation of appropriate management plans and the implementation of best practice measures, including sediment capture barriers and liming. A PFOS/PFAS strategy will be developed based on the latest guidelines at the time.

The current runway designs also propose that some stormwater from the taxiway network is directed towards Munday Swamp. This water can carry particulate contaminants including hydrocarbons, surfactants, nutrients and sediments, which, if not intercepted and treated, will impact on the water quality within Munday Swamp and degrade habitat quality. As such, the detailed design stage will incorporate structural controls to intercept and treat run-off (via swales and biofilters or similar).

10.7.7 Summary of impacts to wetland retention areas

Apart from the NRP project, the Perth Airport Master Plan 2020 provides for the clearing and development of (or likely unavoidable impacts to) a significant portion of the airport estate wetlands, with detailed design and opportunities for retention still to be finalised in many areas. As such, impacts as a result of the construction and operation of the NRP are considered here only as they relate to wetlands outside of the airport estate or areas within the airport estate that fall outside of likely future Major Development Plan boundaries.

Wetland areas which may be retained (referred to from here forward as 'wetland retention areas') within the Airport Estate include the following (Figure 10-21):

- The remainder of Munday Swamp, outside of the NRP.
- Approximately 6.7 hectares of Wetland 17, outside of the south-west corner of the NRP.
- Most of wetland 19 – the Kwenda Marlark constructed wetland.
- Wetland remnants within the 'Infrastructure Only Conservation Zone' in the south-west corner of the estate.

Outside of the airport estate, a 2.2 hectare CCW is located directly adjacent to the airport boundary, approximately 75 metres from the south-east corner of the NRP. A number of other small CCWs and REWs occur outside the airport estate within one kilometre of the NRP (Figure 10-2) but are unlikely to be impacted by activities associated with the NRP due to separations greater than 500 metres and being hydrologically upstream of the NRP.

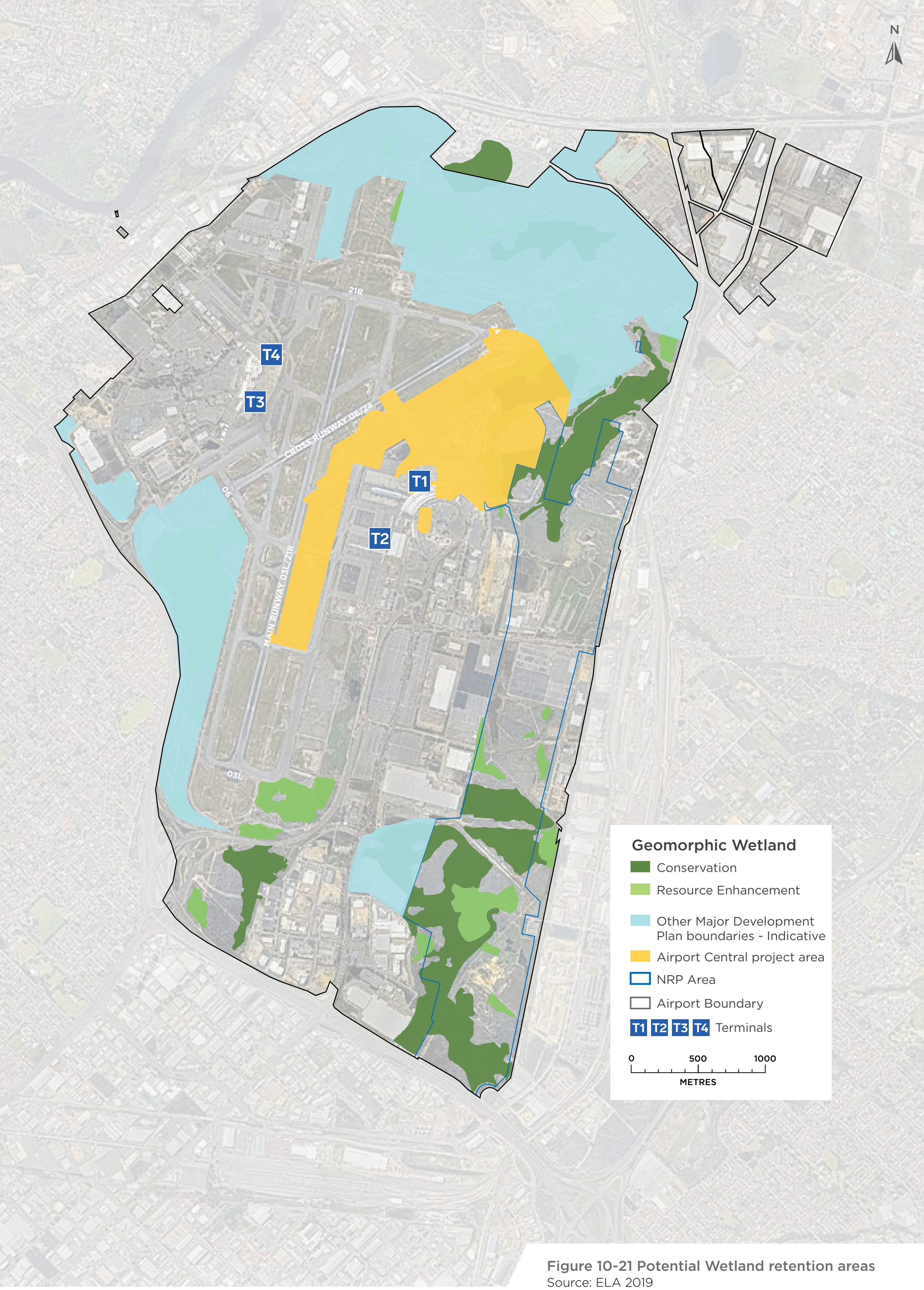


Figure 10-21 Potential Wetland retention areas
Source: ELA 2019

Specific indirect impacts to wetland vegetation and fauna are discussed in Sections 11 and 12 respectively. Potential impacts to wetland vegetation as a result of the following are considered in Section 11, along with related proposed mitigation and management:

- Fragmentation,
- Invasion of weed and pest species,
- Increase in occurrence of Dieback,
- Impact on plant-pollinator regimes, and
- Changes in fire regime

There is likely to be a change in the inherent value of remaining wetland areas due to increased risk of edge effects such as weeds and erosion and disconnection from fauna linkages. Wetland invertebrate fauna richness has been found to be influenced by proximity to other wetlands, due to fauna that actively disperse between adjacent wetlands (Horwitz et al. 2009), and could therefore be affected.

In most cases where a portion of a wetland intersects the NRP boundary and will necessarily be impacted, the remainder of the wetland is not proposed to be retained (with many of these wetland portions intersecting other project areas proposed as part of the Perth Airport Masterplan). Exceptions to this are Munday Swamp, Kwenda Marlark constructed wetland (Wetland 19) and approximately 6.7 hectares of Wetland 17, outside of the south-west corner of the NRP. The interface with remaining areas of Wetlands 17 and 19 will be determined during detailed design and no specific management is proposed. Munday Swamp has been identified as a key ecological and cultural asset within Perth Airport and as such has been identified for targeted mitigation and management to retain these values as far as possible.

Retained wetland areas have the potential to be impacted by changes to the broader hydrological regime which supports them. Changes to the hydrological regime resulting from the NRP are discussed in Section 10.7.2 to 10.7.5 and summarised in Sections 10.7.7.1 and 10.7.7.2 as they relate to wetland retention areas.

10.7.7.1 Changes to wetland hydrology

Hydrological changes could potentially lead to a change in flora, vegetation or fauna values of wetland retention areas, including weed burden, vegetation condition and floristic assemblage.

Modelling of surface and groundwater changes as a result of the NRP have been undertaken as separate exercises and are described in Section 10.4. The modelling indicates that NRP land use changes and associated realignment of the Northern and Southern Main Drains are unlikely to result in significant changes to seasonal high groundwater levels that could impact on the ecological values of wetlands outside of the Perth Airport estate or wetland retention areas apart from Munday Swamp.

Results of this modelling have been used to inform an assessment of potential impacts to the ecological values of Munday Swamp.

During larger rainfall events, which are expected to occur less than once per year, there will be additional stormwater flowing into Munday Swamp than currently exists. The results of stormwater modelling of the water flowing into and through Munday Swamp have been assessed and it was determined that the peak water levels and times of inundation are within the tolerances of the swamp and its associated flora and fauna.

Surface water contributions are likely to be responsible for about half of the winter water levels in Munday Swamp and are thus a critical factor in determining the extent of inundation. They also drive maximum water levels. Peak water levels are predicted to remain relatively unchanged (within 0.1 metres). Storm events will recede at a faster rate than existing conditions, however this is a matter of days, which will not materially affect the vegetation.

Groundwater throughflow maintains permanent pools over summer. Seasonal low groundwater levels between the existing and future 'Ultimate Development' scenarios are inconsequential across most of Munday Swamp, with the largest difference expected to be 40 millimetres lower in the northern areas. Some small very shallow permanent pools in the northern sections of the swamp may transition from inundated to saturated over summer under the Ultimate development conditions, depending on the frequency of surface water inputs in summer. It is possible that this would have eventuated anyway, given a drying climate. Some floating aquatics and aquatic invertebrates may not persist in these pools, however, given that the majority of the permanent pools will maintain water permanency, this is not considered to be a significant impact. No emergent species are present.

Some plant species along the margins of the wetland and some dampland species may be affected if the slight lowering of the summer water table is at the threshold of their rooting depth. Whilst these changes are possible, they are local, will not affect any conservation significant species, and are already apparent in some areas due to previous changes within the airport and drying climate affects. No major impacts to the vegetation communities in these areas are expected.

Whilst a substantial change in the wetted perimeter at Munday Swamp is predicted over winter based on modelled groundwater levels alone, surface water inputs are likely to compensate for this change. Detailed design will incorporate consideration of maintaining winter water levels, highlighting any localised risk points and identifying appropriate controls.

The sumpland areas are dominated by wetland trees and shrubs with root systems extending more than 1m and as such are not expected to be impacted by changes to summer or winter water levels.

The superficial aquifer within the NRP is effectively full, with the current inverts of drains constraining the maximum groundwater levels across the area. Localised groundwater drawdown occurs along the NMD and SMD. As a result, where these drains are to be filled in, the groundwater will rise by approximately 0.4 metres. Likewise, new drains will cause a lowering of the groundwater by up to 0.4 metres. In the case of the SMD realignment, this change in the groundwater table is very localised and is unlikely to impact on the remaining portions of Wetlands 17 or 19.

Any dewatering activities that are required during the construction phase are likely to cause localised groundwater levels to decline. The location, degree and timing of dewatering will be assessed and managed to help ensure that any negative impacts are nil or within accepted tolerances of any flora, fauna or infrastructure within the impact zone. The results of groundwater modelling will be used to inform the management of dewatering activities. Dewatering plans will be determined at the beginning of the construction phase.

10.7.7.2 Wetland water quality

Indirect impacts to water quality in wetland retention areas include the following:

- dewatering of in-situ acid sulfate soils,
- erosion and sedimentation during construction, and
- mobilisation of contaminants in surface water or groundwater.

Pathways for possible water quality impacts to retained wetland areas include surface water drain discharge (relevant to Munday Swamp), direct rainfall runoff via overland flow and contaminated groundwater movement.

Pollution capturing devices will be incorporated into the NMD upstream of Munday Swamp. The NMD flow will drain through a gross pollutant basin, contaminant basin and then into an infiltration basin. The contaminant basin is where most of the weed seeds and propagules will be captured. The infiltration basin that is downstream of this will capture any remaining non-soluble pollutants. Section 11 discusses the impacts of weeds on Munday Swamp. The infiltration basin will capture and infiltrate all flows from storm events that occur once per year or more often. Based on historical rainfall information recorded at the Perth Airport Bureau of Meteorology weather station, this basin will infiltrate approximately 80 per cent of all water from upstream of the airport in the NMD catchment. This treatment train is also expected to result in a positive benefit to water quality downstream of Munday Swamp, where the NMD flows ultimately into the Swan River, also a CCW.

The SMD realignment associated with the NRP (upstream of Horrie Millar Drive) will not pass through any retained wetland areas and is therefore not expected to pose a risk to surface water quality within to these areas. The retained areas of Wetland 17 and 19 currently receive storm water runoff from developed areas in a 1 Event Per Year storm and this is not proposed to change significantly as a result of the NRP.

Any areas from the NRP works where rainfall runoff is likely to drain directly into Munday Swamp will have this runoff intercepted. This water will either be treated via a biofilter and then released towards the swamp, or it may be directed to the local drains in the taxiway network which bypass the swamp. The most suitable option will be determined during the detailed design stage. This will generally affect the area west of the proposed runway at the northern end, as well as part of the taxiway network that is closest to Munday Swamp. Rainfall runoff from areas of the NRP works that drain into the NMD will be treated via the treatment train previously described.

Management of contaminants is discussed in more detail in Chapter 9, including provision for water quality treatment from new pavement areas and implementation of an Operational Environmental Management Plan. Risks to groundwater quality as a result of temporary groundwater drawdown for dewatering required for construction of infrastructure will be addressed through the preparation and implementation of a Construction Environmental Management Plan, as well as an Acid Sulfate Soil and Dewatering Management Plan. These measures in combination would be expected to effectively manage the risk of contaminants affecting the water quality of surface water or groundwater entering the remnant wetland areas.

Changes in water quality to wetlands outside of the Perth Airport Estate are considered unlikely given that the only close wetland (greater than 500 metres) sits hydrologically upgradient of the NRP.

10.8 Mitigation

Standard mitigation measures such as implementation of management plans will be in place during the construction and operational phases of the NRP, and additional mitigation measures have been developed to manage environmental impacts discussed in the previous section. These standard mitigation measures are outlined in the following section.

10.8.1 Standard Mitigation Measures

To manage the risk of impacting wetland and ecosystem health, acidification of in-situ acid sulfate soil, surrounding groundwater users and settlement of surrounding structures, the management of groundwater level drawdown is important. Flora, vegetation and fauna are susceptible to changes in water levels, water quality and associated impacts to their habitats.

A list of standard mitigation measures typically employed to minimise groundwater level drawdown during construction dewatering is provided below:

- staging of dewatering operations to minimise the area over which the required groundwater level drawdown is required at any given time,
- development of a Dewatering Management Plan (DMP) specific to the construction dewatering activities that outlines the acceptable amount of groundwater level drawdown allowed before potential impacts occur. It should be noted that a DMP would typically outline a regime of groundwater level and quality monitoring for comparison to a set of acceptance criteria. Where these criteria are not met, the mitigation is typically to cease dewatering until such a time as the construction dewatering can be carried out without causing the potential impacts, and
- engineering and design controls to account for these expected changes in levels.

Implementation of a CEMP, which outlines the following mitigation measures, would also contribute to the reduction of impact risk to the environment:

- acid sulfate soil-management measures during ground disturbance activities,
- spill and emergency response measures, e.g. for chemical spills such as fuel,
- regular monitoring of groundwater and surface water quality to inform ongoing management actions, and
- soil and erosion management measures and monitoring requirements.

Locations where long-term groundwater levels rise will occur as indicated by groundwater modelling results, by decommissioning and infilling of the existing NMD and SMD to a level that will be higher than the predicted rise. Therefore, there will not be any additional open water areas created.

10.8.2 Additional Mitigation Measures

Additional mitigation-management measures have been identified where the initial risk levels were identified as medium or higher after the standard mitigation measures have been applied.

Introduction and Spread of Weeds in Munday Swamp

Prolonged inundation can have some positive and negative effects on the weeds within the wetland. Positive impacts would be a reduction of weeds within the wetland basin. Negative effects would be the proliferation of weeds alongside wetland margins.

The potential increase in the risk of weeds and pollution entering Munday Swamp has been identified as a medium risk. Any disturbance of the pollutants (weed seeds and propagules) captured in the upstream treatment train can be minimised in the detailed design phase by use of high-level overflow structures or similar engineered elements. Management of contamination and nutrient transport that may affect vegetation growth will be monitored and managed in line with Perth Airport's environment strategy. Weed management within the Munday Swamp area will continue to be undertaken as required.

Section 11 discusses the effects of weeds in Munday Swamp.

Groundwater Level Fluctuations at Munday Swamp

The groundwater modelling undertaken has been at a scale for the whole project area and beyond as required, and not targeted to specific areas such as Munday Swamp. Therefore, the results are not detailed enough to undertake an assessment using only that groundwater data.

The assessment of impacts due to groundwater changes at Munday Swamp was undertaken by extrapolating groundwater changes to water levels provided from the stormwater modelling to represent the general change in groundwater level effects. There is an assumption that no inflows are received from surface water and therefore the results are a worst case scenario.

For the seasonal low (Summer-Autumn period) the largest difference is expected to be 40 millimetres lower at some small permanent pools in the northern area of the swamp. These pools may transition from inundated (permanent pool) to saturated (seasonal sumpland); the extent of which will depend on the frequency of surface water inputs in summer (mostly expected via the Water Corporation branch drains). However, it is likely this shift may become permanent given the trajectory of a drying climate.

Direct rainfall contributions within the swamp are sufficient each winter to overprint the groundwater effects in terms of a wetted perimeter. Inflow from the two Water Corporation branch drains is likely to compensate for the altered groundwater relatively quickly.

The assessment concluded that the predicted changes to groundwater levels (and surface water flows) is not considered to cause a significant impact to the wetland or associated groundwater dependent vegetation. Whilst there will be effects, these are likely to be within the tolerance limits of most species, albeit some localised changes to species composition is probable. The surface stormwater is a major control factor that in effect compensates for the predicted changes to groundwater levels.

A more detailed groundwater model will be created as part of the detailed design stage to provide data for the design of the infiltration basin. If localised impacts around the swamp are found to be unsatisfactory, then contingency measures can be applied to provide more water such as allowing some treated surface water flow from the infiltration basin area.

Contamination of Stormwater from Upstream Sources

Gross pollutants and oil or chemical spills from upstream are possible risks to the NMD and SMD. Removal of garbage, papers and cardboard plus small (based on volume) oil spills can be managed by the Perth Airport Environment team. Large oil spills and chemical spills would be notified to the Airport Control Centre (ACC) to action a spill response procedure which includes emergency services.

With Munday Swamp proposed to be part of the NMD, the most likely pollutant to cause a major adverse consequence is a possible major fuel spill. If a B-double tanker carrying 80,000 litres of fuel was to spill its entire load from both tanks prior to emergency services responding on site, and that fuel was to drain to the infiltration basin it would create a film of fuel 2.7 millimetres thick over the three-hectare site if there was water in the basin. Spills of that magnitude occur over a larger time frame enabling response teams to stop/intercept spills downstream of the source. There would also be infiltration into the soil along the NMD prior to reaching the proposed treatment train consisting of the gross pollutant trap, the contaminant basin and finally the infiltration basin. The need for a fuel water separator will be assessed during the detailed design phase.

Increased Sediment Loading

Maintenance of the treatment train elements on the NMD upstream of Munday Swamp is required. Perth Airport has a Maintenance Management System (MMS) where programmed maintenance items are output and the inspection of the three basin areas (gross pollutant, contaminant and infiltration) will be added into the MMS system. This will help ensure that the basins all maintain the minimum capacity required to operate as designed.

Accidental Spills or Leaks During Construction

Selection of low impact or low toxicity chemicals for use during construction is a way of minimising any negative impact in the event that there is an accidental spill. Site planning of storage areas can be undertaken based on risk of damage downstream of the store.

PFAS and Other Contaminants

Management of issues relating to Per- and poly-fluoroalkyl substances (PFAS) is to be undertaken based on guidelines available at the time. For further information on PFAS and other contaminants relating to the NRP refer to Section 9.

10.8.3 Future Design and Management Plans

Further groundwater and stormwater modelling will be undertaken to refine the groundwater changes and confirm the degree of the impacts that have been identified. This work will then be used for detailed design as well as developing parts of management plans. (e.g. management of Acid Sulfate Soils in the CEMP)

10.8.4 Summary of Impacts

A summary of the impacts identified, standard and additional mitigation measures and the residual impacts are detailed in Table 10-10.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Realignment of open channels (NMD & SMD) and other stormwater infrastructure	Flooding	Operation	Design – • Concept design as per Master Drainage Strategy • Hydrology/Flood modelling of detailed design	Negligible	Unlikely	Very low	No additional mitigation measures identified			
Realignment of open channels (NMD & SMD) – Diversion of channel water	First flow of water into new drains results in erosion and sediment plumes downstream	Construction	Design - Scope of Design Works brief to specifically state a requirement for: • erosion control design elements for soil types being excavated • requirement for erosion design report or an erosion control section in a design report • peer review of erosion control design report and drawings Construction phasing to allow stabilisation elements to be functioning as designed prior to opening of drains to water flows	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD & SMD) – Diversion of channel water	First flow of water into new drains results in erosion and sediment plumes downstream	Construction	Construction - • contractor to submit a methodology for diverting first water into new drains for approval by a qualified stormwater engineer, or • a methodology for diverting first water into new drains to be developed by a qualified stormwater engineer	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD & SMD) - Earthworks	Infill of existing sections of NMD and SMD allows groundwater flows in those areas to be reinstated to an environment that is not open to air or able to be released into surface water flows	Operation	Infill of existing sections of open channel	Beneficial						

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology
Source: Perth Airport

Impacting Process	Impact Detail	Project Phase	Initial Assessment				Residual Assessment			
			Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Realignment of open channels (NMD & SMD) – outside Munday Swamp area	Open channel levels being lower than groundwater resulting in nearby groundwater levels being lowered and negatively affecting vegetation	Operation	Design: Drain levels to be at or above Master Drainage Strategy 2017 concept design levels	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD & SMD)	Open channel levels being lower than groundwater resulting in Acid Sulfate Soil contaminants being released to surface water	Operation	Acid Sulfate Soils and Dewatering Management Plan to be undertaken prior to relevant works being undertaken. Creation of Plan to be informed by groundwater modelling results Ongoing monitoring of water quality to determine if treatment required post construction	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD & SMD)	Open channel levels being lower than groundwater resulting in nearby groundwater levels being lowered and negatively affecting nearby structures	Operation	Design: Drain levels to be at or above Master Drainage Strategy 2017 concept design levels NRP impermeable area to be at or less than Preliminary Design	Moderately Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channel (NMD) – Munday Swamp	Increased flows into Munday Swamp changing normal water level, flood levels and flood inundation times creating a negative ecological impact	Operation	Design: Infiltration basin to be constructed upstream to contain the one exceedance per year storm Design of swamp outlet to manage outflows to minimise any change from existing situation levels and inundation period to within flora and fauna tolerances	High Adverse	Highly Unlikely	Low	No additional mitigation measures identified			
Realignment of open channel (NMD) – Munday Swamp	Introduction and spread of weeds in Munday Swamp affecting native flora and fauna habitat	Operation	Upstream treatment train to include a contaminant basin and a vegetated infiltration basin sized to fully infiltrate up to one exceedance per year storm to capture weed propagules	Moderate Adverse	Possible	Medium	Engagement with upstream stakeholders Active weed management of the NMD, gross pollutant, contaminant and infiltration basins post development	Moderate Adverse	Unlikely	Low

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology (Continued)

Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Initial Assessment: Significance/ Consequence	Initial Assessment: Likelihood	Initial Assessment: Initial Risk	Residual Assessment: Additional Mitigation	Residual Assessment: Significance	Residual Assessment: Likelihood	Residual Assessment: Residual Risk
Realignment of open channel (NMD) – Munday Swamp	Increased metals, nutrients, hydrocarbons and other pollutants in water affecting vegetation growth and fauna	Operation	Incorporate Water Sensitive Urban Design into NMD catchment as per engineered treatment train described in the 'Infiltration Storage' section: • Gross pollutant basin • Contaminant basin • Vegetated infiltration basin to fully infiltrate up to one event-per-year • Monitoring of water quality	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD) – Munday Swamp	Ecological impacts from large (greater than one exceedance per year) storm events	Operation	Design of swamp outlet to manage outflows to minimise any change from existing situation levels and inundation period to within flora and fauna tolerances	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Realignment of open channels (NMD)	Gross pollutants and minor (based on volume) oil/ chemical spills, most likely from upstream sources entering Munday Swamp	Operation	Engineered treatment train as described in the 'Infiltration Storage' section	Moderate Adverse	Highly Unlikely	Low	No additional mitigation measures identified			
Realignment of open channels (NMD)	Groundwater level fluctuations at Munday Swamp negatively affecting flora and fauna	Operation	Design: Drain levels to be at or above Master Drainage Strategy 2017 concept design levels	High Adverse	Unlikely	Medium	Detailed groundwater modelling specifically for the Munday Swamp area to be undertaken to a sufficient degree of detail to inform design	High Adverse	Highly Unlikely	Low
NMD - Contamination of surface water from upstream sources	Major (based on volume) oil/ chemical spills, most likely from upstream sources entering Munday Swamp	Operation	Engineered treatment train as described in the 'Infiltration Storage' section	Major Adverse	Highly Unlikely	Medium	Incident to be notified to Airport Control Centre (ACC) to action a spill response procedure which includes emergency services	High Adverse	Highly Unlikely	Low
Stormwater from NRP area draining directly into Munday Swamp	Transport of pollution directly into the swamp negatively affecting flora and fauna	Operation	Design: Any stormwater that would drain directly to the swamp to be captured in a swale and treated before being released or directed to other local drains not in the swamps catchment	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Vegetation Clearing	Groundwater levels raised and negatively affecting nearby structures	Construction	Nil - Modelling has shown that changes to groundwater levels are less than typical seasonal variability	Moderately adverse	Unlikely	Low	No additional mitigation measures identified			

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology (Continued)

Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Initial Assessment: Significance/ Consequence	Initial Assessment: Likelihood	Initial Assessment: Initial Risk	Residual Assessment: Additional Mitigation	Residual Assessment: Significance	Residual Assessment: Likelihood	Residual Assessment: Residual Risk
Realignment of open channels (NMD)	NMD realignment with increased sediment loads, turbidity reporting to Munday Swamp impacting local water dependent flora and fauna	Operation	• Integration of a gross pollutant control basin and infiltration basin upstream of Munday Swamp. • Sediment to be captured in gross pollutant basin prior to entering infiltration basin. • Regular monitoring and maintenance of gross pollutant basin via PAPL MMS system • Regular monitoring of surface water downstream of the gross pollutant basin i.e. within Munday Swamp via PAPL MMS system. Design to consider plant species and other requirements to minimise bird strike risk	High Adverse	Unlikely	Medium	Maintenance of the treatment train pollution capturing elements to help ensure that capacity is available for pollutants Design of area between infiltration storage and swamp to be bioengineered to provide a high Manning value to keep stormwater velocity low enough to avoid sands and gravels being carried by water	Moderate Adverse	Highly unlikely	Low
Construction of NRP pavement (change of rainfall recharge)	Change in rainfall recharge pattern resulting in groundwater level drawdown beneath new runway and taxiways (the cumulative effect of decrease in infiltration due to increase in paved surface and runoff via drains, versus increased infiltration in areas that are currently vegetated but will be cleared)	Operation	Nil - Modelling has shown that changes to groundwater levels are less than typical seasonal variability	Negligible	Highly Unlikely	Low	No additional mitigation measures identified			
Earthworks (ex NMD & SMD)	Soil disturbance causing erosion and sediment mobilisation to local and downstream environments	Construction	Implementation of a CEMP including site-specific erosion and sediment control plan(s): • implementation of staged development planning and installation of water quality and erosion and sediment control measures prior to construction, • regular monitoring and maintenance of water quality control and treatment measures, and • regular monitoring of surface water downstream of the project.	Minor Adverse	Possible	Low	No additional mitigation measures identified			

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology (Continued)

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Normal construction operations - Accidental chemical, fuel spills or other dangerous goods	Accidental spills or leaks from construction equipment mobilised by stormwater runoff into the surface-water drainage system	Construction	CEMP to include: • appropriate measures for the storage and use of hazardous substances as per statutory requirements • spill response procedures • regular maintenance of vehicles to prevent leaks or spills • Monitoring of construction water quality control measures	Moderate Adverse (dependent upon nature, quantity and timing of spill or leak)	Possible	Medium	Select low impact or low toxicity chemicals during construction Physical spill containment bunds/barriers Pumping options to remove contaminated surface waters Incident register to be monitored to identify recurring problems which can then inform maintenance programs	Minor Adverse	Possible	Low
Earthworks - Dewatering	Groundwater level fluctuations from dewatering activities causing negative impacts to Munday Swamp, flora or structures	Construction	Acid Sulfate Soils and Dewatering Management Plan to be undertaken prior to relevant works being undertaken. Creation of Plan to be informed by groundwater modelling results. Plan to stage construction to avoid any negative impacts	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Earthworks - Dewatering	Release of Acid Sulfate Soil contaminants	Construction	Acid Sulfate Soils and Dewatering Management Plan to be undertaken prior to relevant works being undertaken. Creation of Plan to be informed by groundwater modelling results. Plan to stage construction to avoid any negative impacts	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Earthworks (ex NMD & SMD)	Increased erosion and sediment mobilisation from NRP area after construction to local and downstream environments from runoff from non-stabilised areas	Operation	Rehabilitation of disturbed areas to occur as part of the construction phase and to continue to be monitored in Operation phase • Progressive planting and seeding as construction activities are completed to stabilise exposed soils • Regular monitoring and maintenance of water quality control and treatment measures • Regular monitoring of surface water downstream of the NRP	Minor Adverse	Possible	Low	No additional mitigation measures identified			

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology (Continued)

Impacting Process	Impact Detail	Project Phase	Initial Assessment				Residual Assessment			
			Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Normal construction operations - Excavations	Exposure of Acid Sulfate Soil and other contaminants to surface-water runoff which may impact surface water and groundwater quality and ecological receptors	Construction	Acid Sulfate Soils and Dewatering Management Plan including: Release of treated groundwater to align with proposed groundwater management strategies.	Moderate Adverse	Possible	Medium	PFAS strategy to be developed based on latest guidelines	Moderate Adverse	Unlikely	Low
Infill of southern section of Munday Swamp	Loss of storage area produces negative affects due to changes in peak water levels and inundation times	Operation	Design to ensure that peak water levels and inundation times are close to existing and are within tolerance levels of the wetland flora and fauna.	High Adverse	Highly Unlikely	Low	No additional mitigation measures identified			
Clearing and filling wetlands	Loss of 98 hectares of priority wetlands (80 hectares of CCW and 18 hectares of REW) including areas considered part of the Perth Airport Woodlands Swamp listing on the Directory of Important Wetlands in Australia.	Construction	Restrict clearing footprint to NRP area, demarcate clearing extent and exclusion zones.	High Adverse	Almost certain	High	No additional mitigation measures identified	High Adverse	Almost certain	High
Infill of southern section of Munday Swamp	Changes to hydrochemistry affecting vegetation and faunal communities	Construction	Design of infill areas to minimise area as far as practicable	High Adverse	Likely	Medium	Sourcing, testing and verification of suitable soils free from chemical or biological contaminants including weeds and pathogens and compatible with existing wetland hydrochemistry.	High Adverse	Highly Unlikely	Low
Pruning/clearing of part of Munday Swamp wetland vegetation for construction of high intensity approach lighting	Changes to wetland ecology due to increased exposure to sunlight, evaporation, and artificial light.	Construction	Detailed design will seek to minimise area of disturbance as far as practicable. Pruning will be employed in preference to clearing.	High Adverse	Likely	Medium	Guidance on tree pruning to be developed focussing on minimisation of potential impacts. Revegetation of cleared areas with low vegetation compatible with the approach lighting to ensure continued groundcover.	High Adverse	Possible	Medium
Access track construction for high intensity approach lighting	Changes to Munday Swamp surface water flows or quality due to access track construction	Construction	Design appropriate access track ensuring no adverse impacts such as compaction, ponding or preferential runoff.	Moderate adverse	Unlikely	Low	No additional mitigation measures identified.			

Table 10-10 Summary of impacts, risks and mitigation measures - hydrology (Continued)

Based on residual impacts identified in Table 10-10, hydrological changes as a result of the construction and operation of the NRP generally present a Low or Very Low residual risk to the environment after mitigation. Activities with a residual risk of Medium or High relate to potential impacts to wetlands.

Significant impact guideline 1.2, *Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies*, provides no specific guidance on determination of significance in relation to wetlands, other than to advise that the determination of significance should consider environmental context, the severity and nature of potential impacts and planned avoidance, mitigation and management.

Historically there has been significant loss of wetlands on the Swan Coastal Plain. In addition, remaining wetlands in the region are under threat from land clearing associated with a highly urbanised environment and drying as a result of reduced rainfall. In a cumulative sense, impacts to Swan Coastal Plain wetlands are therefore considered at a critical level.

Munday Swamp has been identified as a high value wetland due to its heritage significance. As a wetland of high priority, direct impacts to Munday Swamp have been largely avoided. However, avoidance of the loss of other wetlands within the NRP is not possible due to the extent of infrastructure requirements within this portion of Perth Airport. The predicted residual impact on wetlands within the NRP includes the permanent loss of 80 hectares of wetlands considered commensurate with CCWs and 18 hectares considered commensurate with REWs. This loss is considered significant as:

- CCWs and REWs are considered significant ecosystems, with CCWs representing wetlands of the highest priority.
- Vegetation within the wetlands to be cleared is in Very Good to Excellent condition.
- Historical loss of wetlands on the Swan Coastal Plain is already at a critical level.
- The role of these wetlands as fauna habitat and ecological linkages within the Perth Airport.

Outside of the direct loss of wetlands within the NRP, indirect impacts are likely to occur to those wetlands with portions outside the NRP. Indirect impacts include flow on effects to wetland ecology as a result of fragmentation and isolation, changes to hydrochemistry as a result of introduced fill in the portion within the NRP, and in the case of Munday Swamp, increased exposure to sunlight and artificial light. Perth Airport will seek to minimise these impacts as far as practicable through the detailed design process, however it is possible that these could be significant.

Perth Airport is committed to build on the available baseline information and regularly monitor the macroinvertebrates of Munday Swamp, other wetland retention areas and the proposed Living Streams. The objective of the monitoring and adaptive management plans will be to ensure that:

a) The biodiversity of Munday Swamp and the other wetland retention areas are being maintained.
b) The created wetlands as part of the Northern Main Drain are being managed as Living Streams and have some native macroinvertebrate communities being established in these wetlands.

The Perth Airport Wetland Monitoring and Adaptive Management Plan will be prepared and implemented prior to construction of the NRP.

10.9 Conclusion

The major physical impacts to stormwater infrastructure of the NRP are:

- The NRP will fill in areas that are currently used as stormwater storage, both excavated and naturally low-lying areas.
- The existing overflow channel that drains stormwater into Munday Swamp from the NMD in storm events larger than one exceedance per year will be cut off due to the taxiway layout.
- The required NMD realignment will result in Munday Swamp receiving additional surface water in storm events that are larger than a one exceedance per year event.

The flood-modelling work undertaken as part of the Master Drainage Strategy has shown that the storage being lost for the NRP can be managed by incorporating storage within the new storage areas and open channels proposed for the NRP.

The realignment of the NMD will allow for stormwater to continue to drain into Munday Swamp during rain events larger than one exceedance per year, however, the total volume will be more than the current situation. Potential scouring of the swamp base and the banks by the water draining through the swamp can be managed by design of the infiltration basin and the area between that and the swamp to control the water's velocity. Any possible negative hydrological effects on the flora and fauna within the swamp due to the increase in water volume can be negated or minimised through design of the swamp's new outlet structure to keep the depth of water and its inundation time to levels that are tolerable to the flora and fauna.

Construction and new runway operational impacts on the stormwater infrastructure are summarised in Table 10-10. The residual risks were mostly assessed as low or very low except for two of the impacts, the 'Burning/clearing of part of Munday Swamp wetland vegetation for HIAL lightning' impact retaining a medium risk to the NRP and the 'Clearing and filling wetlands' being a high risk that cannot be mitigated.

The design of the HIAL lightning will be undertaken during the detailed design phase with consideration of limiting the extent of pruning/clearing of the vegetation to be undertaken.

In summary, the studies and modelling undertaken by Perth Airport suggest that potential hydrological impacts can be adequately managed through the implementation of the standard and additional mitigation strategies outlined in this section.

11 Flora and Vegetation

This section describes the impacts on flora and vegetation resulting from the construction and operation of the New Runway Project (NRP). This includes:

Detail is also provided on the following areas:

- What flora species and communities are present in the NRP area?
- What is the potential impact of the NRP on flora species and communities?
- What is the significance of potential impacts on flora from the NRP?
- How will the potential impacts on flora be mitigated?

11.1 Introduction

An assessment of the impacts of the NRP on flora and vegetation has been undertaken. This includes a survey of the flora and vegetation within the NRP area to define the existing conditions, assess the potential impacts from the construction and operation of the NRP, and propose mitigation measures.

The NRP will impact flora and vegetation as a result of:

- clearing in the NRP area,
- realignment of drainage infrastructure, and
- the construction and operation of the runway.

Information regarding flora and vegetation assessment methodologies can be found in Section 11.4.1. Additional information on construction of the new runway and associated infrastructure can be found in Section 6 and details of the proposal to offset residual impacts to flora can be found in Sections 11.8 and 17.9.

11.2 Key Findings

Key findings from the investigations into flora and vegetation across the NRP area include potential impact to:

- 139.4 hectares of remnant native vegetation,
- the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed:
  - Banksia Woodlands of the Swan Coastal Plain community (Endangered), 41.4 hectares (40.04 hectares direct impact and 1.36 hectares indirect impact), (equivalent to the DBCA Priority Ecological Community, Banksia dominated woodlands of the Swan Coastal Plain IBRA region, P3),
  - *Conospermum undulatum* (Vulnerable, including State listed), 206 plants, and
  - *Macarthuria keigheryi* (Endangered, including State listed), 855 plants,
- the State *Biodiversity Conservation Act 2016* (BC Act) listed:
  - 4.07 hectares of Forests and Woodlands of Deep Seasonal Wetlands of the Swan Coastal Plain, SCP 15, community (Vulnerable), and
  - eight Priority Species Listed by the State Department of Biodiversity Conservation and Attractions (DBCA).

11.3 Policy Context and Legislative Framework

This MDP has been developed in consideration of the following legislation and guidelines:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act),
- Significant Impact Guidelines 1.1: Matters of National Environmental Significance (DoE 2013) (Guideline 1.1)
- Significant Impact Guidelines 1.2: Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth Agencies (DSEWPaC 2013) (Guideline 1.2)

Guideline 1.2 requires that all potential impacts resulting from airport projects (on Commonwealth land) are assessed. This includes both EPBC Act protected flora and vegetation (Matters of National Environmental Significance (MNES)) and non-MNES flora and vegetation and is known as a “Whole of Environment” approach, covering MNES and non MNES impacts. This “Whole of Environment” approach to flora and vegetation covers the assessment of potential impacts (direct, indirect and offsite), mitigation and significance to MNES, state listed species and other remnant native vegetation. Guideline 1.2 is considered in conjunction with Guideline 1.1 that includes criteria for assessing the significance of potential impacts to flora that may:

- lead to a long-term decrease in the size of a population,
- reduce the area of habitat of a species,
- fragment an existing population into two or more populations,
- adversely affect habitat critical to the survival of a species,
- disrupt the breeding cycle of a population,
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline,
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species’ habitat,
- introduce disease that may cause the species to decline, or
- interfere with the recovery of the species.

Biodiversity in Western Australia is also protected under the Western Australian *Biodiversity Conservation Act 2016* (BC Act), which replaced the *WA Wildlife Conservation Act 1950* at the start of 2019. State and local matters, such as listed species and communities, are also considered in this assessment as part of the “Whole of Environment” approach to flora. In addition to the EPBC Act and Guideline 1.1, this report has been developed in consideration of the following policy documents and guidelines:

- EPA Position Statement No. 2 - Environmental Protection of Native Vegetation in Western Australia (EPA 2000),
- EPA Guidance Statement No. 33 - Environmental Guidance for Planning and Development (EPA 2008),
- EPA Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016),
- Keighery’s Macarthuria (Macarthuria keigheryi) Recovery Plan (DEC 2009),
- Wavy-leaved smokebush (Conospernmum undulatum) Recovery Plan (DEC 2009), and
- Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (TSSC 2016).

11.4 Impact Assessment Methodology

11.4.1 Impact Assessment Approach

Impact assessment of flora and vegetation from the NRP has been based upon Guideline 1.1 and Guideline 1.2 and is outlined in Figure 11-1. The environmental context identifies and describes the baseline flora and vegetation and the occurrence of flora and vegetation communities which are of conservation significance within the project area. Conservation significant flora and vegetation is defined in Section 11.4.2.

The impact assessment identifies threatening processes to flora, in particular to matters of environmental significance, and provides mitigation and avoidance measures. Impact significance is assessed using criteria outlined in Guideline 1.1 and Guideline 1.2. The assessment considers potential direct impacts, and indirect impacts

The potential impacting processes of the NRP have been identified as including:

- the clearing of native vegetation,
- habitat fragmentation,
- the introduction or spread of weed, disease and/or pest species,
- the interruption of plant-pollinator associations,
- the potential for increase in the occurrence of bushfire during construction and operation,
- an increase in the occurrence of dieback, and
- changes in the hydrological regime.

11.4.2 Flora and Vegetation of Conservation Significance

Flora species and vegetation communities of conservation significance are of special importance in impact assessment. The conservation status of flora and vegetation in Australia is assessed under Commonwealth and State Acts such as the EPBC Act and the BC Act. In addition, DBCA recognises and assigns priority levels. Therefore, two broad levels of conservation significance were developed and applied for the assessment (Table 11-1). Remnant native vegetation that are not of listed conservation significance were considered under the "Whole of Environment" component of the assessment.

Conservation Significance Level	Description
CS1	Species and communities listed under State or Commonwealth Acts
CS2	Species and communities listed as Priority by DBCA but not under legislative acts.

Table 11-1 Levels of conservation significance.
Source: Perth Airport (adapted from Woodman Environmental, 2019)

11.4.3 Determination of Significant Impacts

Significant Impacts are determined based on the impact to the species or community at the local and regional scale, as well as taking into consideration any other available information including range, reproductive ability and genetic diversity. Table 11-2 shows how the Impact Category is aligned with the severity of potential Impacts from Guideline 1.2.

Environmental Context within the Project Area

Identify and describe baseline flora and vegetation[1]

Identify occurrence of conservation significant flora and vegetation1 within the project area

Impact Assessment

Identify Threatening Processes to flora and vegetation

Identify broader and cumulative impacts to conservation significant flora and vegetation | Identify broader and cumulative impacts to "Whole of Environment" flora and vegetation

Identify Mitigation and Avoidance Measures to reduce broader potential impacts

Determine whether impacts to conservation significant flora are significant using Significance Criteria in Guideline 1.1 (CS1) and Guideline 1.2 (CS2) | Determine impact to native remnant vegetation (whole of environment flora) using Significance Criteria in Guideline 1.2

Figure 11-1 Impact Assessment Methodology for Assessing Impacts to flora and vegetation under the EPBC Act
Source: Perth Airport (adapted from Woodman Environmental, 2019)

[1] Conservation Significant Flora and Vegetation (CS flora and vegetation) includes MNES and non-MNES. Refer to Section 11.4.2 for definition of CS flora and vegetation.

Impact Category (Severity)	Characteristics of Impact Category	Severity of Potential Impacts Guideline 1.2
Negligible	No impacts to native vegetation. Any impacts are not discernible at the species or community level.	Minor - Generally have two or more of the following characteristics • short/reversible, • small scale/localise, or • low intensity.
Minor (Minor Adverse)	Impacts to native vegetation that are reversible. The EPA target of minimum threshold of pre-clearing extent for ecological communities is not exceeded. For a significant taxon (species, subspecies): • no permanent decrease in a local population, and/or critical habitat for the taxon, • any individuals to be impacted are likely to recover over time, and • there is no change to the conservation status of the taxon. For a significant community: • the occurrence of the community will be impacted; however, there is no permanent reduction in the area of the community, and • there is no change to the conservation status of the community.	
Moderate (Moderate Adverse)	Impacts to native vegetation that are not reversible. The EPA target of minimum threshold of pre-clearing extent for ecological communities is not exceeded. For a significant taxon (species, subspecies): • there is a permanent decrease of a local population, and/or critical habitat associated with the population, • the permanently-impacted population has been not been classified as an important population, and • there is no change to the conservation status of the taxon. For a significant community: • the occurrence of the community is permanently impacted however will not result in a permanent reduction in the area of occurrence of the community, • the occurrence of the community to be impacted is not considered to be an important occurrence, and • there will be no change to the conservation status of the community.	Moderate - Generally have two or more of the following characteristics • medium-long term, • small-medium scale, or • moderate intensity.
Major (High Adverse)	Impacts to native vegetation that are not reversible. The EPA target of minimum threshold of pre-clearing extent for ecological communities may be exceeded. For a significant taxon (species, subspecies): • there is a permanent decrease of a local population, and/or critical habitat associated with the population, • the permanently-impacted population has been classified as an important population, and • there will be a change to the listed conservation status of the taxon to a higher threat category but will not render the species to be listed as Extinct. For a significant community: • the occurrence of the community is permanently impacted resulting in a permanent reduction in the area of occurrence of the community; and • the permanently-impacted occurrence of the community is considered to be an important occurrence; and/or • there will be a change to the listed conservation status of the community to a higher threat category but will not render the community to be listed as Extinct in the wild (Presumed Totally Destroyed).	Severe - Generally have two or more of the following characteristics • permanent/ irreversible, • medium-large scale, or • moderate-high intensity.
Critical (Major Adverse)	Clearing of vegetation that is not reversible. Clearing results in a reduction below the EPA target of minimum threshold of pre-clearing extent for ecological communities, resulting in the community to be considered non-recoverable. For a significant taxon (species, subspecies): • the impact results in the species being listed as Extinct in the wild. • For a significant community: • the impact results in the community being listed as Extinct in the wild (Presumed Totally Destroyed).	

Table 11-2 Impact categories for determining severity of impacts
Source: Woodman Environmental, 2019

11.5 Environmental Context

11.5.1 Background

This subsection provides an overview of the flora and vegetation types that are present within the NRP, with reference to the Perth Airport estate and particular emphasis on conservation significant species. It provides:

- a description of the flora and vegetation types within the NRP,
- a list of conservation significant flora species and communities that occur within the NRP, and
- an examination of the vegetation values within the NRP for input into the impact assessment, including the following:
  - specific vegetation types and floristic composition,
  - vegetation condition, and
  - Listed and Priority Species and Communities.

11.5.2 Sources of Information

The desktop review included a search of the DBCA databases (WAHerb and FloraBase for information about specimens held by the WA Herbarium; and NatureMap), as well as a search of the EPBC Act Protected Matters database for the estate.

This information was supplemented with an analysis of previous survey reports for the Perth Airport estate as well as historical spatial data outlining vegetation mapping and the location of conservation significant flora and vegetation.

Table 11-3 shows the previous studies undertaken that have informed the current data.

Assessment Author	Title
Mattiske Consulting (2008)	Flora and Vegetation at the Perth Airport 2002-2007
Ecologia Environment (2013)	Perth Airport Flora and Vegetation Survey
Mattiske Consulting (2015)	Targeted Level 2 Flora and Vegetation Survey of Perth Airport Remnant Vegetation Areas – Assessment of Threatened and Priority Ecological Communities
Phoenix Environmental Services (2016)	Terrestrial and Aquatic Fauna and Vegetation Survey and Impact Assessment for the New Runway Project
Focused Vision Consulting (2017)	Significant Flora and Community Assessment
Dieback Treatment Services (2017)	*Phytophthora* Dieback Assessment of Vegetation for the New Runway Project
Strategen Environmental (2018)	Commonwealth Conservation Significant Flora and Vegetation Survey
Woodman Environmental (May 2018a)	Known Population Information of *Conospermum undulatum* (T) and *Macarthuria keigheryi* (T). Desktop Review
Woodman Environmental (May 2018b)	Known Population Information of Priority Flora – Perth Airport.
Woodman Environmental (2019)	Perth Airport New Runway Project. Flora and Vegetation Assessment

Table 11-3 Previous Studies undertaken on Perth Airport estate flora and vegetation
Source: Woodman Environmental, 2019

11.5.3 Overview of Flora and Vegetation Types

The flora and vegetation survey undertaken identified and defined ten native vegetation types, plus degraded and rehabilitated vegetation, within the NRP area. Table 11-4 shows the areas of vegetation type and conservation status of the associated EPBC Act (Commonwealth) and BC Act (WA) Listed communities in the NRP area. Table 11-5 provides descriptions of the ten native vegetation types. The location of the vegetation types mapped within the NRP area is shown in Figure 11-2.

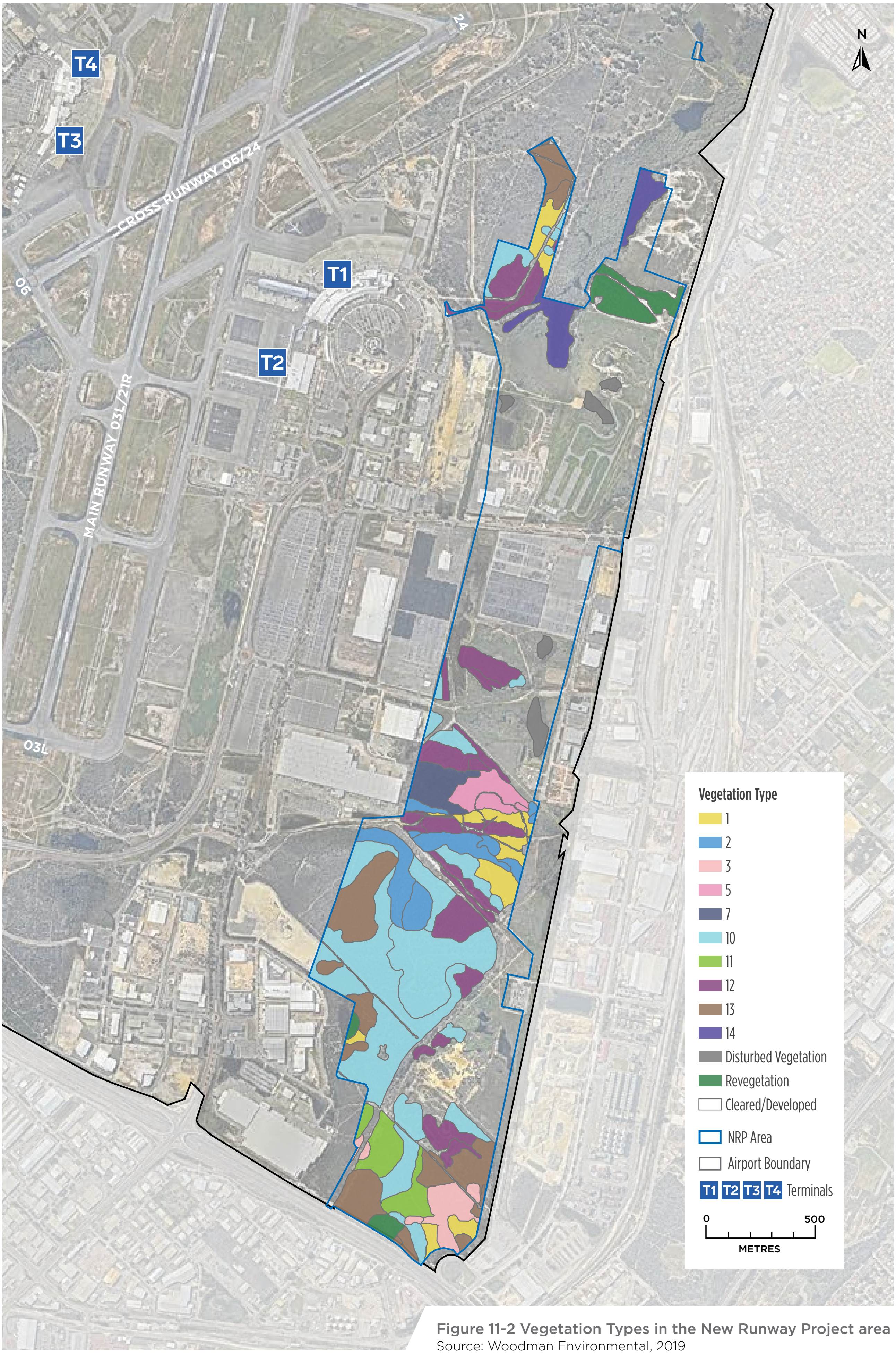


Figure 11-2 Vegetation Types in the New Runway Project area
Source: Woodman Environmental, 2019

Vegetation Type	Area Within NRP (ha)	Percentage of NRP Area	SCP Vegetation Type (Gibson *et al.* 1994)	EPBC Community Name	EPBC Conservation Status	WA Community Name	WA Conservation Status
VT 1	9.02	3.08	5	-	-	-	-
VT 2	10.24	3.50	5		-	-	-
VT 3	4.72	1.61	5	-	-	-	-
VT 5	4.08	1.39	15	-	-	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable
VT 7	3.94	1.35	13	-	-	-	-
VT 10	48.14	16.44	4	-	-	-	-
VT 11	6.28	2.15	4	-	-	-	-
VT 12	22.71	7.76	23a	Banksia Woodlands of the Swan Coastal Plain	Endangered	Banksia dominated woodlands of the Swan Coastal Plain IBRA region	P3
VT 13	20.59	7.03	23a	Banksia Woodlands of the Swan Coastal Plain	Endangered	Banksia dominated woodlands of the Swan Coastal Plain IBRA region	P3
VT14	6.35	2.17	13	-	-	-	-
Disturbed Vegetation	3.30	1.13	-	-	-	-	
Total Native Vegetation	139.35	47.60	-	-	-	-	-
Revegetation	6.64	2.27	-	-	-	-	-
Cleared/ Developed	146.76	50.13	-	-	-	-	-
Total	292.75	100	-	-	-	-	-

Table 11-4 The areas of vegetation type and conservation status of the associated EPBC and WA Listed communities within the NRP area.
Source: Woodman Environmental, 2019

Vegetation Type	Photograph
VT 1 Low isolated trees of *Melaleuca preissiana* over mid to low shrubland of mixed species dominated by *Hakea varia*, *Melaleuca seriata*, *Pericalymma ellipticum* var. *floridum*, *Verticordia densiflora* var. *densiflora* and *Astartea affinis* over low open rushland dominated by *Leptocarpus decipiens*, *Lyginia imberbis*, *Hypolaena exsulca* and *Cytogonidium leptocarpoides* over low sparse forbland of mixed species including *Aphelia cyperoides*, *Centrolepis aristata*, *Hyalosperma cotula*, *Tribonanthes australis* and *Siloxerus humifusus* in depressions or on flats that are seasonally waterlogged, on grey-brown or grey-black sandy loam.	 Plate 1: Typical VT 1 (Quadrat PA02)

Vegetation Type	Photograph
VT 2 Low woodland to forest dominated by *Melaleuca rhaphiophylla* over tall to mid open to sparse shrubland of mixed species including *Astartea affinis*, *Melaleuca lateritia*, *Hakea varia* and *Pericalymma ellipticum* var. *floridum* over low rushland and sedgeland to open rushland and sedgeland dominated by *Leptocarpus decipiens* and occasionally *Lepidosperma longitudinale* over low sparse forbland of mixed species including *Centrolepis aristata*, *Isolepis stellata*, *Juncus capitatus*, *Siloxerus filifolius* and *Isolepis cyperoides* on flats or in basins that are seasonally inundated, on grey or brown sand or sandy loams.	 Plate 2: Typical VT 2 (Quadrat PAIR48)  Plate 3: Variant of VT 2 – (*Banksia littoralis)* present in low woodland stratum, understorey also degraded (Quadrat PAIR34)

Table 11-5 Vegetation types identified in the Perth Airport estate.
Source: Woodman Environmental, 2019

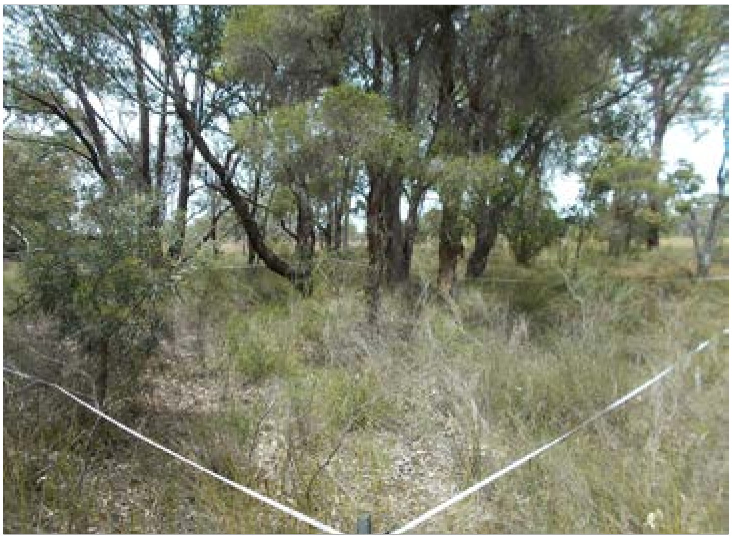
Vegetation Type	Photograph
VT 3 Low woodland to open woodland dominated by *Melaleuca preissiana* over mid open shrubland of mixed species including *Astartea affinis*, *Hypocalymma angustifolium* subsp. Swan Coastal Plain and *Pericalymma ellipticum* var. *floridum* over low sedgeland and rushland to open sedgeland and rushland of mixed species most often dominated by *Lepidosperma longitudinale*, *Schoenus efoliatus* and occasionally *Dielsia stenostachya* in depressions or drainage lines that are seasonally inundated, on grey or brown sandy loams.	 Plate 4: Typical VT 3 (Quadrat PAIR49)  Plate 5: Variant of VT 3 – Isolated mid trees of (*Eucalyptus rudis subsp.) rudis* and low trees of *Banksia littoralis* present (Quadrat PAIR41)
VT 5 Tall closed shrubland of *Melaleuca viminea* subsp. *viminea* over low sparse rushland of *Leptocarpus decipiens* over low open forbland of mixed species dominated by *Isolepis cernua* var. *setiformis* in deep depressions that are seasonally inundated, on grey brown sandy clay.	 Plate 6: VT 5 (Quadrat PA08)

Table 11-5 Vegetation types identified in the Perth Airport estate (Continued)

Vegetation Type	Photograph
VT 7 Low woodland dominated by *Melaleuca rhaphiophylla* and occasionally *Melaleuca viminea* subsp. *viminea* over low sedgeland and rushland dominated by *Baumea juncea* and *Leptocarpus coangustatus* on lake edges that appear semi-permanently inundated, on grey sandy loam.	 Plate 7: VT 7 (Quadrat PA10)
VT 10 Isolated mid trees of *Corymbia calophylla* over open low woodland of *Melaleuca preissiana* over mid to low open shrubland to shrubland of mixed species dominated by *Hypocalymma angustifolium* subsp. Swan Coastal Plain, *Jacksonia gracillima*, *Pericalymma ellipticum* var. *floridum*, *Melaleuca seriata* and *Daviesia physodes* over low rushland and sedgeland to open rushland and sedgeland of mixed species dominated by *Cytogonidium leptocarpoides*, *Dasypogon bromeliifolius*, *Patersonia occidentalis* var. *occidentalis*, *Phlebocarya ciliata* and *Schoenus efoliatus* on lower slopes of broad rises and flats that are seasonally waterlogged, on grey or white sand or sandy loam.	 Plate 8: Typical VT 10 (Quadrat PAIR42)
VT 11 Mid to low shrubland of mixed species dominated by *Hypocalymma angustifolium* subsp. Swan Coastal Plain, *Pericalymma ellipticum* var. *floridum*, *Melaleuca seriata*, *Euchilopsis linearis* and *Lechenaultia floribunda* over low open rushland and sedgeland dominated by *Cytogonidium leptocarpoides*, *Lyginia imberbis*, *Hypolaena exsulca*, *Dasypogon bromeliifolius* and *Phlebocarya ciliata* on lower slopes of broad rises and flats that are seasonally waterlogged, on brown sand.	 Plate 9: VT 11 (Quadrat PAIR50)

Table 11-5 Vegetation types identified in the Perth Airport estate (Continued)

Vegetation Type	Photograph
VT 12 Mid woodland of *Eucalyptus marginata* subsp. *marginata* over low woodland of *Allocasuarina fraseriana*, *Banksia menziesii* and *Banksia attenuata* over mid open to sparse shrubland of mixed species dominated by *Jacksonia floribunda* and *Calytrix fraseri* over low open shrubland of mixed species dominated by *Hibbertia hypericoides* subsp. *hypericoides*, *Bossiaea eriocarpa, Eremaea pauciflora* var. *pauciflora* and *Stirlingia latifolia* over low open to sparse sedgeland and rushland of mixed species including *Alexgeorgea nitens*, *Desmocladus flexuosus*, *Mesomelaena pseudostygia* and *Lyginia imberbis* on dunes and low rises on grey sand.	 Plate 10: Typical VT 12 (Quadrat PAIR01)  Plate 11: Variant of VT 12 – *Eucalyptus marginata* and *Allocasuarina fraseriana* absent, *Eucalyptus todtiana* present (Quadrat PAIR08)  Plate 12: Variant of VT 12 – *Xanthorrhoea brunonis subsp. brunonis* dominating mid shrubland stratum (Quadrat PAIR32)  Plate 13: Variant of VT 12 – Banksia trees few in low woodland stratum, *Corymbia calophylla* in mid woodland (Quadrat PAIR06)

Table 11-5 Vegetation types identified in the Perth Airport estate (Continued)

Vegetation Type	Photograph
VT 13 Low woodland to open forest of *Banksia menziesii, B. attenuata* and occasionally *Eucalyptus todtiana* over tall sparse shrubland dominated by *Adenanthos cygnorum* subsp. *cygnorum* over mid open to sparse shrubland of mixed species dominated by *Jacksonia floribunda* and *Melaleuca seriata* over low open shrubland of mixed species dominated by *Eremaea pauciflora* var. *pauciflora*, *Hibbertia hypericoides* subsp. *hypericoides*, *Scholtzia involucrata* and *Bossiaea eriocarpa* over low open to sparse sedgeland and rushland of mixed species dominated by *Alexgeorgea nitens*, *Dasypogon bromeliifolius*, *Patersonia occidentalis* var. *occidentalis*, *Desmocladus flexuosus* and *Lyginia imberbis* on dunes and low rises on grey sand.	 Plate 14: Typical VT 13 (Quadrat PAIR18)  Plate 15: Variant of VT 13 – tall and mid shrubland strata absent (Quadrat PAIR33)  Plate 16: Variant of VT 13 – Xanthorrhoea species prominent in mid shrubland stratum (Quadrat PAIR23)  Plate 17: Variant of VT 13 – *Banksia illicifolia* present in woodland stratum (Quadrat PAIR53)

Table 11-5 Vegetation types identified in the Perth Airport estate (Continued)

Vegetation Type	Photograph
VT 14 Low forest of *Melaleuca rhaphiophylla* and *Eucalyptus rudis* over low sparse forbland dominated by *Lemna disperma* in basins that are apparently semi-permanently or permanently inundated, on black sandy clay.	 Plate 18: VT 14
D - Disturbed Vegetation Highly degraded land with occasional native species present, however no intact vegetation structure and too few native taxa present to allocate a vegetation type or description.	 Plate 19: Examples of areas mapped as D, including areas with isolated remnant Banksia menziesii trees, planted Eucalyptus species, and isolated native understorey shrubs over weeds (left), and areas with isolated remnant Melaleuca rhaphiophylla trees over weeds (right).
R – Rehabilitated Historically disturbed areas revegetated with locally sourced seed of native species.	 Plate 33: Example of rehabilitation vegetation.

Table 11-5 Vegetation types identified in the Perth Airport estate (Continued)

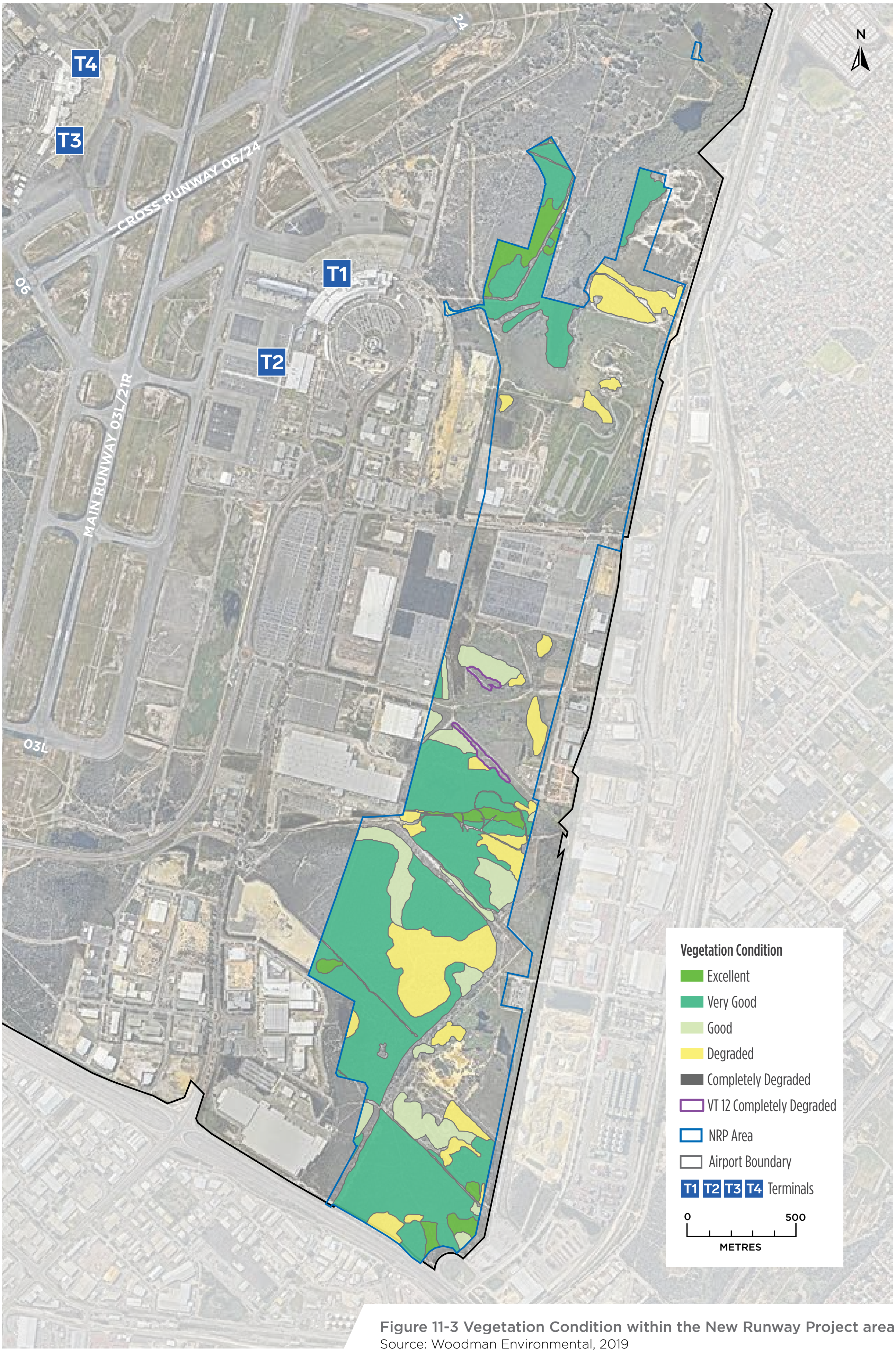


Figure 11-3 Vegetation Condition within the New Runway Project area
Source: Woodman Environmental, 2019

11.5.4 Vegetation Condition

The condition of vegetation across the NRP area is shown in Figure 11-3 and summarized in Table 11-6. The vegetation condition in over 50 per cent of the NRP area was classified as Completely Degraded About 40 per cent of the remnant vegetation in the NRP area was considered to be in Good to Excellent condition. A small area (1.27 hectares representing 0.43 % of the NRP) of Vegetation Type 12 VT-12 (associated to the EPBC Act Banksia Woodlands of the Swan Coastal Plain) was categorised as vegetation being in a Completely Degraded condition. Although the vegetation in these areas lacked structure and was almost completely devoid of native flora, the areas were assigned a VT based on their position in the landscape, local topography and the presence of trees species indicative of the adjacent VT-12. The assignment of the area to the VT-12 supports the Conservation Advice for the Banksia Woodlands TEC that degraded/modified areas that may not meet condition thresholds may still retain important natural values. The Conservation Advice states the areas should not be excluded from recovery and other management action that may improve the patches to a point that they may be regarded as part of the ecological community and become fully protected under the EPBC Act.

No vegetation in the NRP area was considered to be in pristine condition due to the presence of weed species and evidence of disturbance, including feral animals, and vehicle tracks across the entire NRP area.

11.5.5 Threatened Flora – Commonwealth and State Listed Species

An assessment of relevant Commonwealth and State databases and review of reports prepared since 2008 was undertaken to identify Commonwealth and State listed threatened flora within the Perth Airport estate (Woodman Environmental 2019). Table 11-7 shows the ten listed species reported to occur within the NRP and their conservation status.

Vegetation Condition Category	Area (Hectares)	Per cent of NRP Area
Pristine	0	0
Excellent	7.64	2.61
Very good	91.54	31.27
Good	17.45	5.96
Degraded	21.47	7.33
Completely Degraded (VT-12)	1.27	0.43
Total area of remnant vegetation – Completely Degraded to Pristine	**139.37**	**47.60**
Revegetation	**6.64**	**2.27**
Completely Degraded (Cleared/Developed)	**146.76**	**50.13**
Total	**292.77**	**100**

Table 11-6 Summary of the vegetation condition within the NRP
Source: Woodman Environmental, 2019

Listed species in the Perth Airport estate	EPBC Act Conservation Status	WA Conservation Status	Reference
Conospermum undulatum	Vulnerable	Vulnerable	Mattiske Consulting (2008); Ecologia Environmental (2013); Phoenix Environmental Services (2016); Focused Vision Consulting (2017); Strategen Environmental (2018); Woodman Environmental (2019)
Jacksonia gracillima	-	P3	Mattiske (2015); Focused Vision (2017); Strategen Environmental (2018); Woodman Environmental (2019)
Johnsonia pubescens subsp. *cygnorum*	-	P2	Woodman Environmental (2019)
Macarthuria keigheryi	Endangered	Endangered	Mattiske (2008); Ecologia (2013); Phoenix Environmental (2016); Focused Vision (2017); Strategen Environmental (2018); Woodman Environmental (2019)
Ornduffia submersa	-	P4	Mattiske (2008); Mattiske (2015)
Platysace ramosissima	-	P3	Mattiske (2008); Phoenix Environmental (2016)
Schoenus benthamii	-	P3	Mattiske (2008); Phoenix Environmental (2016); Woodman Environmental (2019)
Schoenus pennisetis	-	P3	Woodman Environmental (2019)
Stylidium longitubum	-	P4	Mattiske (2008); Ecologia (2013); Woodman Environmental (2019)
Verticordia lindleyi subsp. *lindleyi*	-	P4	Ecologia (2013); Mattiske (2015); Phoenix Environmental (2016); Strategen Environmental (2018); Woodman Environmental (2019)

Table 11-7 Listed flora species within NRP area
Source: Woodman Environmental, 2019

11.5.6 Ecological Communities reported as present within NRP

Table 11-8 shows the ecological communities reported as occurring within the NRP area. However, the most recent survey and statistical analysis (Woodman Environmental, 2019) have shown that four of the previously reported ecological communities do not occur within the NRP. These are:

- SCP21c - Low lying *Banksia attenuata* woodlands or shrublands,
- SCP20a - *Banksia attenuata* woodland over species rich dense shrublands,
- SCP20b - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain, and
- SCP07 - Herb rich saline shrublands in clay pans.

For the purposes of this impact assessment these four Floristic Community Types (FCTs) are regarded as not present in the NRP.

Ecological Community	Reported Present in NRP	EPBC Act status	WA Status	Comment
SCP20a - *Banksia attenuata* woodland over species rich dense shrublands	Yes Mattiske 2015 Phoenix 2016;	Endangered As a component of the Banksia Woodlands of the Swan Coastal Plain TEC	Endangered	DBCA occurrence based on quadrat Perth07, and not found by Woodman (2019).
SCP20b - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Yes Phoenix 2016	Endangered As a component of the Banksia Woodlands of the Swan Coastal Plain Ecological Community	Endangered	DBCA occurrence based on quadrat Perth03, and not found by Woodman (2019).
SCP07 - Herb rich saline shrublands in clay pans	No Not found in any study including most recent (Woodman 2019)	Critically Endangered As a component of the Claypans of the Swan Coastal Plain Ecological Community	Vulnerable	DBCA occurrence based on quadrat Perth05, and not found by Woodman (2019).
SCP21c - Low lying *Banksia attenuata* woodlands or shrublands	Yes Mattiske 2015 Phoenix 2016 Focused Vision 2017 Strategen 2018	Endangered As a component of the Banksia Woodlands of the Swan Coastal Plain Ecological Community	P3	-
SCP15 – Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Yes Woodman Environmental 2019	N/A	Vulnerable	-
Banksia dominated woodlands of the Swan Coastal Plain IBRA region	Yes DBCA Mattiske 2015 Phoenix 2016 Focused Vision 2017 Strategen 2018 Woodman 2019	Endangered – As a component of the Banksia Woodlands of the Swan Coastal Plain Ecological Community	P3	Considered equivalent to the Banksia Woodlands of the Swan Coastal Plain Ecological Community. Occurrence based on previous reports and DBCA records
Banksia Woodlands of the Swan Coastal Plain	Yes DoEE Mattiske 2015 Phoenix 2016 Focused Vision 2017 Strategen 2018 Woodman 2019	Endangered	Not Applicable	Occurrence based on previous reports and DBCA records

Table 11-8 Ecological Communities reported as present in the NRP
Source: Woodman Environmental, 2019

SCP07 Herb rich saline shrublands in clay pans

Herb rich saline shrublands in clay pans is listed as a TEC and classified as Vulnerable pursuant to the EPBC Act. This TEC also forms a component of the EPBC Act listed Clay pans of the Swan Coastal Plain ecological community, which is classified as Critically Endangered.

SCP07 was originally identified within the Airport estate by the DBCA (then DPaW). However, the Woodman Environmental (2019) analysis of mapped vegetation types against the FCTs defined by Gibson *et al*. (1994) found no association between the quadrat sampled on the estate with the majority of DBCA quadrats classified as SCP07. The single DBCA quadrat which was recorded within the reported TEC occurrence is more floristically similar to quadrats of SCP05 and not SCP07.

The Woodman Environmental (2019) analysis concludes that classification analysis of floristic data collected during spring 2018 has demonstrated that the record of SCP07 at Perth Airport is likely to be erroneous. It is therefore concluded that the Clay pans of the Swan Coastal Plain ecological community is not present in the Perth Airport estate and therefore not present within the NRP.

11.5.7 Dieback

11.5.7.1 Dieback Assessment

A dieback (*Phytophthora cinnamomi*) disease assessment was undertaken during 2017 (Dieback Treatment Services, 2017) over an area within the Perth Airport estate that encompassed the NRP. The assessment was conducted in accordance with guidelines set out by the *Phytophthora* Dieback Interpreters Manual for Lands Managed by the Department of Parks and Wildlife Forest and Ecosystems Management (DPaW, 2015b) Fieldwork was undertaken in April and May of 2017 following heavy (190 mm) rainfall conditions in February considered ideal for expression of the disease by indicator plants and for sampling to recover (identify) *Phytophthora* in soil and plant-tissue.

11.5.7.2 Dieback Status

Figure 11-4, Dieback Status within the New Runway Project Area, shows the dieback status of the assessed area within the Perth Airport estate that encompasses the NRP. The areas of each dieback category and the contribution to the NRP area are summarised in Table 11-9.

Dieback Interpretation Category	Area (hectares)	Per cent of NRP
Uninfested	16.3	5.6
Infested	116.2	39.7
Uninterpretable	11.3	3.9
Excluded	149.2	50.8
Total	**293**	**100**

Table 11-9 Area of each dieback category within the NRP
Source: Woodman Environmental, 2019

The observed disease impact was considered moderate to high along all mapped disease edges, with obvious loss of vegetation structure, biodiversity and biomass within a short distance from the active disease edge moving into the infested vegetation.

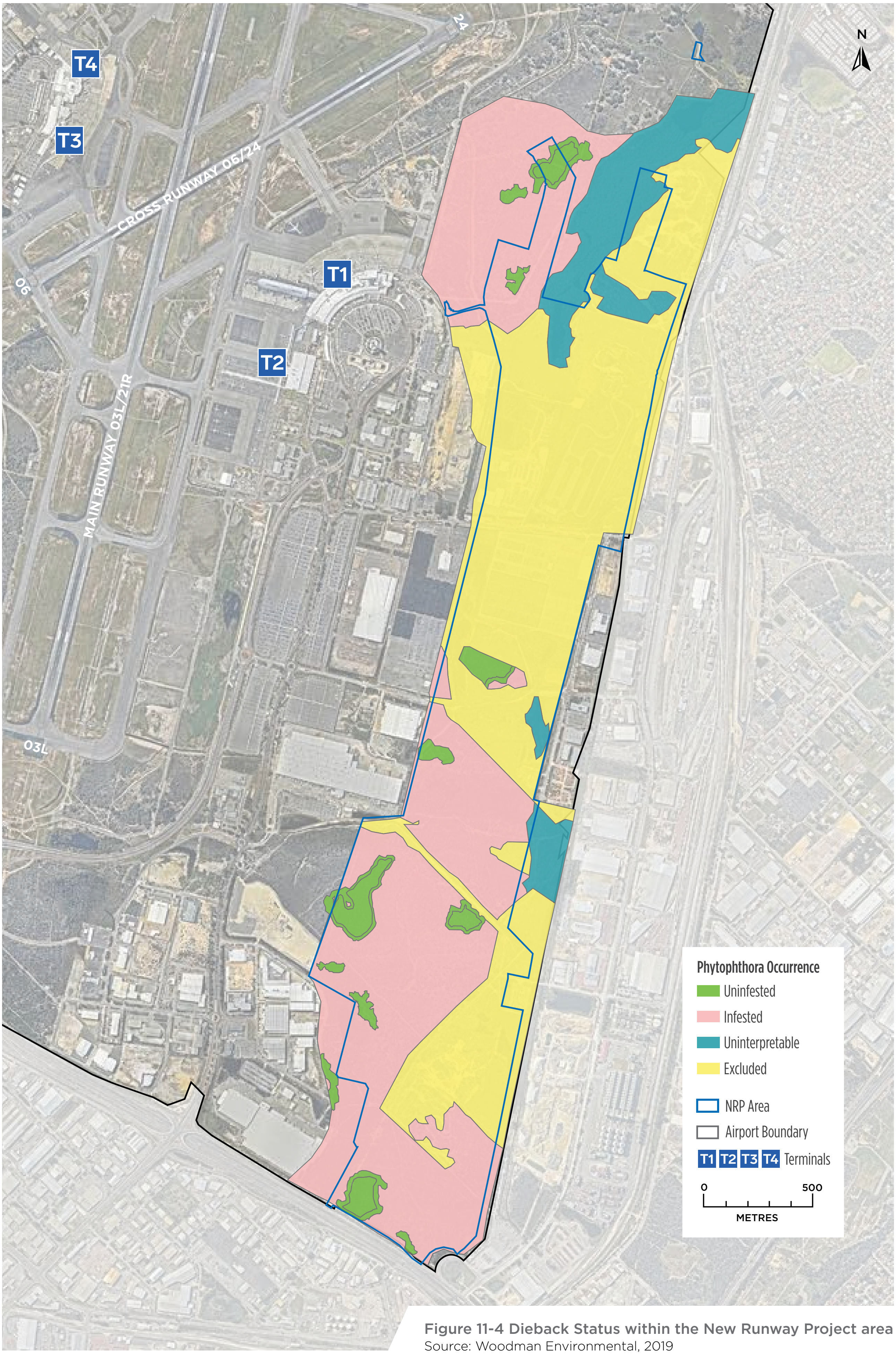


Figure 11-4 Dieback Status within the New Runway Project area
Source: Woodman Environmental, 2019

11.5.8 Aquatic Flora

Sampling of aquatic flora was conducted in Munday Swamp in 2015 (Phoenix 2016), utilising the methodology of Strehlow *et al*. (2011). Samples were collected from three locations in Munday Swamp, two under the canopy of Melaleuca trees, the other in open water. Physico-chemical parameters were measured at each of the three sites. Where present, submerged macrophyte biomass and depth of benthic microbial community were estimated. The percentage cover of macrophytes algae or benthic communities was also estimated in the field.

Three species were recorded from the samples and identified as follows:

- *Elatine gratioloides* – both shallow sites
- *Ottelia ovalifolia* – open-water site and
- *Lepilaena australis* – open-water site

11.5.9 Conservation Significant Flora and Vegetation

As part of the vegetation survey of Perth Airport estate (Woodman Environmental 2019), a desktop review of historical surveys as well as both national and state databases was undertaken to identify conservation significant flora and vegetation within the Perth Airport estate area. These include State and commonwealth listed communities and flora. The conservation significant flora and vegetation within NRP are listed in Table 11-10. Section 11.6 assesses the potential impacts of the NRP project on each of the conservation significant flora and vegetation.

Conservation Significant Flora and Vegetation	Conservation Significance	EPBC Act Conservation Status	BC Act Conservation Status	Other
Banksia Woodlands of the Swan Coastal Plain TEC	(CS1)	Endangered	-	P3 DBCA Priority Flora category
SCP15 – forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	(CS1)	-	Vulnerable	-
Conospermum undulatum	(CS1)	Vulnerable	Vulnerable	-
Jacksonia gracillima	(CS2)	-	-	P3 DBCA Priority Flora category
Johnsonia pubescens subsp. *cygnorum*	(CS2)	-	-	P2 DBCA Priority Flora category
Macarthuria keigheryi	(CS1)	Endangered	Endangered	-
Ornduffia submersa	(CS2)	-	-	P4 DBCA Priority Flora category
Platysace ramosissima	(CS2)	-	-	P3 DBCA Priority Flora category
Schoenus benthamii	(CS2)	-	-	P3 DBCA Priority Flora category
Schoenus pennisetis	(CS2)	-	-	P3 DBCA Priority Flora category
Stylidium longitubum	(CS2)	-	-	P4 DBCA Priority Flora category
Verticordia lindleyi subsp. *lindleyi*	(CS2)	-	-	P4 DBCA Priority Flora category
Clearing of Remnant Native Vegetation	(CS2)	-	-	Environmental Protection Authority (2008)

Table 11-10 Conservation significant flora and vegetation that occur within the NRP area
Source: Woodman Environmental, 2019

11.6 Impact Assessment

This section provides details on the potential impacts that may occur as a result of the project, taking into account all elements and project phases. Impacts to conservation significant flora and vegetation, and "Whole of Environment" flora are assessed against the definition of significance in Guideline 1.1. Refer to Section 11.4 (Impact Assessment Methodology) for the approach to assessing impacts to flora and to definitions of impact classes.

11.6.1 Clearing of Remnant Vegetation – Whole of Environment

11.6.1.1 Overview

The NRP potentially impacts on 139.4ha of remnant native vegetation: 81.4 per cent was rated in Good to Excellent condition and 18.6 per cent in Degraded condition.

The areas of vegetation in the NRP recorded to be in excellent condition may be considered locally significant as they represent patches of comparatively high native species diversity in otherwise degraded vegetation. Most of the remnant native vegetation may be considered locally significant representing habitat for conservation significant flora. This includes the threatened flora *Conospermum undulatum* and *Macarthuria keigheryi* and State-listed priority flora.

The NRP occurs within the Swan Coastal Plain 2 IBRA subregion which is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains and paperbark (Melaleuca) in swampy areas.

11.6.1.2 Direct Impacts

A maximum of 139.4 hectares of remnant native vegetation will be cleared for NRP.

There is currently 1,195 hectares of the Bassendean 1018 Vegetation System Association remaining on the Swan Coastal Plain, representing 14.9 per cent of the pre-European extent of approximately 8,000 hectares. Of the remaining patches 0.17 per cent lies within conservation estate (Government of Western Australia 2019). Impacts of the NRP will lead to a decline of up to 142 hectares, approximately 1.76 per cent of the pre-European extent of the system, with the remaining 1,053 hectares representing approximately 13.14 per cent of the pre-European extent.

The EPA (2000) considered the threshold level below which species loss appears to accelerate exponentially at an ecosystem level as being at a level of 30 per cent of the pre-clearing extent of the vegetation type. A level of ten per cent of the original extent is considered being a level representing "endangered". The EPA (2018) proposes that ecological communities in constrained areas of the Swan Coastal Plain are maintained at above ten per cent of the pre-clearing extent of the ecological community. The potential impact of the NRP on the remaining remnant vegetation constitutes a minor adverse impact as the target of minimum threshold of pre clearing extent for ecological communities is not exceeded (see Table 11-2). Further discussion on the impacts, severity and proposed avoidance and mitigation measures is shown in Table 11-11.

11.6.1.3 Indirect Impacts and Mitigation Measures

Indirect impacts include:

- unintended disturbance/clearing of vegetation outside the project boundary during construction activities,
- spread of weeds or dieback into the remaining vegetation outside the project area as a result of construction activities,
- changes in fire regime during construction and operational phases, and
- impact from dust, chemicals such as oil and fuel, during construction and operations.

11.6.1.4 Significance of Residual Impacts on Native Vegetation

At the local scale the NRP potentially reduces the extent of remnant native vegetation from 23.4 per cent to 16.8 per cent of the Perth Airport estate. At the regional scale the current extent of the vegetation association is below the threshold of 30 % of pre-clearing extent which the EPA (2000) considers species loss appears to accelerate. The NRP potentially impacts on 11.9 per cent of the remaining area (1,195ha) of the vegetation association leaving 1,053ha representing 13.14 per cent of the pre-European extent. Although this potentially reduces the representation of the vegetation, the remaining extent remains above a level representing "endangered" (EPA 2000).

The remnant vegetation within the NRP provides habitat for conservation significant vegetation and conservation significant flora (addressed in following sections) and therefore the potential impacts of the NRP on remnant vegetation are considered significant.

Impact Type	Threatening Process	Severity	Discussion (Potential Impacts)	Proposed Mitigation Measures
Direct	Clearing and site preparation	Moderate	The NRP will potentially impact 139.4 hectares of remnant vegetation: This represents 28.4 per cent of local extent within the Perth Airport estate The NRP potentially impacts on 11.9 per cent of the remaining area of the vegetation association leaving 1053 hectares representing 13.14 hectares of the pre-European extent (above the EPA target of ten per cent in constrained areas of the Swan Coastal Plain)	Avoidance from direct impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction
Indirect	Unintentional clearing and site preparation	Minor	There is potential for unintentional clearing of areas of remnant vegetation outside the Project area	A Conservation Environmental Management Plan (CEMP) will address the design and operations for clearing area and demarcate (signage/fencing) exclusion zones for areas needing protection. Disturbed areas can be rehabilitated
Indirect	Introduction of invasive species	Minor	Spread of weeds	A CEMP will address soil hygiene to prevent introduction and spread of weeds
Indirect	Plant pollinator associations	Negligible	Plant pollinator populations are likely to be widespread and potentially mobile across large distances There are no recorded plant species in the NRP that have unique pollinators that may be impacted by the clearing Given the localised nature of clearing and the current isolated nature of the vegetation from large areas of intact native vegetation, impacts to plant pollinator relationships (impact to pollinator populations or remnant vegetation) is unlikely to be detectable	Avoidance from potential indirect impact of the NRP is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction
Indirect	Introduction of disease - dieback	Minor	Currently most of the remnant vegetation within the NRP is infested with dieback. Unintentional spread will accelerate the rate of infestation	A CEMP will address soil hygiene procedures to prevent introduction and spread of dieback
Indirect	Habitat fragmentation	Moderate	Very small areas of remnant vegetation remain on the eastern side of the NRP. These are likely to be infested with dieback and are unlikely to be viable remnants in the long term	Avoidance from impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction
Indirect	Change to fire regime	Minor	Increase burning may adversely affect the vegetation, however native plants are adapted to fire and the vegetation likely to recover after burning with management of weed invasion	Perth Airport currently maintains a fuel load management fire regime and a CEMP that will address control of introduced species in the estate

Table 11-11 Impacts, Severity and Proposed and Mitigation Measures for remnant vegetation
Source: Woodman Environmental, 2019

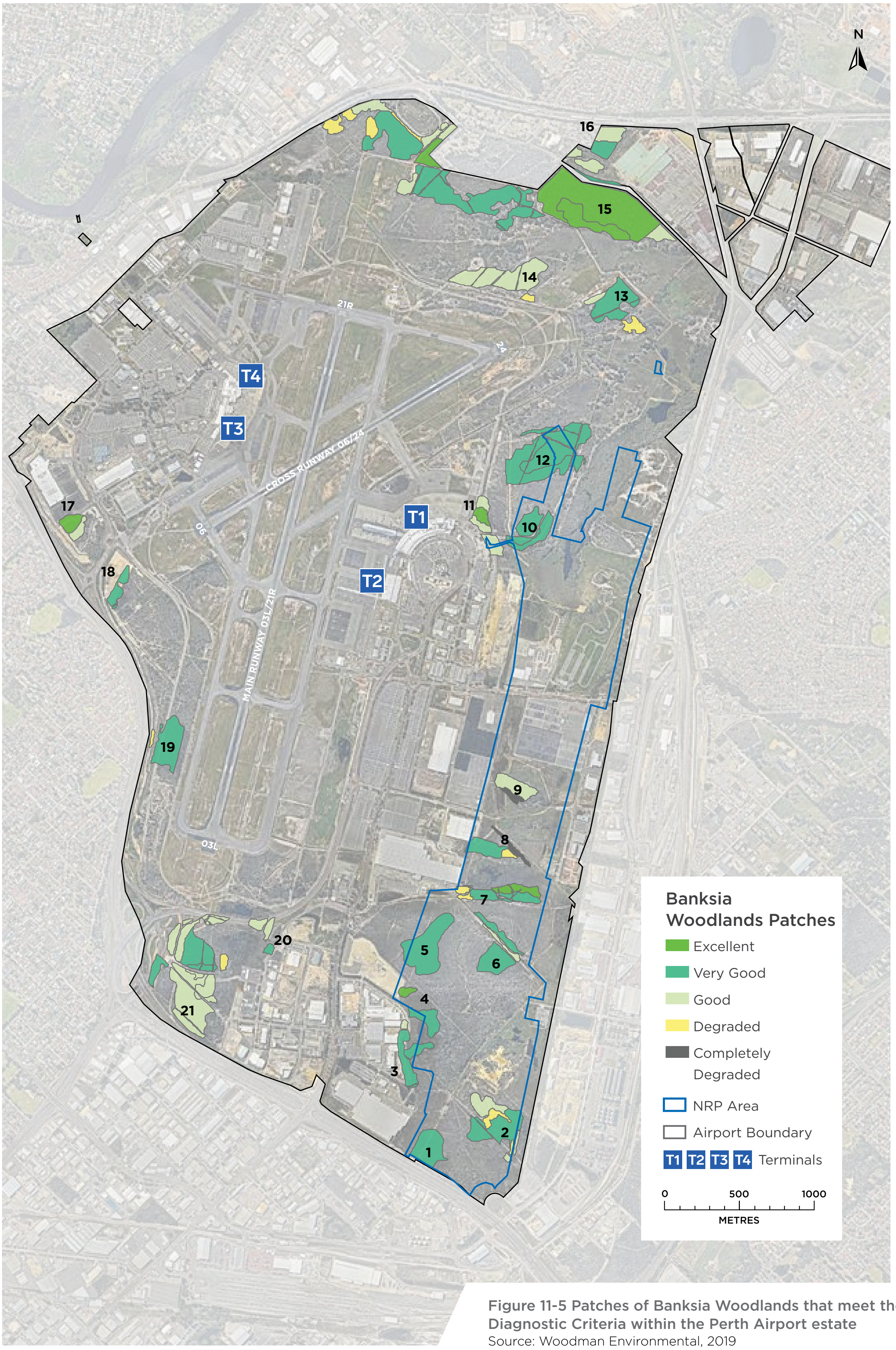


Figure 11-5 Patches of Banksia Woodlands that meet the Diagnostic Criteria within the Perth Airport estate
Source: Woodman Environmental, 2019

11.6.2 Vegetation - Threatened Ecological Communities (TECs)

11.6.2.1 Banksia Woodlands of the Swan Coastal Plain TEC

Overview

The EPBC Act lists the Banksia Woodlands of the Swan Coastal Plain community as endangered. Under State conservation management by DBCA, this community is considered equivalent to the Banksia dominated woodlands of the Swan Coastal Plain IBRA Region and classified as a Priority 3 Ecological Community. Priority Ecological Communities are those ecological communities which have insufficient information available to be considered a TEC, or which are rare but not currently threatened. Woodman (2019) identified Vegetation Type 12 and 13 as Banksia Woodlands TEC. Figure 11-2 shows the vegetation types by area within the NRP, and Table 11-4 shows the areas of vegetation type and conservation status of the associated EPBC Act and WA BC Act listed communities found within the Perth Airport Estate and NRP area (Woodman Environmental 2019).

The Conservation Advice (TSSC 2016) for the TEC indicates the extent of the Banksia Woodlands remaining on the Swan Coastal Plain bioregion is approximately 336,490 hectares. Of the current extent, 81,830 hectares, representing 24.4 per cent, is within reserves. In total about 60 per cent of the original extent of the community has been cleared. The community has become heavily fragmented with the number of patches being divided from around 132 into over 12,000 patches. The original median patch size estimate of 146 hectares has been reduced to 1.6 hectares. (DoEE, 2016c).

The EPBC Conservation advice for the Banksia Woodlands TEC specifies threshold vegetation conditions and sizes for a patch to be considered as part of the listed community. These involve a minimum patch size based on vegetation condition as follows:

- Pristine - no minimum patch size,
- Excellent – 0.5 hectares,
- Very Good – one hectare, and
- Good – two hectares.

Figure 11-5 shows the location and condition of the 21 patches within the Perth Airport estate that meet the criteria for the Banksia Woodlands TEC.

The Perth Airport estate supports a total of 146.87ha of Banksia Woodlands TEC comprising:

- 24ha in Excellent condition,
- 79.06ha in Very Good condition,
- 36.23ha in Good condition,
- 6.49ha in Degraded condition, and
- 1.27ha in Completely Degraded condition.

Pristine patches of Banksia Woodlands TEC with no obvious signs of disturbance and zero (or almost absent) weeds were not recorded in the Perth Airport estate.

To inform the assessment of significance, the Conservation Advice requests additional contextual information. Table 11-12 provides this information for the Banksia Woodlands TEC within the NRP area.

Key Diagnostic Characteristics	Information	Key Diagnostic Questions	Response
Patch condition	Condition thresholds	What is the patch condition using the condition categories outlined in the consultation advice?	There are twelve patches of the Banksia Woodlands TEC in the NRP area with condition ranging from excellent to degraded. Figure 11-5 shows the distribution of the patches and their condition rating.
Patch size	Patch size in hectares	Is the patch size large enough to meet criteria in the consultation advice?	The patches identified to occur in the NRP area have been determined based on the Conservation Advice for condition and patch sizes. Table 11-13 summarises the patch sizes and condition within the NRP area.
	Surrounding buffer	What is the size and vegetation type in the surrounding buffer? And what is the connectivity to the surrounding vegetation?	All Banksia Woodlands TEC patches are connected to adjacent native vegetation, of which most is dieback infested, or disturbed/ cleared land that is uninterpretable. These larger patches of remnant vegetation are isolated from other areas of native vegetation within the Airport Estate
Location and physical environments	Regional distribution and quality	Quantity/quality of vegetation community in, and in the region around, the site of the proposed action	Most of the area surrounding the NRP is developed or under development. The NRP area is bounded by roads, airport infrastructure and Munday Swamp. The quality of vegetation communities in and around the NRP area varies from completely degraded to excellent condition. External to the estate there are a number of reserves that contain native vegetation which resembles the TEC. These reserves include: • Bush Forever site 481 (31.5 ha, 2 km north-east of the Estate) • Bush Forever site 123 (15.1 ha, 1.5 km east of the Estate) • Bush Forever site 319 (58.1 ha, 0.5 km east of the Estate) • Bush Forever site 311 (21.4 ha, 1 km north of the Estate)

Table 11-12 Key diagnostic characteristics and other information of the Banksia Woodlands Threatened Ecological Community
Source: Woodman Environmental, 2019

Key Diagnostic Characteristics	Information	Key Diagnostic Questions	Response
Other condition considerations	Presence/absence and spread of *Phytophthora cinnamomi* (dieback)	If present, how much dieback exists and is the proposed action likely to spread dieback further or increase its impact? If not present, can its introduction be avoided?	Most of the NRP area is infested with *Phytophthora cinnamomi* (dieback disease) as shown in Figure 11-4. A Dieback Management Plan should form part of the Construction and Operational Environmental Management Plans.
	Presence/absence weeds	Does the patch contain weeds? Which species are present, in what densities, and how can they be managed?	Weeds were recorded in all the quadrats established during the survey. Hygiene procedures should form part of the Construction and Operational Environmental Management Plans.
	Any other notable disturbance to the site where relevant (i.e. fragmentation, introduction of edge effects, fire regimes, bare patches, erosion, feral animals)	What disturbance is present which may degrade the quality of the community? For any/each form of disturbance, what is the degree of the disturbance? Is there evidence of recruitment of key native plant species following disturbance?	The area surrounding the site is either developed (roads) or swamp. Within the site, there are highly disturbed areas, developed areas and bare patches infested with weeds. Other disturbances recorded in the NRP area include digging by rabbits and the presence of dieback.
	Patch isolation	Is the patch connected to other areas of Banksia Woodlands or is it isolated? What are the characteristics of those connected areas?	The site contains 12 eligible patches or parts of patches of Banksia Woodlands TEC; some extend beyond the boundaries of the NRP area. The site also contains other non-TEC vegetation as shown in Figure 11-2.
	Presence of other biodiversity values	Does the site (or surrounds) contain other biodiversity values?	The site contains habitat for black cockatoos. The NRP area also contains other listed flora taxa discussed in 11.6.4.
Sub-community and vegetation unit	Broad scale structural unit (Beard vegetation associations)	Provide the closest corresponding Beard vegetation association(s)	The site sits within the Bassendean – 1018 vegetation association.
	Broad scale structural unit (Vegetation complexes)	Provide the closest corresponding vegetation complex(s)	The site sits within the Southern River complex
	Swan Coastal Plain (SCP) vegetation type (see table 11-4)	Provide the closest resemblance of floristic community type(s).	Results of the 2018 (Woodman Environmental 2019) survey undertaken to verify the presence of Banksia Woodlands on the estate identified the patches presented the closest resemblance to SCP 23a (Banksia Woodlands).
	Western Australian ecological community listing	Is this ecological community listed in WA?	SCP 23a is listed in Western Australia as a Priority 3 Ecological Community.
Surveying	Timing of the surveying	Ideally surveys should be undertaken in spring with two sampling periods to capture early and late flowering species. When was sampling undertaken at the proposed site? If vegetation community has not been identified, is there any specific reason?	Surveys were undertaken from mid-October to early December 2018 (Woodman 2019)

Table 11-12 Key diagnostic characteristics and other information of the Banksia Woodlands Threatened Ecological Community (continued)
Source: Woodman Environmental, 2019

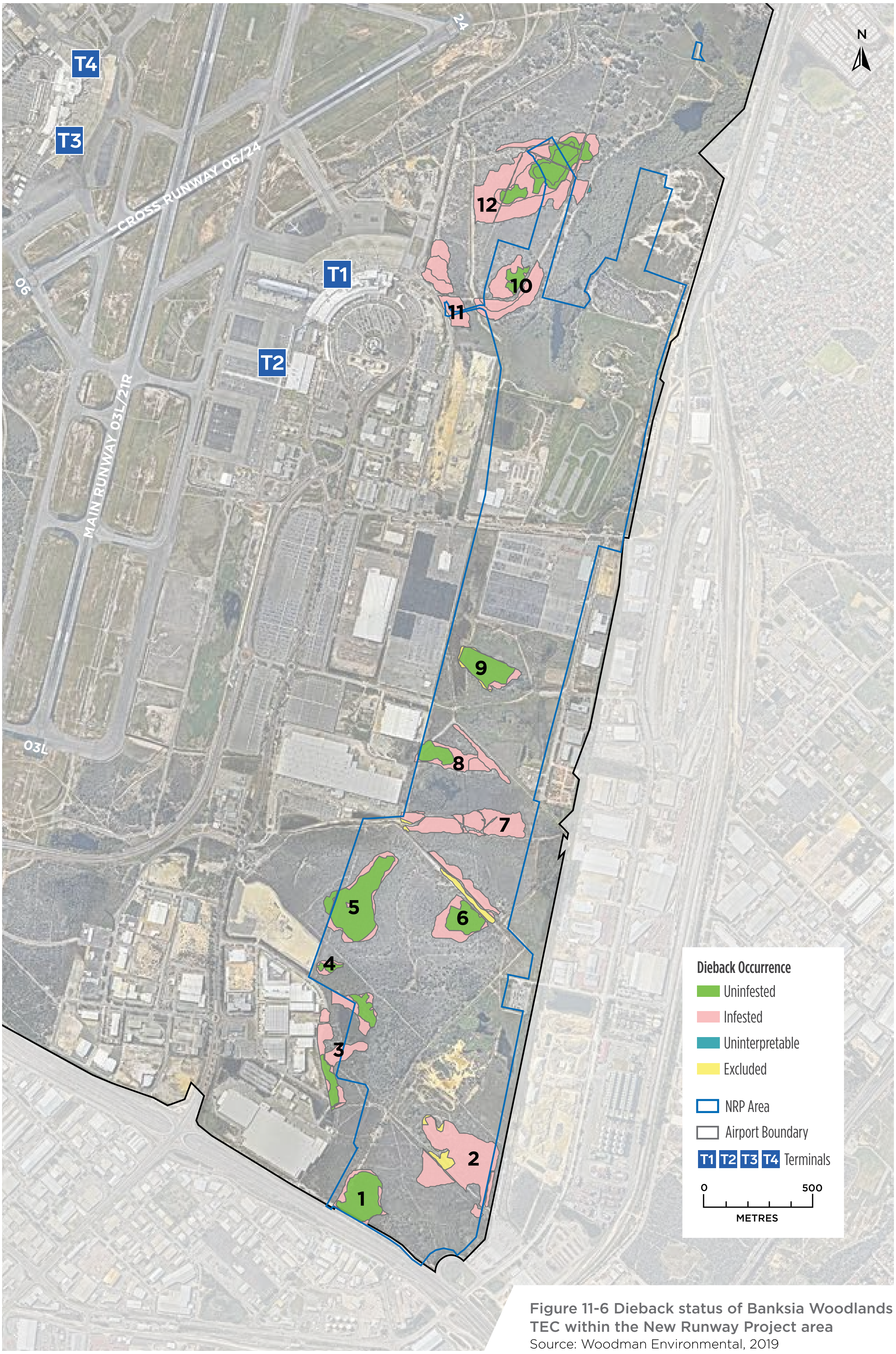


Figure 11-6 Dieback status of Banksia Woodlands TEC within the New Runway Project area
Source: Woodman Environmental, 2019

Direct Impacts and Mitigation

A total of up to 40.04 hectares of Banksia Woodlands TEC will be directly impacted by the NRP. Figure 11-6 shows the location and dieback status of all eligible Banksia Woodlands TEC patches within the Perth Airport estate. Patches 1-12 will be impacted by the NRP area. Table 11-13 shows the area and condition of each patch directly impacted by the NRP.

Table 11-14 shows the potential severity of impacts on the Banksia Woodlands TEC and associated avoidance and mitigation measures to manage residual risks of impacts to the TEC as a result of the NRP.

Patch Number	Area of Patch Condition (hectares)					Area of Patch Within the NRP (hectares)	Total Area of Patch (hectares)	Area of Patch Remaining (hectares)
	Excellent	Very good	Good	Degraded	Completely Degraded			
1	0	3.50	0	0	0	3.50	3.50	0
2	0	4.38	2.03	0.91	0	7.32	7.86	0.54[1]
3	0	1.91	0	0	0	1.91	5.19	3.28
4	0.50	0	0	0	0	0.50	0.50	0
5	0	5.87	0	0	0	5.87	6.40	0.53[1]
6	0	4.17	0.65	0	0	4.82	4.82	0
7	0	2.32	0	0.64	0	2.96	2.98	0.02[1]
8	0	2.00	0	0.37	0.75	3.12	3.17	0.05[1]
9	0	0	2.26	0	0.52	2.78	2.78	0
10	0	4.04	0	0	0	4.04	4.26	0.22[1]
11	0	0	0.16	0	0	0.16	3.15	2.99
12	0	3.06	0	0	0	3.06	12.76	9.70
Total area impacted within NRP (hectares)	0.50	31.25	5.10	1.92	1.27	40.04	-	-

Table 11-13 Area of Banksia Woodlands Threatened Ecological Community patches impacted as a result of the NRP
Source: Woodman Environmental, 2019

[1] Remainder of Patch no longer meets criteria

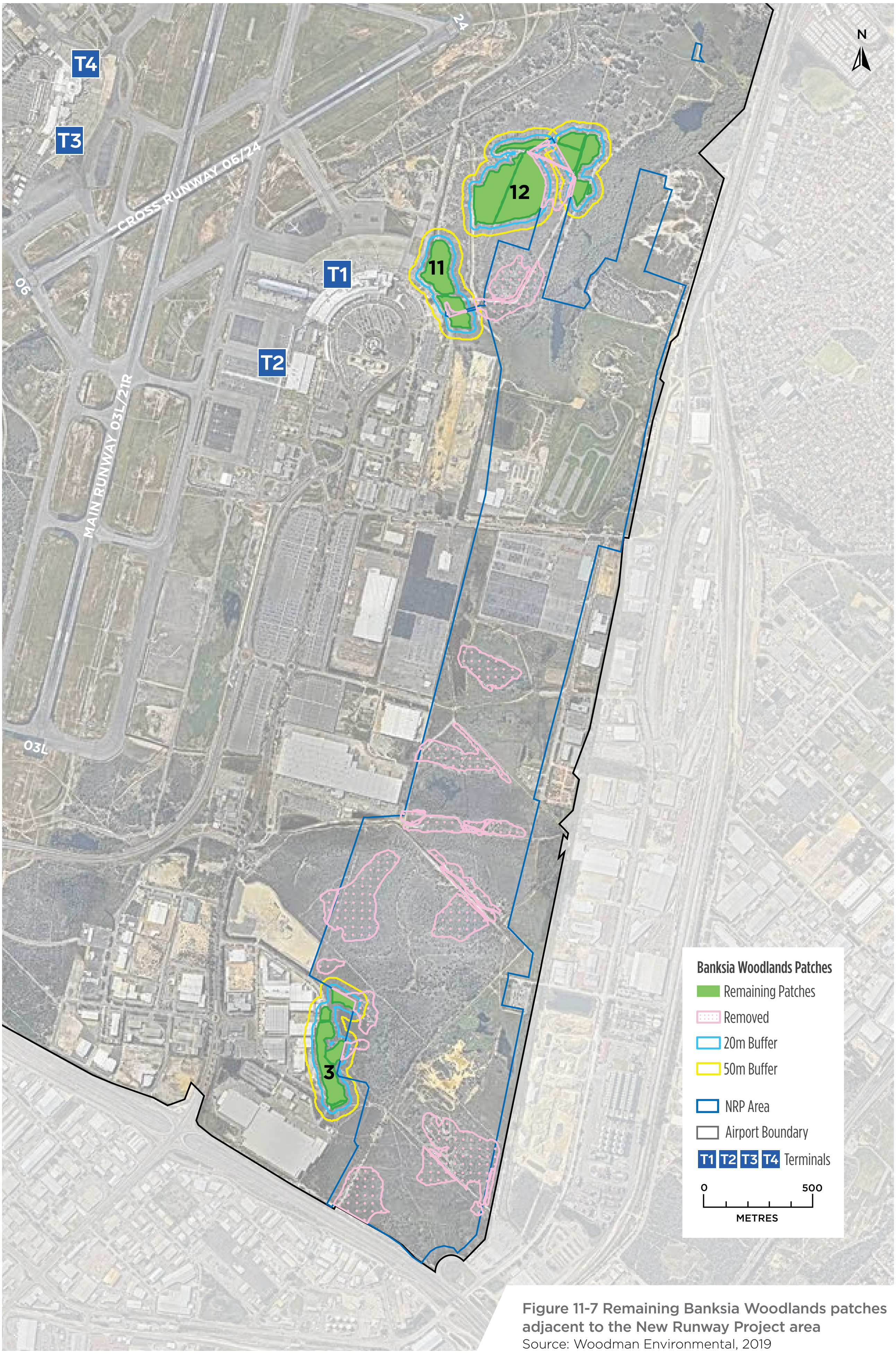


Figure 11-7 Remaining Banksia Woodlands patches adjacent to the New Runway Project area
Source: Woodman Environmental, 2019

Impact Type	Threatening Process	Severity	Discussion (Potential impacts)	Proposed Mitigation Measures
Direct	Clearing	Major	The NRP will potentially impact 40.04 hectares of Banksia Woodlands TEC: This represents • 29.1 per cent of local extent within the Perth Airport estate, and • 0.013 per cent of the regional extent of the Banksia Woodlands TEC.	Avoidance from direct impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	Clearing	Major	A total of 1.36 hectares of patches of Banksia Woodlands TEC will no longer meet criteria and are therefore considered potentially impacted by the NRP.	Avoidance from indirect impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impact will be minimised during detailed design and construction.
Indirect	Unintentional clearing	Minor	There is potential for unintentional clearing of areas of Banksia Woodlands TEC outside the Project area.	A CEMP will address the design and operations for clearing area, and demarcate (signage/fencing) exclusion zones for areas needing protection
Indirect	Introduction of invasive species	Minor	Spread of weeds.	A CEMP will address soil hygiene to prevent introduction and spread of weeds
Indirect	Introduction of disease - dieback	Minor	Currently all patches of Banksia Woodlands TEC have some level of infestation. Unintentional spread will accelerate the rate of infestation.	A CEMP will address soil hygiene procedures to prevent introduction and spread of dieback.
Indirect	Fragmentation of patches	Moderate	Fragmentation of patches 11 and 12.	Avoidance from impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impact will be minimised during detailed design and construction.
Indirect	Spills into adjacent vegetation	Minor	Impact from chemical spills during construction and operations.	A CEMP will address spill prevention and management during both construction and operations.
Indirect	Dust deposition onto adjacent vegetation	Negligible	Dust impacts plants during construction.	A CEMP will address management of emission to air including dust suppression during construction and operations.
Indirect	Change to fire regime	Minor	Increase burning may adversely affect the vegetation, however native plants are adapted to fire and the vegetation likely to recover after burning with management of weed invasion.	Perth Airport currently maintains a fuel load management fire regime and a CEMP that will address control of introduced species in the estate.

Table 11-14 Potential severity of impacts on the Banksia Woodlands TEC
Source: Woodman Environmental, 2019

Indirect and Offsite Impacts

Figure 11-7 shows the remaining areas of eligible Banksia Woodlands outside the NRP with the 20m and 50m buffers. The Conservation Advice (TSSC 2016) incorporates buffers with a minimum of 20m, but optimally up to 50m around areas of the TEC to protect the integrity of the Banksia Woodlands from edge effects.

Portions of patches 2, 3, 5, 7, 8, 10, 11 and 12 are outside the NRP area. As Table 11-13 shows, the remaining area (total of 1.36 hectares) of patches 2,5,7,8 and 10 will no longer meet the minimum patch size and therefore are likely to be indirectly impacted by the NRP. Patches 3, 8, 10, 11 and 12 will still retain eligibility as Banksia Woodlands TEC.

Significance of Residual Impacts

The potential impacts, both direct and indirect, of the NRP on the Banksia Woodlands TEC will reduce the community's extent within the Perth Airport estate by about 29 per cent. Indirect impacts also include the fragmentation of two of the remaining patches. Table 11-15 presents the assessment of the NRP against the significant impact criteria for endangered ecological communities as per Guideline 1.1. Implementation of the NRP is likely to trigger four of the seven criteria indicating a potentially significant impact on the occurrences of this ecological community within the Perth Airport estate.

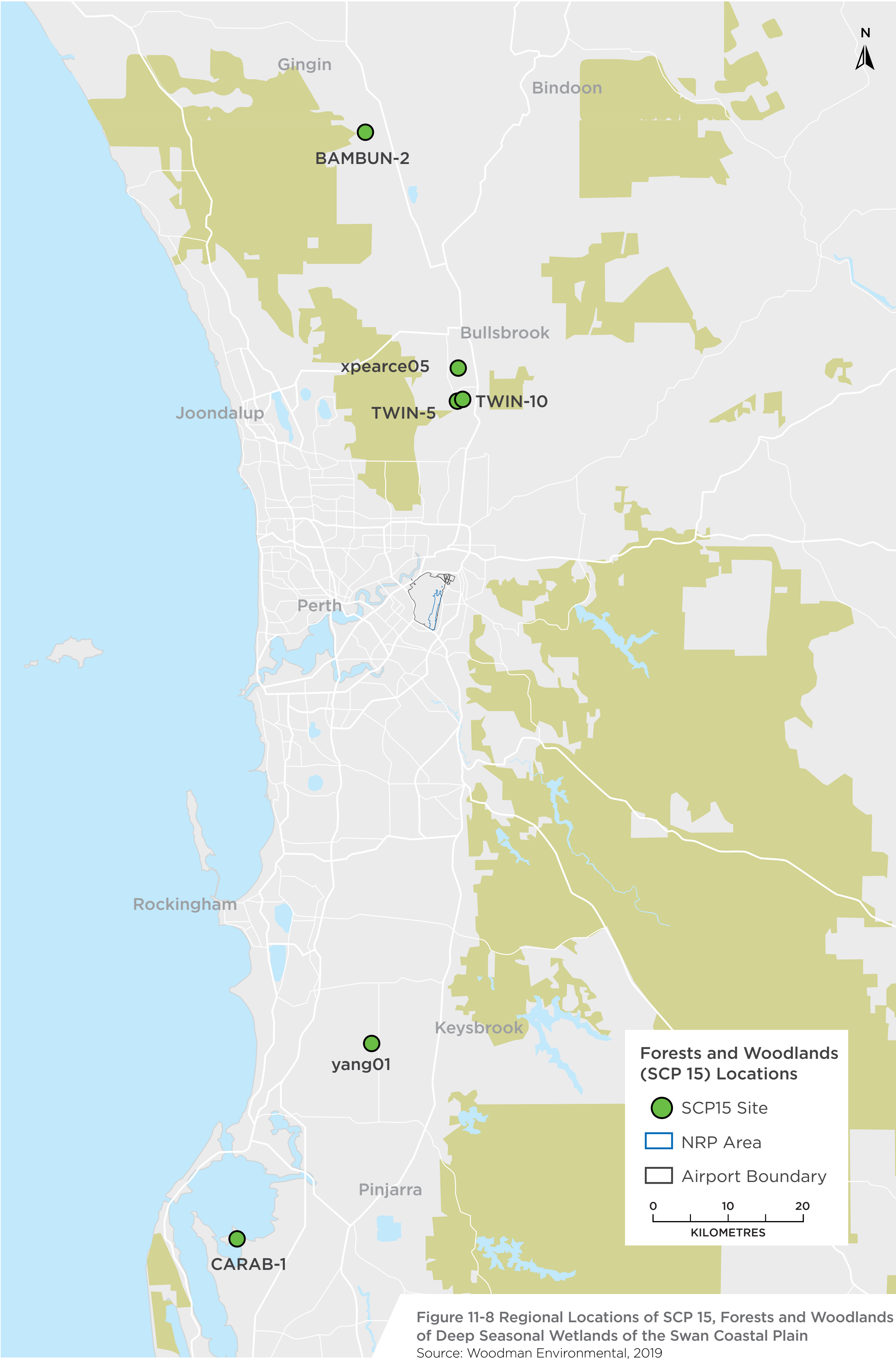


Figure 11-8 Regional Locations of SCP 15, Forests and Woodlands of Deep Seasonal Wetlands of the Swan Coastal Plain
Source: Woodman Environmental, 2019

At a regional scale the 41.40ha potentially impacted by the NRP represents 0.013 per cent of the extant area of the Banksia Woodlands TEC on the Swan Coastal Plain. The Banksia Woodlands TEC is also known from conservation estate, with approximately 24.3 per cent of the estimated regional extent of the TEC located in reserves (TSSC). Due to the large remaining area, with much in conservation reserves, and the localised impact are, the NRP's potential impacts on the Banksia Woodlands TEC are not considered significant with respect to the survival of the ecological community across its range.

11.6.2.2 Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain

Overview

Under the BC Act, the Forests and woodlands of Deep Seasonal Wetlands of the Swan Coastal Plain, (SCP 15), community is listed as Vulnerable. Figure 11-8 shows the location of six records of the SCP 15 community over a 270 km range of the Swan Coastal Plain from Point Grey, near Mandurah in the South to Bambunup Nature Reserve in the north (Keighery *et al*., 2012.)

Criterion Number	Significant Impact Criteria (under Guideline 1.1)	Likelihood and Rationale
1	Reduce the extent of an ecological community.	**Likely to occur.** A total of 41.40 hectares of Banksia Woodlands TEC of varying quality is proposed be removed as part of the NRP.
2	Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines.	**Likely to occur.** The entire NRP area will potentially be cleared including Banksia Woodlands TEC and other vegetation. This will increase fragmentation and edge effects on Banksia Woodlands TECs patches 11 and 12.
3	Adversely affect habitat critical to the survival of an ecological community.	Unlikely. The 41.40 hectares of Banksia Woodlands TEC to be cleared represents a very small fraction (0.013 per cent) of the TEC remaining on the Swan Coastal Plain and unlikely to be critical to the survival of the TEC as a whole.
4	Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns.	Unlikely. An area of 41.40 hectares (representing 0.013 per cent of the TEC remaining on the Swan Coastal Plain) will potentially be permanently cleared; construction works will involve some impact to soil in relation to the permanent clearing area only. The works will not have critical impact to the extent of the TEC as a whole.
5	Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting.	**Likely to occur.** All flora species are proposed to be permanently removed from 41.40 hectares of Banksia Woodlands TEC of varying condition.
6	Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: • assisting invasive species, that are harmful to the listed ecological community, to become established, or • causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community.	**Likely to occur.** The NRP will potentially permanently remove 41.40 hectares of Banksia Woodlands TEC of varying quality from 146.87 hectares within the Perth Airport estate. Clearing of the NRP area may result in a reduction in the integrity of the adjacent remaining patches affected by partial clearing. The clearing also has the potential to encourage the spread of weed and dieback into adjacent areas of the TEC.
7	Interfere with the recovery of an ecological community.	Not applicable. No recovery actions of the TEC are currently underway or proposed in the NRP area.

Table 11-15 Banksia Woodlands TEC assessed as per Guideline 1.1
Source: Woodman Environmental, 2019

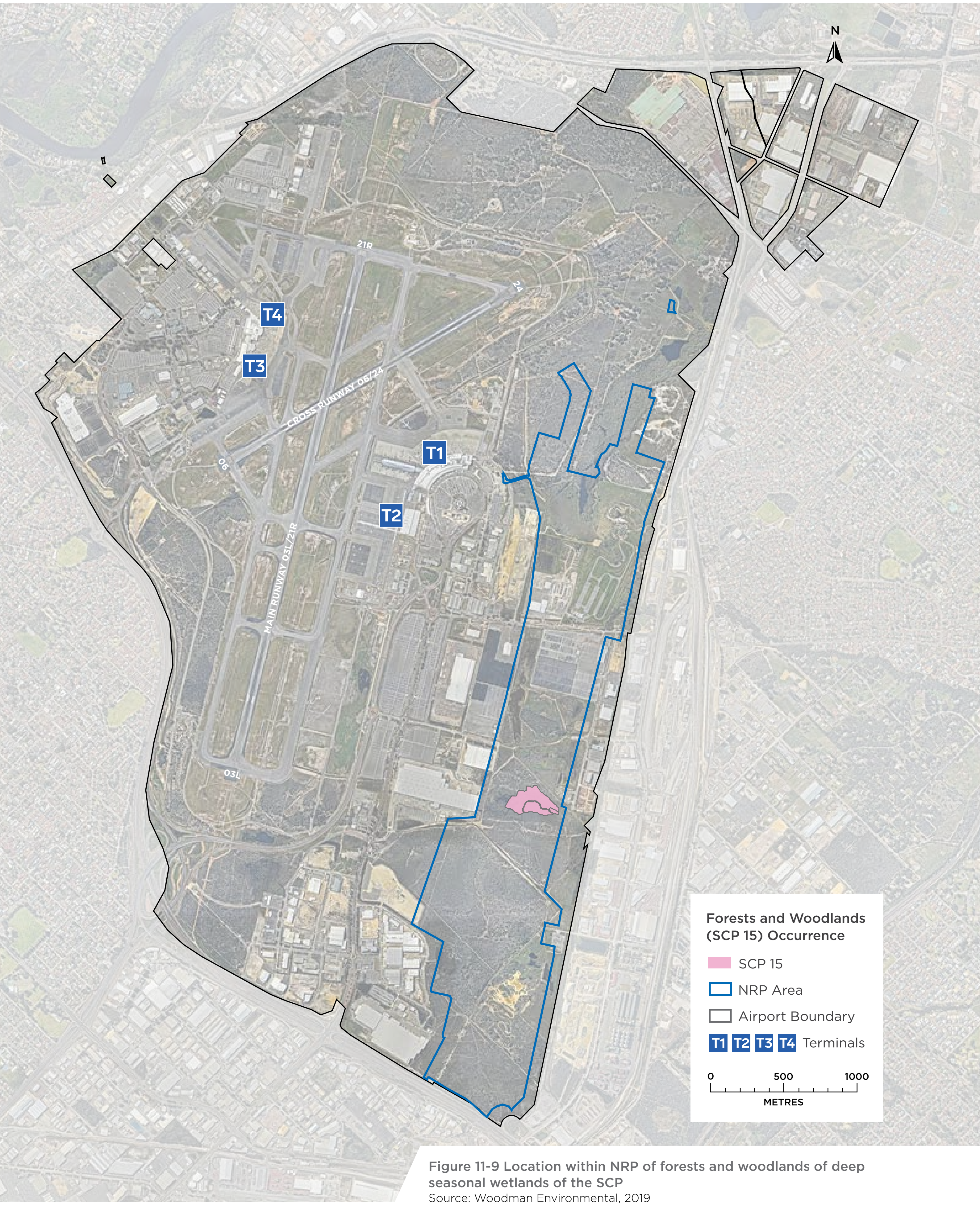


Figure 11-9 Location within NRP of forests and woodlands of deep seasonal wetlands of the SCP
Source: Woodman Environmental, 2019

Direct Impacts and Mitigation Measures

Figure 11-9 shows the location of the SCP 15 community within the NRP area. Table 11-16 summarises the potential impacts of the NRP on the SCP 15 community and proposed mitigation measures.

Impact Type	Threatening Process	Severity	Discussion (Potential impacts)	Proposed Avoidance/ Mitigation Measures
Direct	Clearing	Major	A total of 4.07 hectares of the TEC SCP 15 was mapped in the Perth Airport estate. 100 per cent of this will potentially be removed by the NRP. The potential impact is to one of seven known locations of TEC SCP 15. It is considered likely that all known occurrences are important of the survival of the community. Due to limited information on other occurrences of the community there is an unknown impact to the overall extent of area of TEC.	Avoidance from direct impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	-	-	There are no indirect or offsite impacts of the NRP as all 4.07 hectares of the SCP 15 community within the Perth Airport estate will potentially be removed by the NRP.	-

Table 11-16 Summary of potential impacts to forests and woodlands of deep seasonal wetlands of the SCP and proposed mitigation measures
Source: Woodman Environmental, 2019

Indirect and Offsite Impacts and Associated Avoidance/ Mitigation Measures

There are no indirect or offsite impacts of the NRP as all 4.07 hectares of the SCP 15 community within the Perth Airport estate will potentially be removed.

Significance of Residual Impacts

Table 11-17 presents the assessment of the potential impacts of the NRP on TEC SCP 15 against the significant impact criteria for endangered ecological communities (DoE, 2013). Implementation of the NRP is likely to trigger four of the seven criteria indicating a potentially significant impact on the occurrences of TEC SCP 15 within the Perth Airport estate.

The significance of the potential impacts of the NRP on TEC SCP 15 at the community scale, (addressing the survival of the community - Criteria 3), is difficult to determine, given the limited available regional data on this TEC. The location of the new occurrence of this community within the Perth Airport estate is not a range extension and is central to the distribution of the known occurrences of the community indicating it may not represent a significant occurrence of the community. There are six other known locations of this TEC, over a 270 km range. However, details regarding the extent and condition of vegetation at these locations is limited. Based on the limited occurrences of the community and potential for the extent of the community to also be limited, the potential impacts of the NRP on TEC SCP 15 is likely to be significant.

Criterion Number	Significant Impact Criteria (under Guideline 1.1)	Likelihood and rationale
1	Reduce the extent of an ecological community.	**Likely to occur.** A total of 4.07 hectares of the community will potentially be removed as part of the NRP.
2	Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines.	Not applicable. The entire occurrence of this TEC will potentially be removed from the Perth Airport estate. The linkages between this location of the TEC and the other occurrences is unknown; therefore, the potential effects of fragmentation are unknown
3	Adversely affect habitat critical to the survival of an ecological community.	**Likely to occur.** The NRP occurrence of 4.07ha represents a new location within a highly disturbed environment; however, six other known occurrences of the TEC will remain
4	Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns.	Unlikely. 4.07 hectares of habitat will potentially be permanently cleared; however, the works will not have critical impact to the extent of the TEC as a whole.
5	Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting.	**Likely to occur.** The entire occurrence of the TEC SCP 15 in the Perth Airport estate is proposed to be impacted.
6	Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: • assisting invasive species, that are harmful to the listed ecological community, to become established, or • causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community.	**Likely to occur.** The NRP will potentially permanently remove the entire occurrence of the TEC SCP 15.
7	Interfere with the recovery of an ecological community.	Not applicable. No recovery actions of the TEC are currently underway or proposed in the NRP area.

Table 11-17 Forrest and woodlands of deep seasonal wetlands of the SCP assessed as per Guideline 1.1
Source: Woodman Environmental, 2019

11.6.3 Flora - EPBC Act Listed Species

11.6.3.1 *Conospermum undulatum*

Overview

Conospermum undulatum (*C. undulatum*) is an erect shrub up to two metres with wavy leaves that taper to the base. It has woolly flowers with long white hairs and is typically multi stemmed. It is listed as Vulnerable by both Commonwealth and State legislation.

The Recovery Plan for *C. undulatum* (DEC 2009) identified that in 2008 it was known from 25 historical populations (65 sub-populations) between the Swan and Canning Rivers of which 20 contained extant plants, with two known populations located at Perth Airport at that time. The Recovery Plan listed all 65 populations and sub-populations as most important and that provided the greatest contribution to the long-term survival of the species.

The known populations of *C. undulatum* are mostly within heavily fragmented landscapes in the Perth metropolitan area (Swan Coastal Plain and adjacent Jarrah forests), over a range of approximately 21 km extending from Belmont towards Roleystone (Woodman Environmental 2018). Information was collated on 113 populations/sub-populations of which 63 had been assessed as being of moderate (8), good (2) or healthy (53) condition at the time of recording. Other populations/sub-populations were recorded in poor condition (3), extinct (9) or had no record of condition (38) (Woodman Environmental, 2018).

DBCA database records (2018) report a total of 32 populations of *C. undulatum*, of which 28 are extant. The total reported number of individuals of *C. undulatum* is 11,400 (Woodman 2018). Figure 11-10 shows the regional distribution of records for *C. undulatum* (Woodman Environmental 2018a).

There have been three assessments (Phoenix 2016; Focused Vision 2017 and Strategen 2018) that have surveyed for the presence of *C. undulatum* within the NRP. Additionally, during a vegetation survey of the Perth Airport estate in 2018, plants were opportunistically recorded in a location adjacent to an existing population (Woodman, 2019). Due to the issue of repeated surveys counting the same plants found at the same location, only the most recent floristic survey by Strategen (2018) and Woodman Environmental (2019) has been used to assess the impact of the NRP project. This approach considers the variation in the number of individuals recorded during the three flora surveys and to reflect the extant number of *C. undulatum* plants in the NRP area as shown in Figure 11-11.

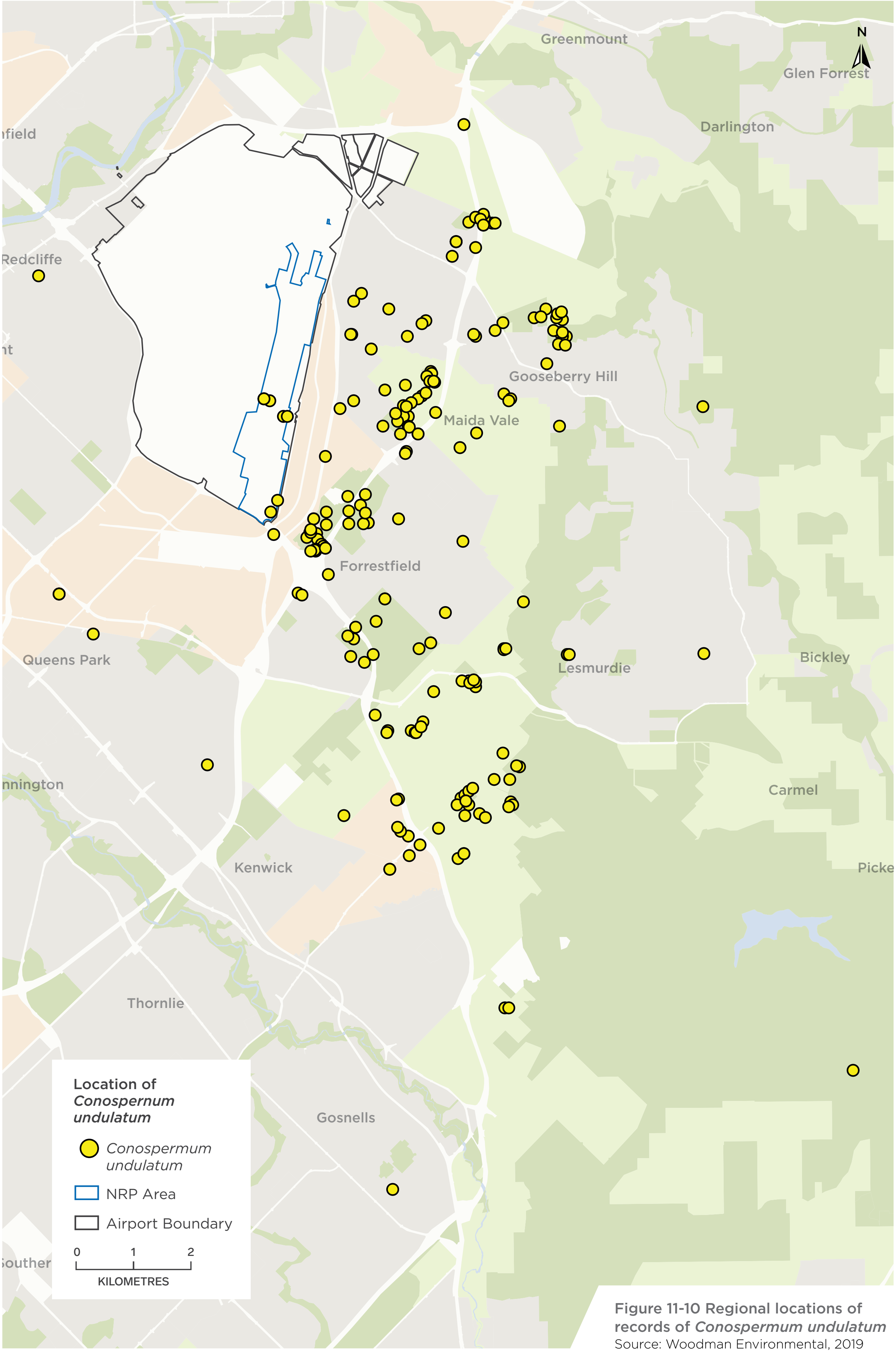


Figure 11-10 Regional locations of records of *Conospermum undulatum*
Source: Woodman Environmental, 2019

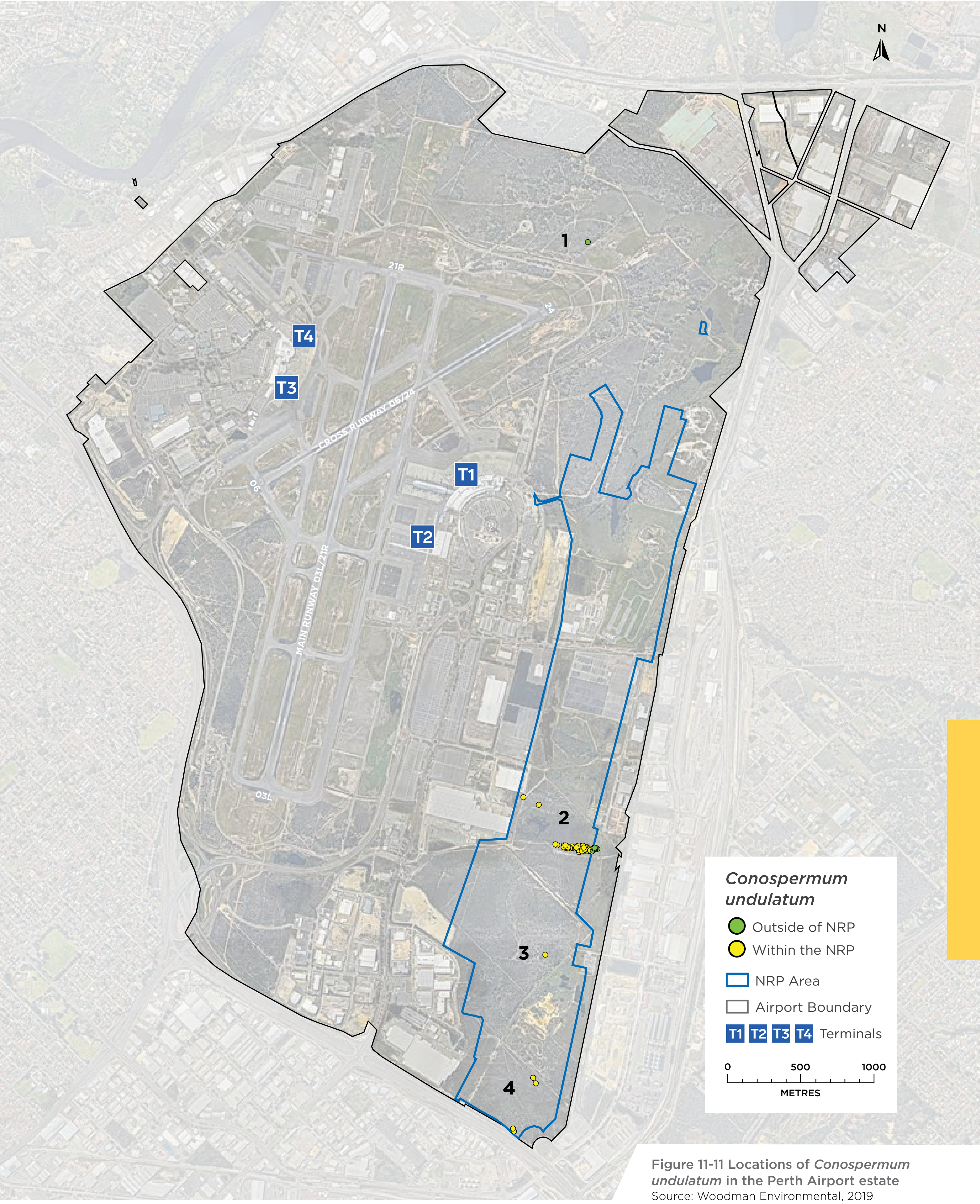


Figure 11-11 Locations of *Conospermum undulatum* in the Perth Airport estate
Source: Woodman Environmental, 2019

Direct Impacts and Mitigation Measures

Impact Type	Threatening Process	Severity	Discussion (Potential impacts)	Proposed Mitigation Measures
Direct	Clearing and site preparation	Major	The NRP potentially results in the loss of: • 3 populations (populations 2, 3 and 4) of the 4 populations within the Perth Airport estate • 206 plants from 237 within the Airport estate • The loss of 1.8 per cent of the total 11,400 individuals recorded by the DBCA The Recovery Plan for *C. undulatum* identifies the Perth Airport estate populations as important sub-populations/population for the long term survival of the species (DEC 2009).	Avoidance from direct impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	Unintentional clearing and site preparation outside the NRP	Moderate	Disturbance/clearing of plants outside the project boundary during construction activities The Recovery Plan for *C. undulatum* includes the Perth Airport estate populations in the list of the 65 most important sub-populations/ populations for the long term survival of the species (DEC 2009).	A CEMP will address the design and operations for clearing area, and demarcate (signage/fencing) exclusion zones for areas needing protection.
Indirect	Habitat fragmentation	Minor	Plants remaining from population 2 will be in a patch of native vegetation isolated from other areas of native vegetation within the Airport estate.	Avoidance is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	Invasion of weeds and pest species	Minor	Spread of weeds into the area supporting the remaining plants (Population 2) adjacent to the NRP may compete with the remaining *C. undulatum* plants.	A CEMP will address soil hygiene to prevent introduction and spread of weeds.
Indirect	Movement and/ or introduction of dieback	Minor	Dieback may potentially be spread into the area supporting the remaining plants (population 2) adjacent to the NRP. Most of population 2 and all of population 4 occur within dieback infested zones indicating *C. undulatum* has some level of tolerance to Phytophthora disease. Potential impacts to other plants in the community may modify the environmental suitability for *C. undulatum*.	A CEMP will address soil hygiene procedures to prevent introduction and spread of dieback.
Indirect	Bushfire regime	Minor	There is potential for increased occurrence of fire during construction and operational phases.	Perth Airport currently maintains a fuel load management fire regime and a CEMP that will address control of introduced species in the estate.
Indirect	Hydrology and ground water impacts	Negligible	The potential impacts of the NRP on the groundwater levels within the estate are predicted to be minor and localised and have no discernible effect on the vegetation.	Not applicable.

Table 11-18 Potential direct and indirect impacts on *Conospermum undulatum* and mitigation measures
Source: Woodman Environmental, 2019

Indirect and Offsite Impacts and Mitigation Measures

The potential indirect and offsite impacts and the associated avoidance and mitigation measures for *C. undulatum* are described in Table 11-18.

Significance of Residual Impacts

Table 11-19 presents the assessment of the NRP against the significant impact criteria for vulnerable species as per Guideline 1.1. Implementation of the NRP is likely to trigger three of the nine criteria for *C.undulatum* indicating a potentially significant impact to this taxon. The Perth Airport estate populations are considered important to the survival of the species in the Recovery Plan. The potential impact of the NRP on these populations decreases the size (by 86.52 per cent), and the area of occupancy, (Criteria one, and two respectively) of the population of *C. undulatum* within the Perth Airport estate. Disruptions to the breeding cycle (Criteria 5) of the remaining population by the reduction in the population size and distribution are also considered likely. This taxon is a long-lived species with a known low recruitment of new individuals, and therefore the loss of these individuals will potentially be detrimental to the sustainability of the local population at the genetic level.

Criterion Number	Significance Criteria under Guideline 1.1	Likelihood and rationale
1	Lead to long-term decrease in the size of an important population of a species.	**Likely to occur.** The *C. undulatum* Recovery Plan identifies the Airport population as important to the long term survival of the species. The proposed clearing from the NRP will remove 86.52 per cent (206 individuals) of the known individuals (237) within the Perth Airport estate. NRP will remove 86.52per cent of the known individuals within the Perth Airport estate. The Recovery Plan identifies the Perth Airport estate populations as important to the long term survival of the species.
2	Reduce the area of occupancy of an important population.	**Likely to occur.** The *C. undulatum* Recovery Plan identifies the Perth Airport estate populations as important to the long term survival of the species. The majority of the area occupied by the plants will be permanently cleared.
3	Fragment an existing important population into two or more populations.	Unlikely to occur. A small portion of the main population (#2) will remain.
4	Adversely affect habitat critical to the survival of a species.	Unlikely to occur. The plants within the NRP represent a small portion (1.8 per cent) of the recorded total population of 11,400.
5	Disrupt the breeding cycle of an important population.	**Likely to occur.** The *C. undulatum* Recovery Plan identifies the Perth Airport estate populations as important to the long term survival of the species. A significant portion (86.52 per cent) of individuals will be permanently removed thereby reducing the reproductive population
6	Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. The NRP will result in the loss of 213 plants from a recorded total population of 11,400 individuals. This represents 1.75 per cent of the known individuals. NRP potentially removes 86.52 per cent of a population (that is considered important) on the western edge of its known range. However, species has recorded populations extend over a range of 21 km (Figure 11-10) and is unlikely to decline.
7	Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat.	Unlikely to occur. Invasive species will have no impact within the NRP area that will be permanently cleared Management plans are likely to protect plants in remaining habitat from the impacts of invasive species.
8	Introduce disease that may cause the species to decline.	Unlikely to occur. Management plans are likely to protect remaining plants from indirect impacts.
9	Interfere substantially with the recovery of the species.	Unlikely to occur The NRP impacts on a small proportion (1.75 per cent) of the total population of 11,400 *C.undulatum* and the range from which the species is recorded (Figure 11-10).

Table 11-19 Assessment of the likelihood of NRP impacts meeting significance criteria for *Conospermum*
Source: Woodman Environmental, 2019

Figure 11-12 Regional locations of records of *Macarthuria keigheryi*
Source: Woodman Environmental, 2019

Regionally, the *C. undulatum* plants within the NRP represent 1.75 per cent of the known number of individuals. The species has a restricted distribution with records on known locations distributed over 21 km with 14 other locations across its range having extant populations; several relatively large populations occur in a variety of land use types, including private property, road reserves, shire reserves and it has been recorded in nature reserves within the vicinity of the Perth Airport estate, although plant abundance at these locations is highly variable over time reflecting the resprouter biology of the plant. Based on the limited range of *C. undulatum* occurrence, and the recognised importance of the Perth Airport estate populations to the survival of the species, the potential impacts of the NRP to *C. undulatum* survival as a species are considered significant.

11.6.3.2 *Macarthuria keigheryi*

Overview

Macarthuria keigheryi (M. keigheryi) is small shrub that grows to 0.4m tall by 0.6m wide, with hairy, bright yellow to green stems, with leaves present mainly at the base of the stems. It is listed as Endangered under both the EPBC Act and BC Act.

Figure 11-12 shows the regional distribution of records of *M. keigheryi*. The Recovery Plan for the species identified that in 2009 there were six recorded populations of *M. keigheryi* with an estimated 10,070 plants located over a range of 160 km (DEC 2009a).

Current (2018) DBCA records show a total of nine extant populations and 19 subpopulations of *M. keigheryi*, containing an estimated 41,762 individuals. These records come from four broad regional locations over a range of approximately 167 km: Cooljarloo – Falcon in the north; unallocated Crown Land near Lake Guraga; the Moore River National Park - Whitfield Springs Road; and in the Perth metropolitan area (Kewdale – Forrestfield Area). The Perth metropolitan area has the smallest populations, with 1,368 known individuals representing 3.2 per cent of the known total population (Woodman Environmental, 2018a).

In a genetic study on *M. keigheryi*, Nevill (2017) proposed that the level of genetic differentiation found between populations at the Perth Airport estate and Beermullah (100 km north – Whitfield Springs Road population) suggested long term isolation between the sites had resulted in a genetic differentiation between the populations to the point where they are genetically 'unique', therefore, they should be managed as distinct entities to ensure their long-term survival for the conservation of the species. This conclusion is based on an incomplete spread of data for the taxon as the other locations where populations have been recorded were not sampled or analysed by Nevill (2017) due to difficulties in locating extant plants at the time of the study.

The reported abundance and condition of the plants within regional populations is highly variable across both location and historical sampling period. Woodman Environmental (2018a) collated reported information on 22 populations/sub populations. Of these 11 had no comment on condition, six were unknown, three were poor and two were in a healthy condition. More importantly, there was a large variation in the abundance at a population. For the Cooljarloo/Mullering location, the population/subpopulations abundance was highly variable as indicated with the 2017 overall population exceeding 38,730 in the Meadow Spring fire area; with the overall population extending northwards most likely exceeding 50,000 plants. This compared to earlier records where:

- Population 1a in 1988 was recorded as "Abundant", 1991-1996 only one and zero plants and in 2006 an estimated 10,000.
- Populations 1b to 1f during 2006-08 had abundance records range from of 0 - 124 plants.

This reported variation in both condition and abundance reflects the fire responder ecology of the plant. The plants are prolific following fire, however decrease rapidly within 2-3 years post-fire (Woodman 2018a). This relatively short lifespan with the plants senescing after a few years is likely to be reflected in the condition of the plants.

Recent flora surveys within the Perth Airport estate for the presence of *M. keigheryi* have been undertaken by:

- Phoenix Environmental Services (2016),
- Focused Vision Consulting (2017), and
- Strategen Environmental (2018).

The surveys showed variations in plant numbers. This variation should be considered in respect to the plant being a disturbance opportunist. Strategen Environmental (2018) reported that many of the plants were observed to be surrounded by dry, dead branches and appeared to be regenerating from periods of dormancy or stress (likely a relatively recent fire in the area, or from senescence (dying off) typical of short-lived plant species). Previous plants within a population may persist as rootstock or seeds awaiting disturbance (e.g. by fire) and were not detectable during surveys.

To avoid recounting of plants from different surveys, only the result of the Strategen Environmental (2018) survey which was undertaken in 2017 is used in this impact assessment. The Strategen Environmental data is supplemented with additional plants identified from a new location in the 2018 survey by Woodman Environmental (2019).

Macarthuria keigheryi Population	Individuals within the Estate	Individuals within the NRP Area	Percentage Impact
1	830	823	99.0
2	52	25	48.0
3	7	7	100
4	1	0	0
5	465	0	0
Total	1,355	855	63.1

Table 11-20 Location of *Macarthuria keigheryi* populations within Perth Airport estate and NRP area
Source: Woodman Environmental, 2019

Direct Impacts and Associated Mitigation Measures

Figure 11-13 shows the location of the five populations of *M. keigheryi* plants within the Perth Airport estate and the NRP recorded by Strategen Environmental (2018) and Woodman Environmental (2019). *M. keigheryi* was only recorded in the southern areas of the Perth Airport estate. Table 11-20 shows the number of individual plants from each population within the Perth Airport estate and the NRP. Table 11-21 presents the proposed direct impact of clearing on *M. keigheryi* in the NRP along with associated mitigation measures.

Indirect and Offsite Impacts and Associated Mitigation Measures

The indirect and offsite impacts of the NRP and the associated mitigation measures for *M. keigheryi* are described in Table 11-21.

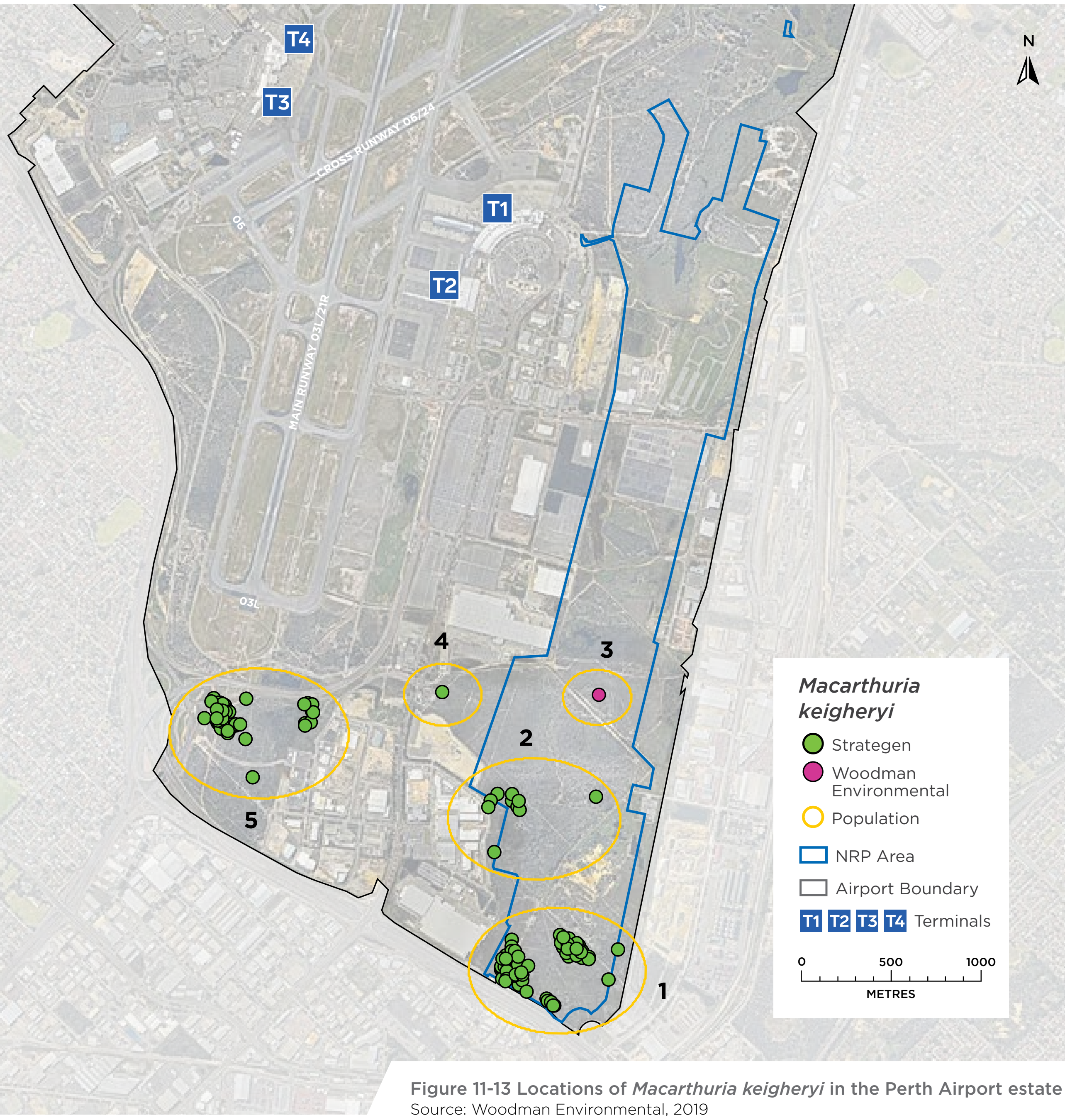


Figure 11-13 Locations of *Macarthuria keigheryi* in the Perth Airport estate
Source: Woodman Environmental, 2019

Impact Type	Threatening Process	Severity	Discussion (Potential impacts)	Proposed Mitigation Measures
Direct	Clearing and site preparation	Major	The NRP potentially results in the loss of: • 2 populations (populations 1 and 3) and most of population 4 • 855 plants from 1,355 plants recorded within the Airport estate. • 2.05 per cent of regional known individuals is proposed The Recovery Plan for *M. keigheryi* identifies the Airport populations as an important population for the long term survival of the species (DEC 2009) A genetic study has identified Perth Airport populations as genetically distinct from a northern population indicating the potential for future differentiation as a separate taxonomic entity.	Avoidance from direct impact is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	Unintentional clearing and site preparation outside the NRP	Moderate	Disturbance/clearing of plants outside the project boundary during construction activities The Recovery Plan for *M. keigheryi* includes the Perth Airport estate populations in the list of the 65 most important sub-populations/ populations for the long term survival of the species (DEC 2009).	A CEMP will address the design and operations for clearing area and demarcate (signage/fencing) exclusion zones for areas needing protection.
Indirect	Habitat fragmentation	Minor	Plants remaining from population 2 will be in a patch of native vegetation isolated from other areas of native vegetation within the Perth Airport estate that support populations 4 and notably population 5 of *M. keigheryi*.	Avoidance is not feasible due to the nature of locating critical infrastructure to comply with safety aviation regulations. As far as possible, impacts will be minimised during detailed design and construction.
Indirect	Invasion of weeds and pest species	Minor	Spread of weeds into the area supporting the remaining plants (populations 2 and 4) adjacent to the NRP may compete with the remaining *M. keigheryi* plants.	A CEMP will address soil hygiene to prevent introduction and spread of weeds.
Indirect	Movement and/or introduction of dieback	Minor	Dieback may potentially be spread into the uninfested areas supporting the remaining plants (population 4) adjacent to the NRP. Plants of population 1 and 2 occur within dieback infested zones indicating *M. keigheryi* has some level of tolerance to dieback disease. Potential impacts to other plants in the community may modify the environmental suitability for *M. keigheryi*.	A CEMP will address soil hygiene procedures to prevent introduction and spread of dieback.
Indirect	Bushfire regime	Minor	There is potential for increased occurrence of fire during construction and operational phases.	Perth Airport currently maintains a fuel load management fire regime and a CEMP that will address control of introduced species in the estate
Indirect	Hydrology and ground water impacts	Negligible	The potential impacts of the NRP on the groundwater levels within the estate are predicted to be minor and localised and have no discernible effect on the vegetation.	Not applicable.

Table 11-21 Direct and indirect potential impacts of the NRP and mitigation measures for *Macarthuria keigheryi*
Source: Woodman Environmental, 2019

Criterion Number	Significance Criteria (Under Guideline 1.1)	Likelihood and rationale
1	Lead to long-term decrease in the size of a population.	**Likely to occur.** The NRP potentially permanently removes 855 *M. keigheryi* plants from the Perth Airport population. This represent 63 per cent of known individuals within the Perth Airport estate. The recovery plan considered all populations, including the populations at the Perth Airport estate as important populations (DEC 2009a).
2	Reduce the area of occupancy of the species.	**Likely to occur.** The area occupied by the plants will potentially be permanently decreased. Areas of occupancy of all known populations, including populations at the Airport estate are considered critical to the survival of the species (DEC 2009a).
3	Fragment an existing population into two or more populations.	Unlikely to occur. A small portion of the main population (#2) will remain.
4	Adversely affect habitat critical to the survival of a species	Unlikely to occur Populations of *M. keigheryi* have a recorded distribution over 160 km. The area of habitat within the NRP potentially impacted represents a small proportion of the total habitat of the species as the plants within the NRP represent a small portion (2.05 per cent) of the recorded total population of 41,762. Genetic analysis differentiated the Perth Airport estate populations from the northern populations, however, there are other populations of this taxon in the surrounding Perth metropolitan area which will not be impacted by the NRP.
5	Disrupt the breeding cycle of a population	**Likely to occur.** Although the NRP will remove plants within the Perth Airport estate that are considered an important population, this species is a short-lived disturbance opportunist and the breeding cycle is reliant on other disturbance factors such as burning. The *M. keigheryi* Recovery Plan includes the Airport populations as important to the long term survival of the species. A significant portion (63.1per cent) of individuals will be permanently removed thereby reducing the reproductive population. Changes to the fire regime may impact the breeding cycle as the species is a short-lived disturbance opportunist reliant on disturbance factors such as burning.
6	Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. Although habitat for this species within the NRP will be permanently removed, other populations of this taxon occur over a 160 km range. This species is a disturbance opportunist and fire responder, and likely more prevalent than currently known.
7	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species habitat.	Unlikely to occur. Invasive species will have no impact within the NRP area that will be permanently cleared. Management plans will be implemented to protect remaining plants from indirect impacts.
8	Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plans will be implemented to protect remaining plants from indirect impacts.
9	Interfere with the recovery of the species.	Unlikely to occur. The NRP impacts on a small proportion (2.05 per cent) of the total known population of 41,762 *M. keigheryi* distributed over a range of 160 km from which the species is recorded.

Table 11-22 Assessment of the likelihood of NRP impacts meeting significance criteria for *Macarthuria keigheryi*
Source: Woodman Environmental, 2019

Significance of Residual Impacts

Implementation of the NRP is likely to trigger three of the nine criteria for *M. keigheryi* (Table 11-22). The Perth Airport estate populations are considered important in the species Recovery Plan. The potential impact of the NRP on these populations decreases the size (by 63.1 per cent), and the area of occupancy, (Criteria one, and two respectively) of the population of *M. keigheryi* within the Perth Airport estate. Disruptions to the breeding cycle of the remaining population (Criteria 5) are considered possible due to the reduction in the population and potential changes to the fire regime: burning starts the regeneration process. Perth Airport currently maintains a fuel load management fire regime, and the NRP will not change this. Therefore, the fire regime is not likely to be a detrimental factor to the survival of the species at the Perth Airport; however, the loss of individual plants is likely to be detrimental to the sustainability of the local population through loss of genetic material.

Regionally the *M. keigheryi* plants within the NRP represent 2.05 per cent of the known number of individuals. The species has a wide distribution with records on known locations distributed over 160 km. Although the NRP is located towards the northern edge of its extant known range in the Perth metropolitan area, there are three other extant populations in the Perth metropolitan area (including two in Bush Forever sites) and other reported populations located between the Perth metropolitan area and the northern (Cooljarloo) population. Abundance data is not available for those populations however this is not unusual due to the biology of the species.

Based on the wide range of *M. keigheryi* occurrence, the low proportion of extant plants potentially taken, and that the abundance at known locations is likely to be under represented by the current data (unless burnt in recent years), the potential impacts of the NRP to *M. keigheryi* as a species are not considered significant. The reported genetic differentiation of the Airport population from the Whitfield Springs Road population indicate additional significance of the Airport population due to genetic differentiation (containing a significant percentage of unique alleles) has been taken into account when determining the potential significance of the proposed impacts. Although the genetic study on this taxon was incomplete, the precautionary principle has been applied to confirm the potential importance of the Perth Airport population to the survival of the taxon with the result that the impact of the NRP is considered significant.

11.6.4 Flora – DBCA Listed Priority Species

11.6.4.1 Overview

Eight Priority flora species were identified as occurring within the NRP. The listing as a Priority species denotes further survey is required to determine their status and potential listing as conservation significant under the BC Act.

Byblis gigantea (Priority 3) has previously been recorded to the immediate west of the south-western boundary of the NRP area. As it is outside of the NRP area and has not been recorded since 2008, it has not been included in Table 11-23 or in the assessment.

Taxon	DBCA Priority Flora Category
Jacksonia gracillima	P3
Johnsonia pubescens subsp. *cygnorum*	P2
Ornduffia submersa	P4
Platysace ramosissima	P3
Schoenus benthamii	P3
Schoenus pennisetis	P3
Stylidium longitubum	P4
Verticordia lindleyi subsp. *lindleyi*	P4

Table 11-23 DBCA Priority Flora occurring within the NRP
Source: Woodman Environmental, 2019

Jacksonia gracillima (P3) is a spreading shrub growing to 1.5 m high occurring on sandy flats and in wetlands. It has a disjunct record of distribution over a known range of approximately 200 km, from near Busselton in the south to Forrestfield in the north (Figure 11-14). Woodman Environmental (2018b) considered the 45 records of the species represent approximately 36 populations at three main localities:

- Busselton-Capel: 9 populations (no plant abundance data available)
- Mandurah-Pinjarra: 1 population (no plant abundance data available)
- Perth Metropolitan Area: 26 populations (1,965+ plants)

The majority of populations are located in the Perth metropolitan area, south of the Swan River, including in remnant bushland locations at Thornlie, Kelmscott, Forrestdale, Banjup, Forrestfield and Southern River.

The NRP potentially impacts on 37.5 per cent of the 13 known locations of *J. gracillima* within the Perth Airport estate. (Figure 11-15). The loss of plants at these locations is unlikely to lead to long-term decline of this species in the local area as there are other known populations of *J. gracillima* in close proximity to the Airport estate with other populations known in the Perth Metropolitan Area, including within the conservation estate. Although the occurrence of *J. gracillima* is limited to the Swan Coastal Plain, records for locations occur over a 200 km range. The potential impacts of the NRP are not considered to be significant.

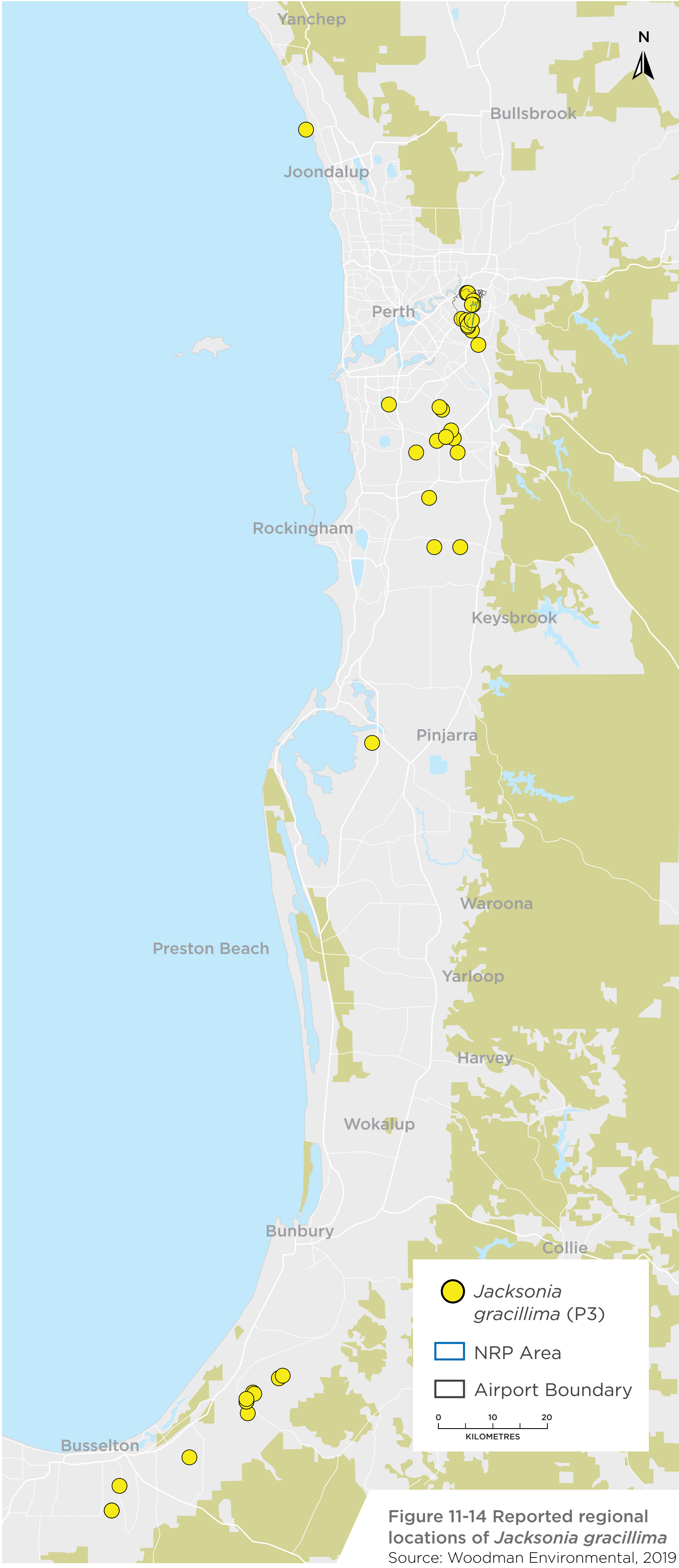


Figure 11-14 Reported regional locations of *Jacksonia gracillima*
Source: Woodman Environmental, 2019

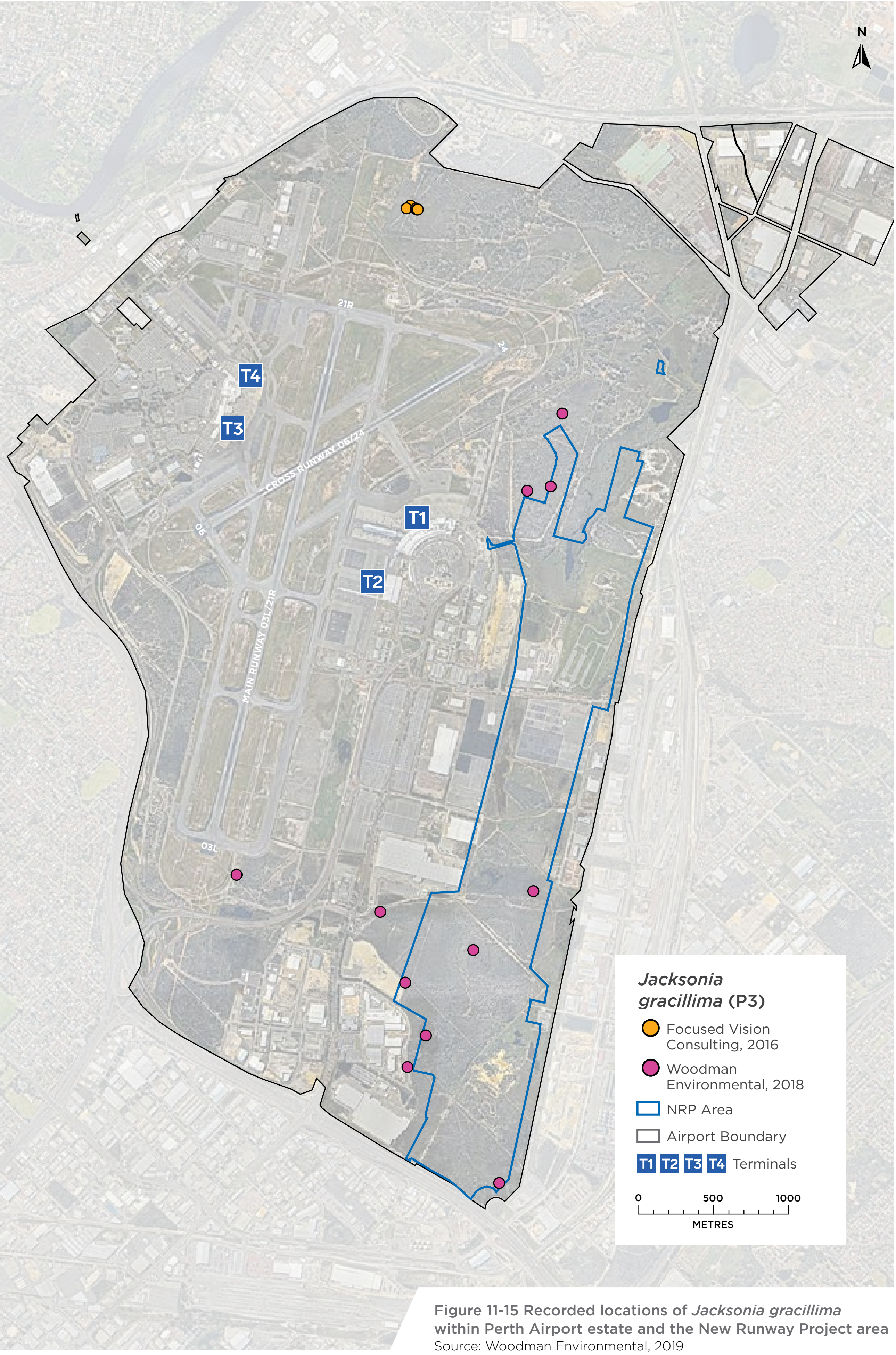


Figure 11-15 Recorded locations of *Jacksonia gracillima* within Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

Johnsonia pubescens subsp. *cygnorum* (P2) is a tufted perennial herb, growing to 0.25 m high on flats and seasonally wet sites. It is known to occur over a range of approximately 70 km from the suburb of Bentley in the Perth metropolitan area in the north to 5 km east of Pinjarra in the south (Figure 11-16). This taxon is known from 17 records (Woodman Environmental 2019).

The location of *J. pubescens* subsp. *cygnorum* at Perth Airport estate represents a new population for the species (See Figure 11-17). The NRP potentially impacts on 30.8 per cent of the 13 known locations within the Perth Airport estate. There are no other known populations in very close proximity to the Perth Airport estate, and therefore the loss of plants at these locations may contribute to the long-term decline of this species within the Perth Airport estate. The new population at Perth Airport estate is close to the northern-most extent of its 70 km range from the Perth metropolitan area extending to Pinjarra. This taxon is known from 13 other populations, of which at least two are located on conservation reserves indicating the impacts of the NRP are unlikely to change the conservation status of this taxon. The potential impacts of the NRP are not considered to be significant.

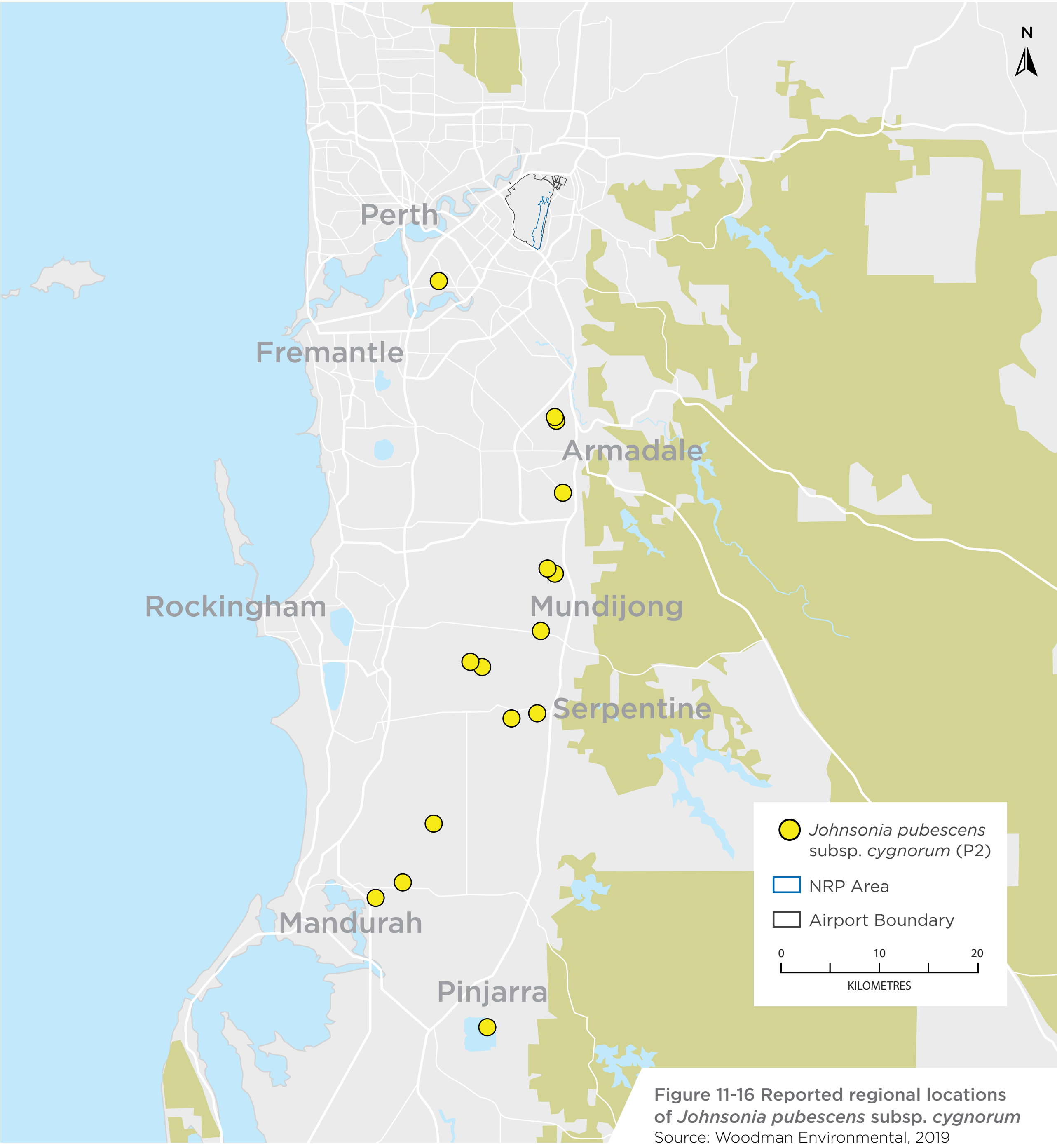


Figure 11-16 Reported regional locations of *Johnsonia pubescens* subsp. *cygnorum*
Source: Woodman Environmental, 2019

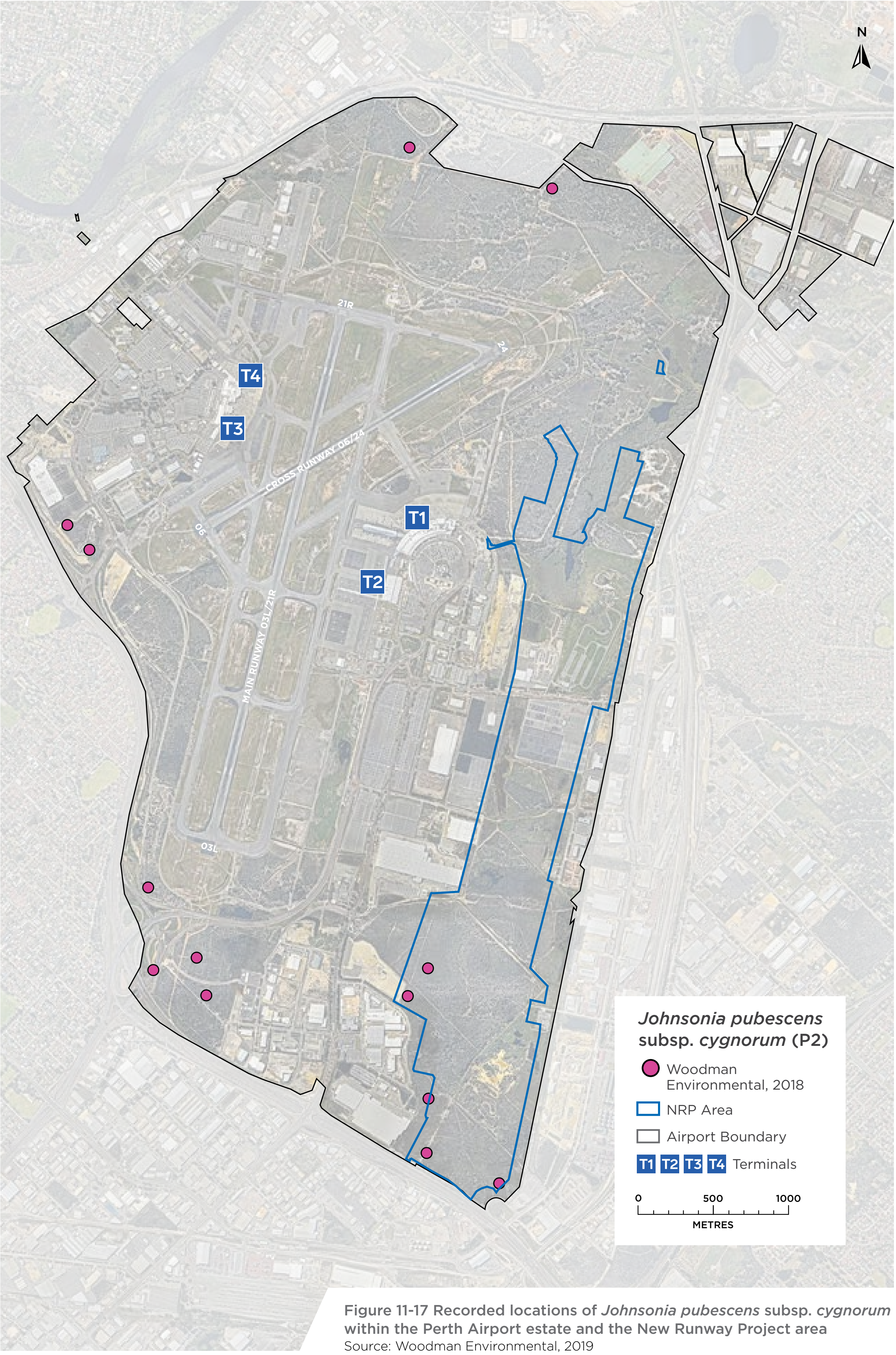


Figure 11-17 Recorded locations of *Johnsonia pubescens* subsp. *cygnorum* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

Ornduffia submersa (P4) is a perennial aquatic herb, occurring on seasonally inundated clay flats and winter-wet areas. It is known to occur over a range of approximately 450 km, from 30 km north of Gingin in the north to 10 km east of Denmark in the south (Figure 11-18). This taxon is known from 91 records (Woodman Environmental 2019).

The NRP will potentially impact on two of the three known locations of *O. submersa* within the Perth Airport estate (see Figure 11-19). However, this taxon is known from locations in close proximity to the estate, including the Brixton Street wetlands. It is unlikely that the NRP will lead to long-term decline in the viability of this species in the local area. *O. submersa* has a wide range (450 km) through the south-west of Western Australia, and the population at the Perth Airport estate is not on the boundary of this range. *O. submersa* is known from conservation reserves throughout its range. The potential impact of the NRP on *O. submersa* is not considered significant.

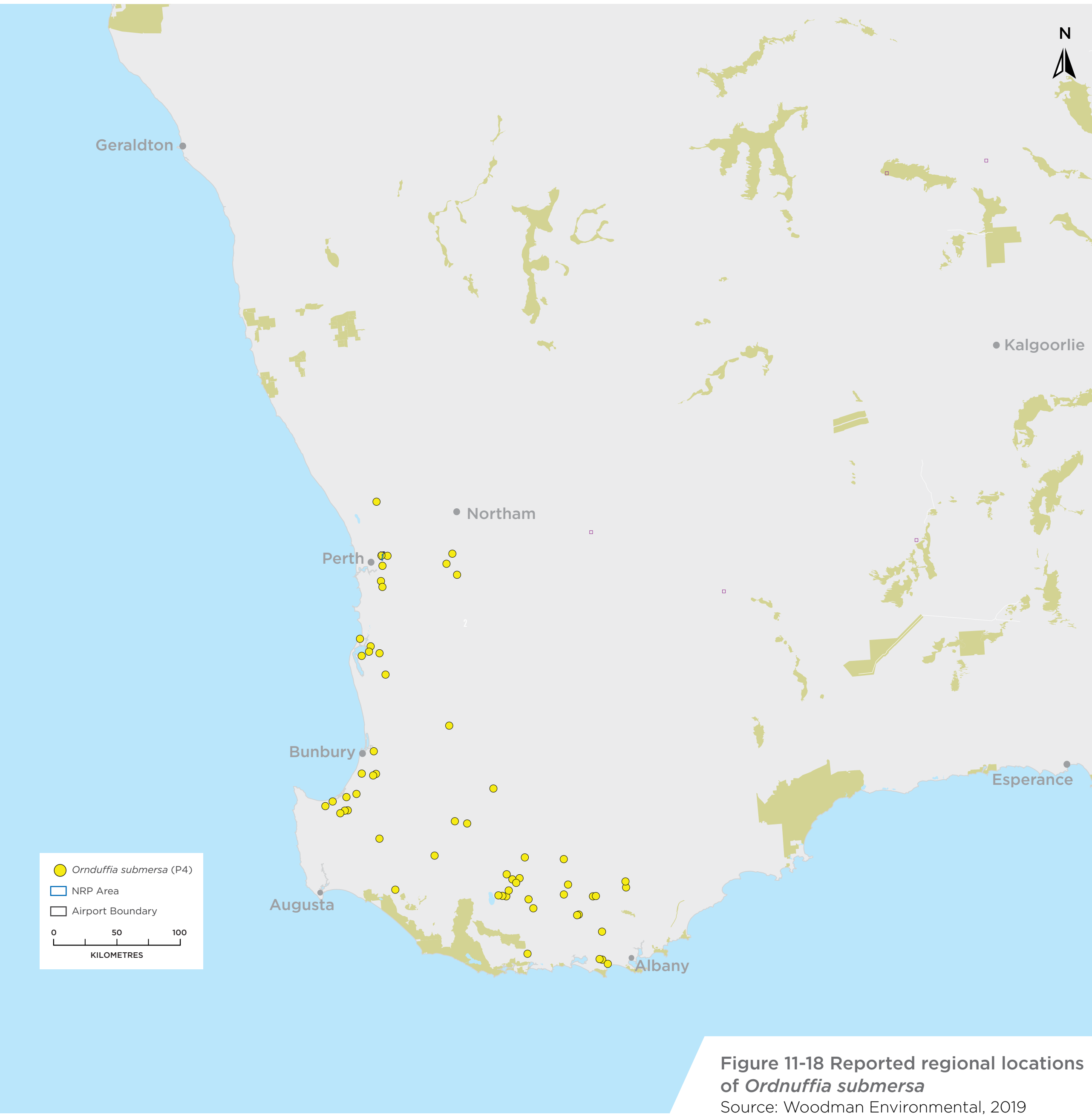


Figure 11-18 Reported regional locations of *Ordnuffia submersa*
Source: Woodman Environmental, 2019

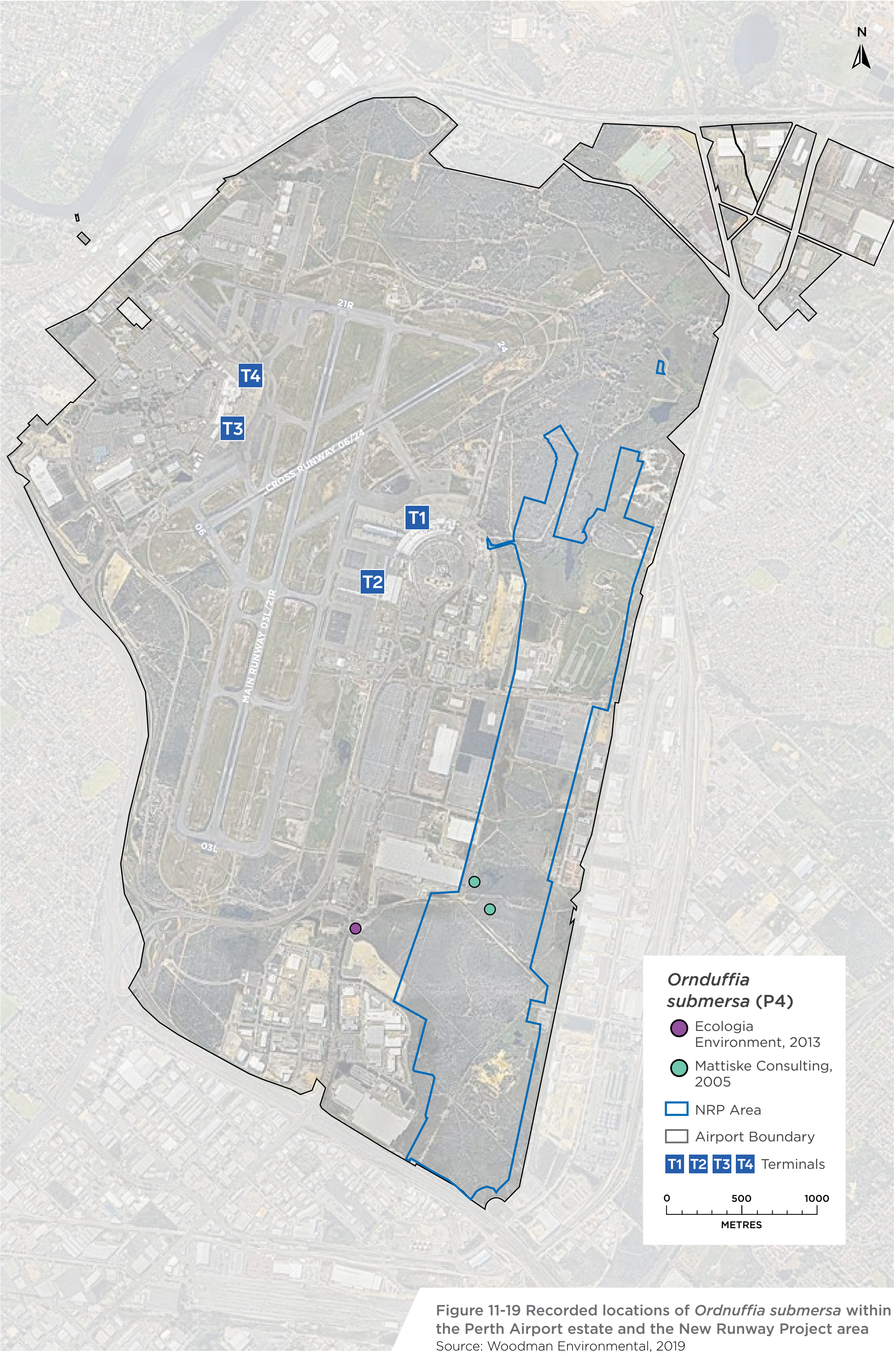


Figure 11-19 Recorded locations of *Ordnuffia submersa* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

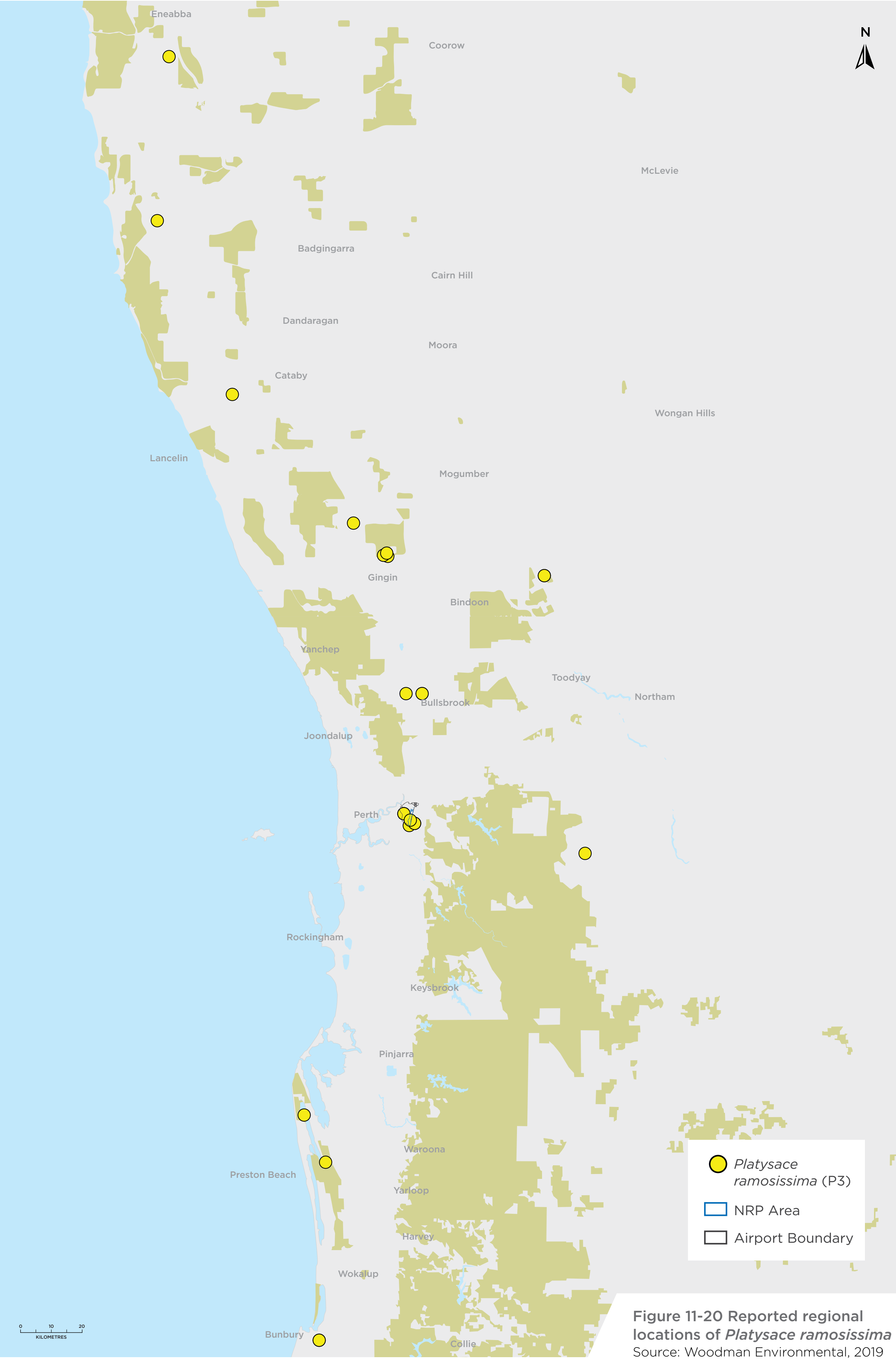


Figure 11-20 Reported regional locations of *Platysace ramosissima*
Source: Woodman Environmental, 2019

Platysace ramosissima (P3) is a perennial herb, growing up to 0.3m high, occurring on sandy soils. Figure 11-20 shows the regional range of records for *P. ramosissima* over approximately 385 km, from near Bunbury in the south to near Eneabba in the north (Woodman Environmental 2018b).

A total of 44 records have been identified, representing approximately 18 populations grouped into four general localities:

- South of Perth (Busselton-Capel to Lake Clifton): 2 populations,
- Perth metropolitan area: 5 populations,
- Swan Coastal Plain/Northern Sandplains: 9 populations, and
- East / North-East of Perth metropolitan area: 2 populations.

At least five populations occur within DBCA-managed tenure, Drummond Nature Reserve, Bartletts Well Nature Reserve, South Eneabba Nature Reserve, Wandoo National Park and Yalgorup National Park.

The NRP will potentially impact on one of the three known locations of *P. ramosissima* within the Perth Airport estate (See Figure 11-21). There are 21 known populations with the small population on Perth Airport estate located central to this species' distribution that ranges over 385 km. Two records of *P. ramosissima* that are located in the Perth metropolitan area are close to the Perth Airport. The NRP potentially impacts on one location of *P. ramosissima* across its large range and based on current information the potential impact is not considered significant.

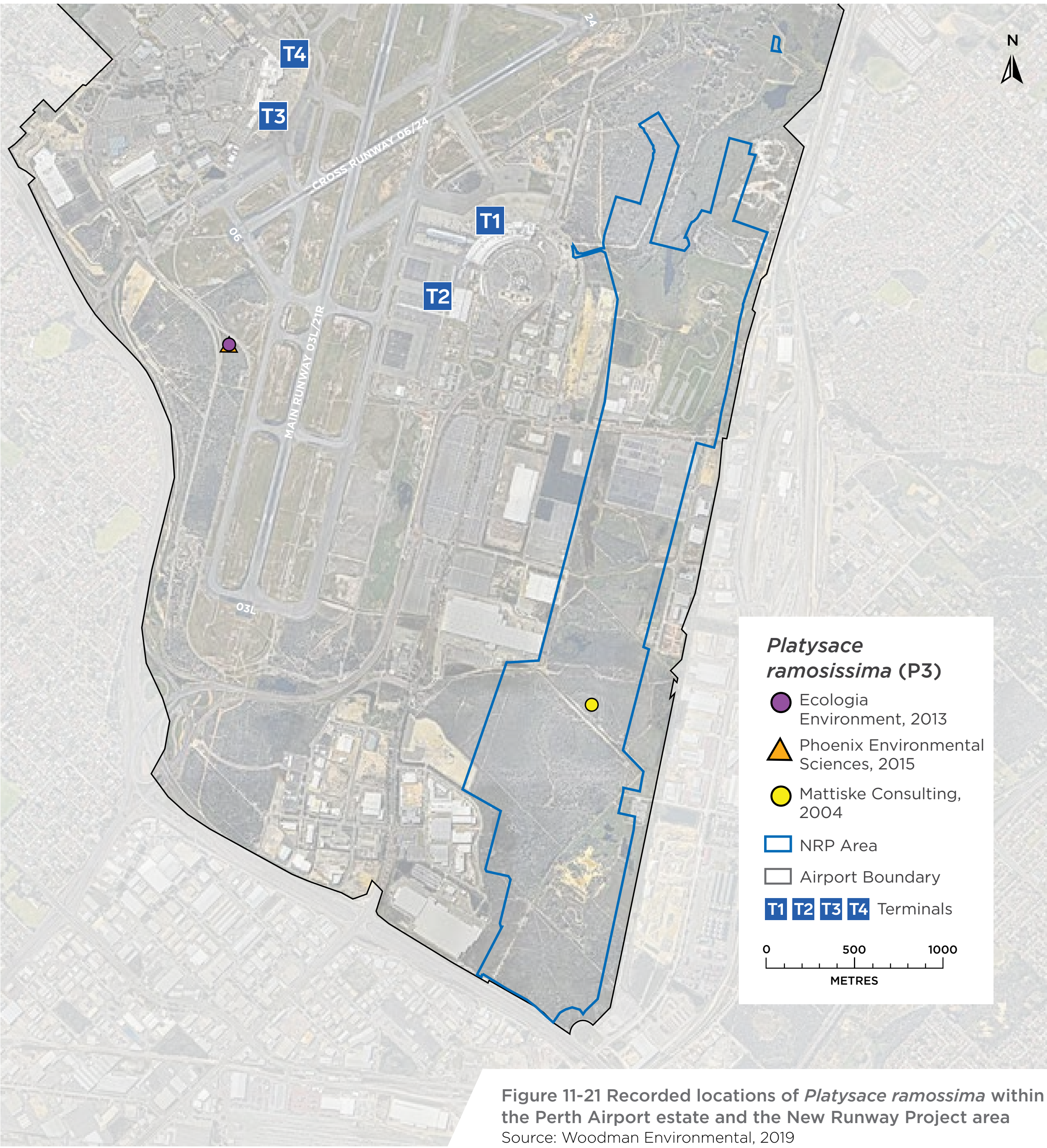


Figure 11-21 Recorded locations of *Platysace ramossima* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

Schoenus benthamii (P3) is a tufted perennial sedge growing to 0.15m to 0.45m occurring on winter-wet flats and in swamps with sand and sandy clay.

Figure 11-22 shows the regional range of records for *S. benthamii* over a range of approximately 750 km from east of Esperance in the south-east to near Mogumber in the north-west (Woodman Environmental 2018b). There are records for 18 populations: These are predominately in the Busselton-Bunbury region (eight populations), or the Perth metropolitan area (nine populations). It has been noted to occur in conservation estate throughout its range, including Kodjinup Nature Reserve, Dundas Nature Reserve, and Fish Road Nature Reserve or in remnant bushland including Manea Park in College Grove near Bunbury, Holmes St Bushland in Gosnells and Yule Brook Reserve (Woodman Environmental 2018b).

The NRP will potentially impact on 11 of 12 (91.7 per cent) known locations of *S. benthamii* within the Perth Airport estate (See Figure 11-23). Specific abundance data is not available for these locations; however, this probably represents about 1,200 plants (assigning one plant to each recorded location). There are 22 populations recorded for *S. benthamii* of which nine occur in the Perth metropolitan area, including reserved areas (Bush Forever site 125, Kodjinup Nature Reserve and Kenwick Nature Reserve). The population at Perth Airport estate is within the known 750 km range of *S. benthamii*. Therefore the potential impact of the NRP on *S. benthamii* is not considered significant.

Figure 11-22 Reported regional locations of *Schoenus benthamii*
Source: Woodman Environmental, 2019

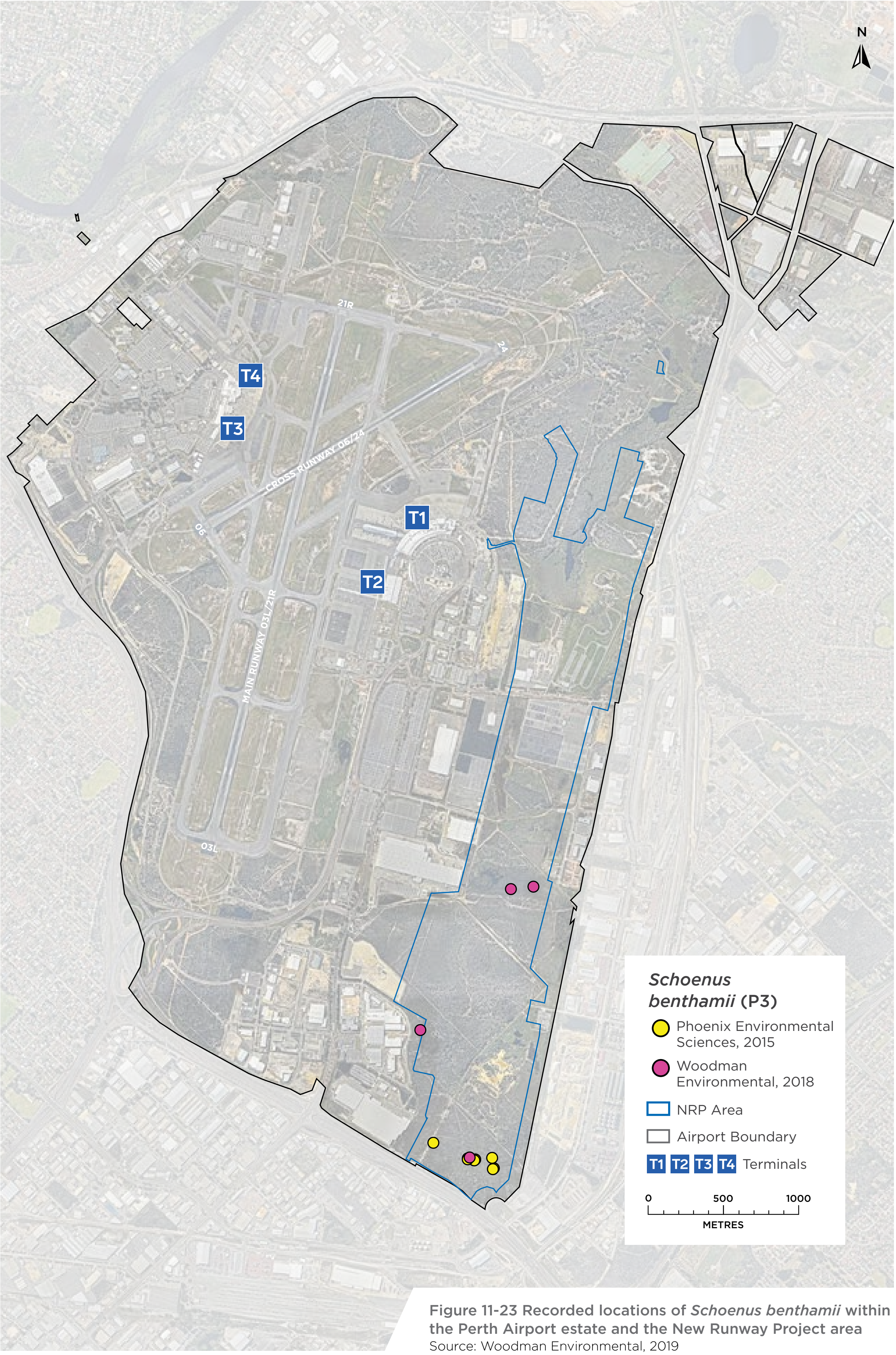


Figure 11-23 Recorded locations of *Schoenus benthamii* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

Schoenus pennisetis (P3) is a tufted annual, grass-like or herb, growing to 0.15 m high on grey or peaty sand or sandy clay in swamps and winter-wet depressions. It is known to occur over a range of approximately 550 km, from 70 km east of Geraldton in the north to 10 km south east of Busselton in the south (Figure 11-24).

The record of *S. pennisetis* at the Perth Airport estate is a new population for the species central to its known distribution occurring over a range of approximately 550 km. The NRP potentially impacts on 50 per cent (two) of known locations of the species within the Perth Airport estate (See Figure 11-25). *S. pennisetis* is known from 50 records, seven within 10 km of the Perth Airport estate. It is unlikely that impacts of the NRP will result in a change to the conservation status of this species. Therefore the potential impact of the NRP on *S. pennisetis* is not considered significant.

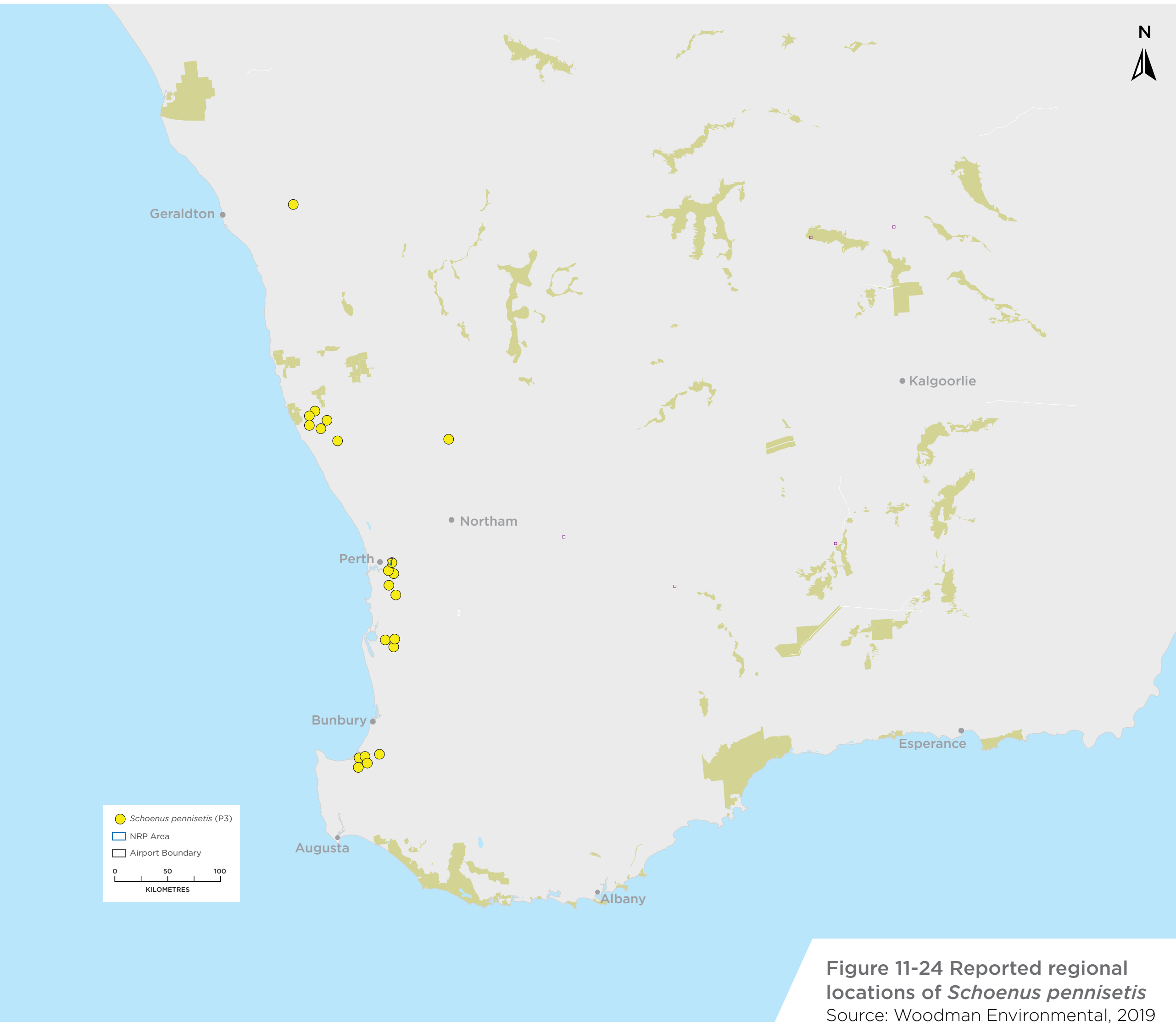


Figure 11-24 Reported regional locations of *Schoenus pennisetis*
Source: Woodman Environmental, 2019

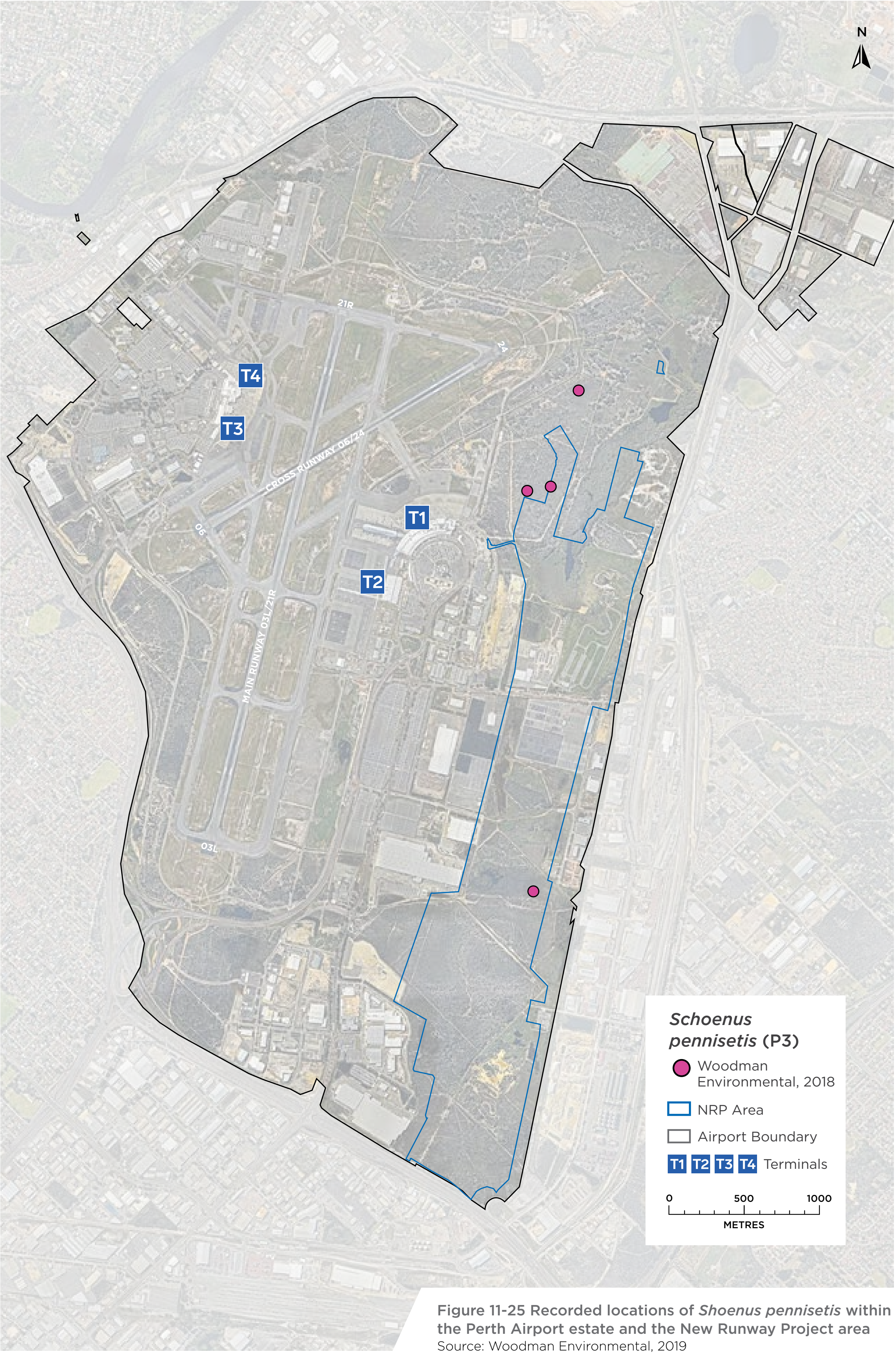


Figure 11-25 Recorded locations of *Shoenus pennisetis* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

Stylidium longitubum (P4) is an erect ephemeral herb, growing to 0.12 m high on sandy clay in seasonal wetlands. It is known to occur over a range of approximately 450 km, from 25 km north west of Eneabba in the north to 10 km south east of Busselton in the south (Figure 11-26).

The NRP will potentially impact on one of seven (14.3 per cent) known locations of *S. longitubum* within the Perth Airport estate (See Figure 11-27). There are 93 records for *S. longitubum* occurring over a large range of approximately 450 km, from 25 km north west of Eneabba in the north to 10 km south east of Busselton in the south. The Perth Airport estate population is central to its known distribution. Several known locations of this species are in the Perth metropolitan area, the closest to the Perth Airport estate being at Cannington and Midland Junction. Based on the large number of records and range of the species, the potential impact of the NRP on *S. longitubum* is not considered significant.

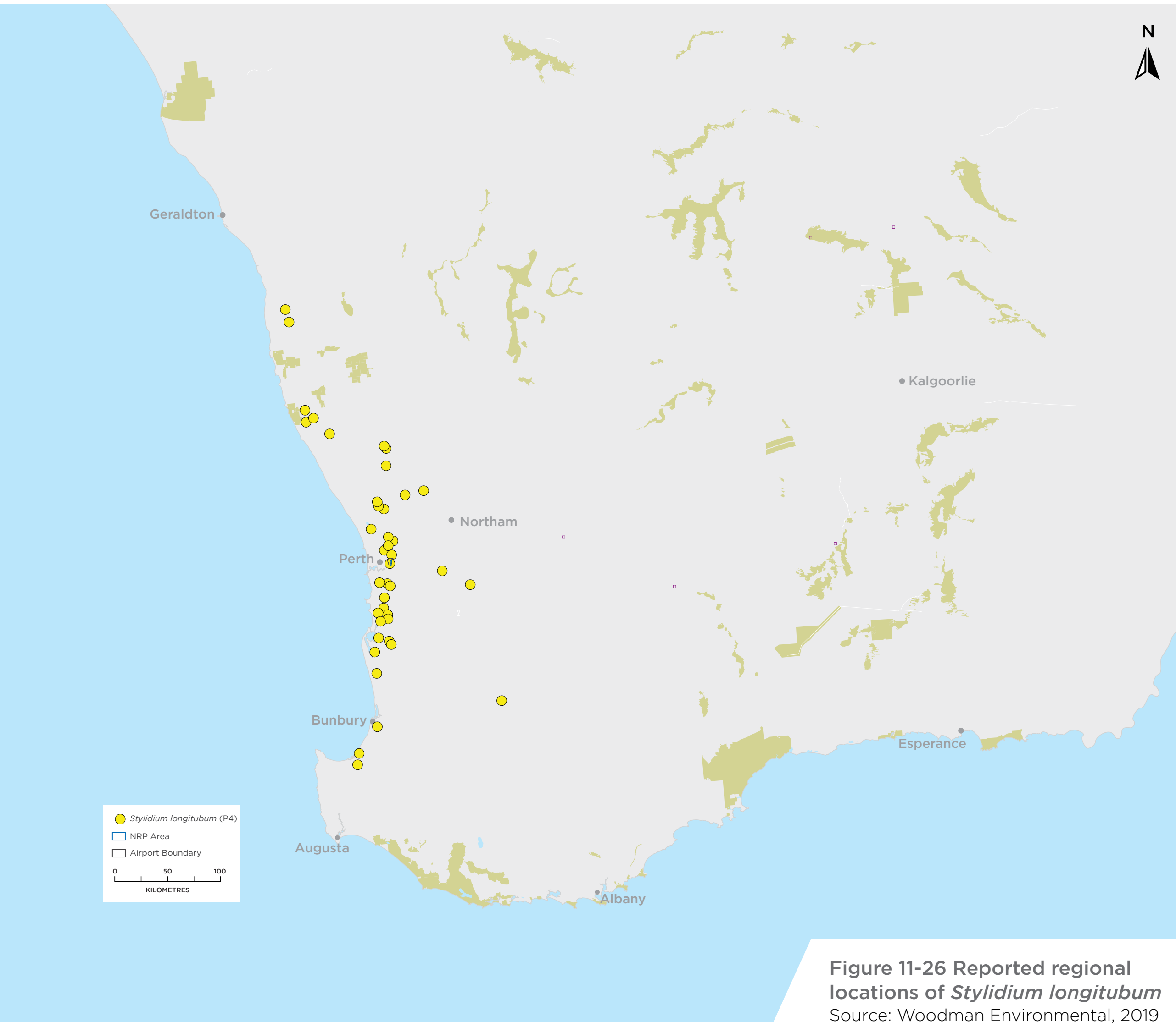


Figure 11-26 Reported regional locations of *Stylidium longitubum*
Source: Woodman Environmental, 2019

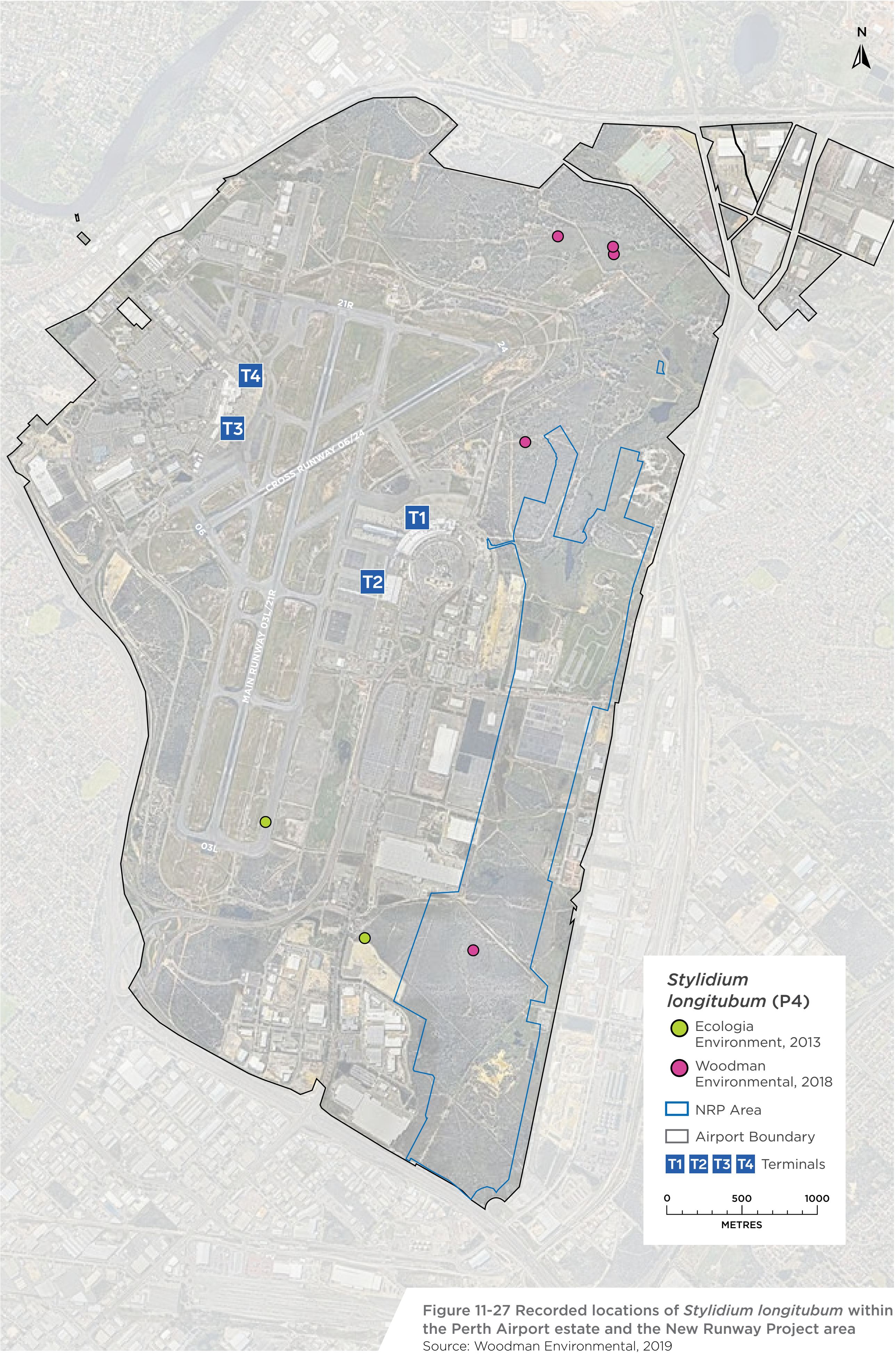


Figure 11-27 Recorded locations of *Stylidium longitubum* within the Perth Airport estate and the New Runway Project area
Source: Woodman Environmental, 2019

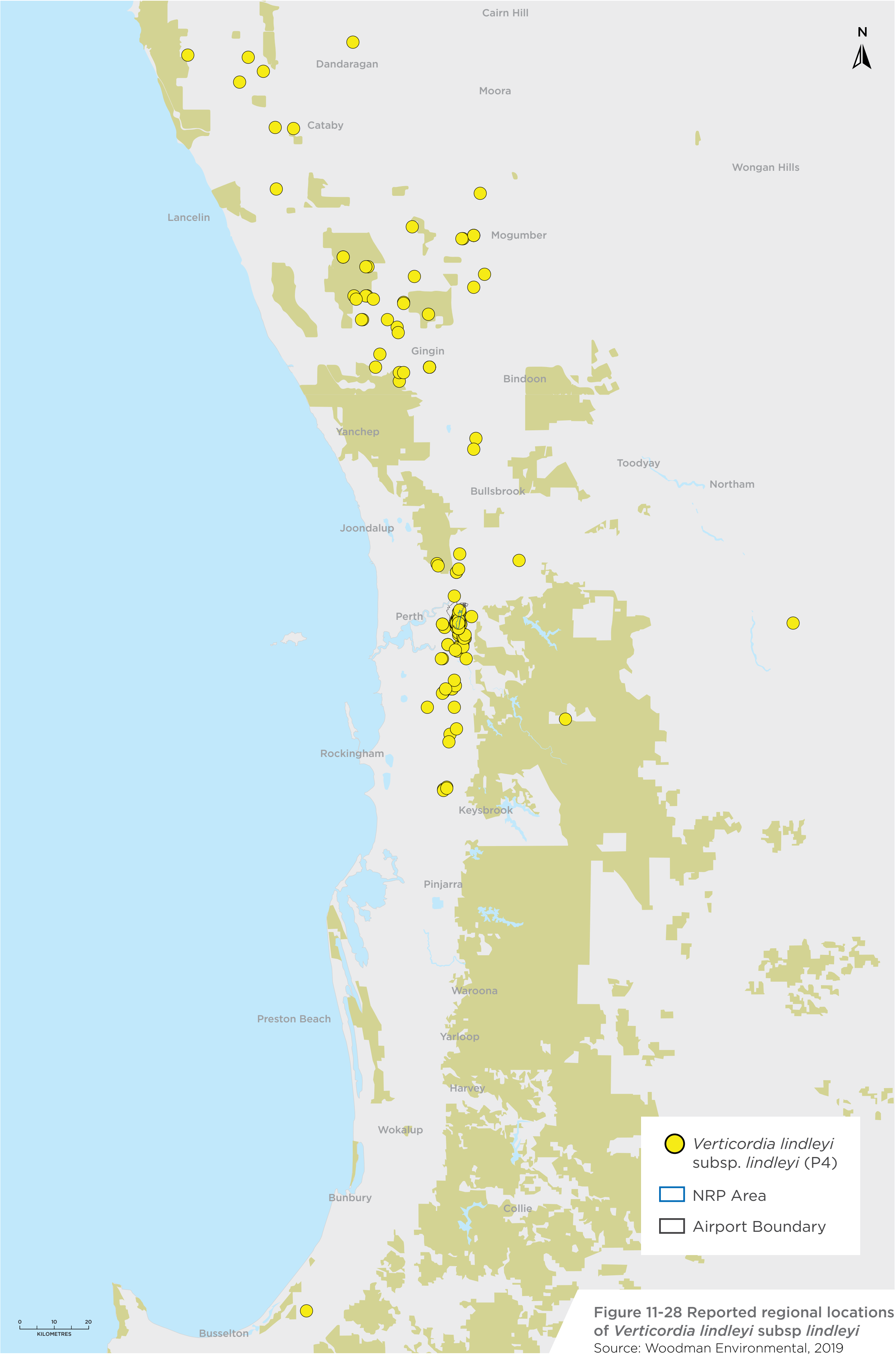


Figure 11-28 Reported regional locations of *Verticordia lindleyi* subsp *lindleyi*
Source: Woodman Environmental, 2019

Verticordia lindleyi subsp. lindleyi (P4) is an erect shrub growing up to 0.75 m, occurring in winter-wet depressions with sand and sandy clay. Figure 11-28 shows the regional distribution of records for V. lindleyi subsp. lindleyi over a range of approximately 220 km from Karnup Road (Shire of Serpentine-Jarrahdale) in the south to near Cooljarloo in the north-west (Woodman Environmental 2018b).

187 records have been identified for this species comprising approximately 97 regional populations. The DBCA threatened flora database recognises a total of 28 populations, with several split into sub-populations. Data was variable with many records not stating the number of individuals present; however, some significant populations are known to occur, including in Moore River National Park; Moore River Nature Reserve and in the Perth metropolitan area.

A total of 702 individuals of *V. lindleyi* subsp. *lindleyi* are known on the Perth Airport estate (See Figure 11-29). The NRP will potentially impact on 58.8 per cent of the 182 known locations: This potentially represents about 410 individuals (assumes average number of plants at each location). This species is known to occur over a large range of 220 km with a large number of known populations, including multiple from the Perth metropolitan area. The population at the Perth Airport estate is well within the known range for this taxon. Populations are also known within seven reserves (including Moore River National Park). Based on the large number of records and the known range of the species, the potential impact of the NRP on *V. lindleyi* subsp. *lindleyi* is not considered significant.

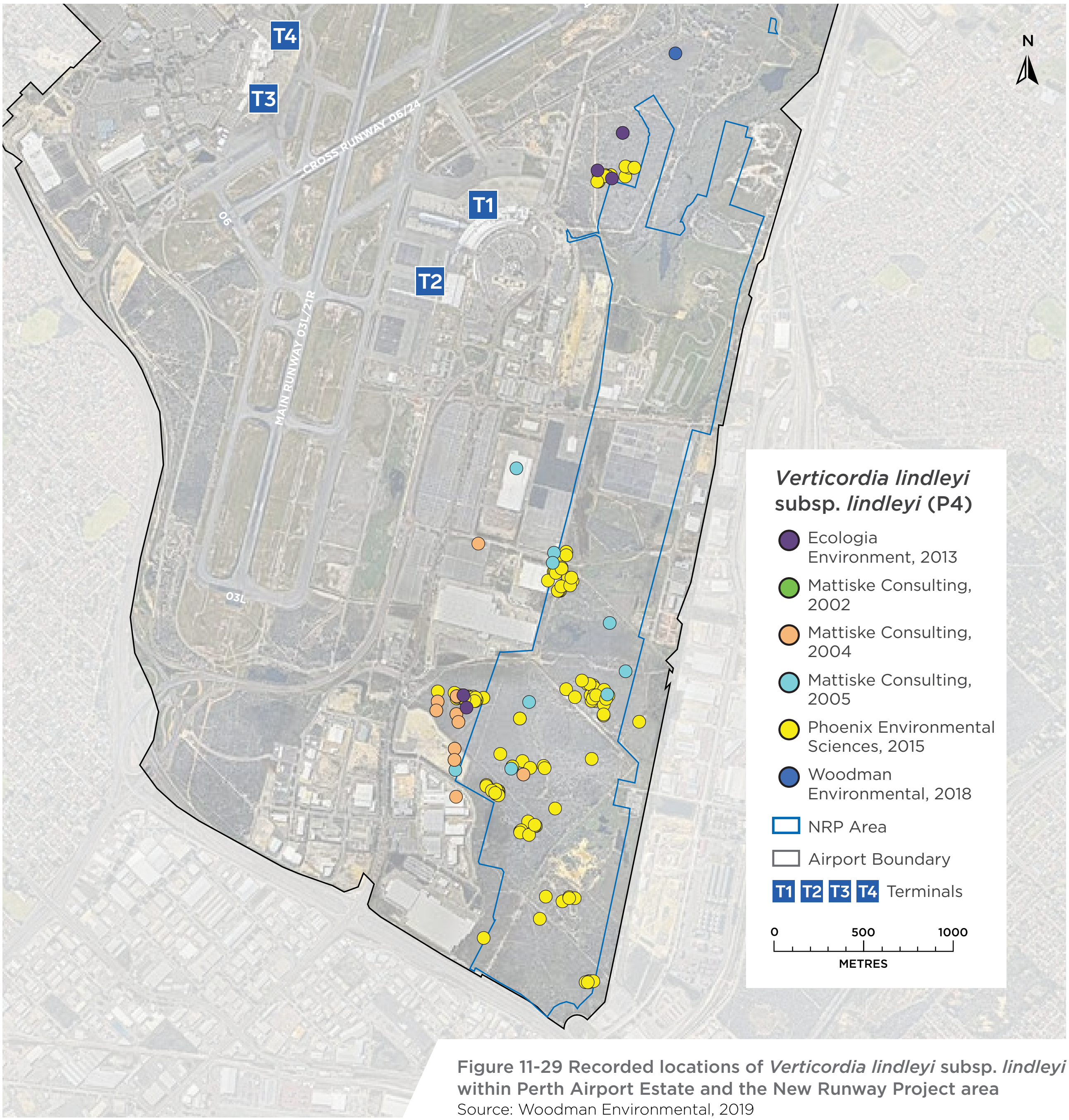


Figure 11-29 Recorded locations of *Verticordia lindleyi* subsp. *lindleyi* within Perth Airport Estate and the New Runway Project area
Source: Woodman Environmental, 2019

11.6.5 Aquatic Flora

In the 2015 survey, three species of macrophytes were retrieved as shown below:

- *Elatine gratioloides*
- *Ottelia ovalifolia*
- *Lepilaena australis*

All of these species have been recorded previously at the estate. Dry weights were obtained, resulting in an average biomass of 5.3gDWm^2.

Previous studies found macrophytes at Munday Swamp to have declined from four species with a biomass of 28gDWm^2 in 2008, to two species with a biomass of 6.4gDWm^2 in 2011. The most current results from 2015 show and increase in richness from two to three species but a decrease in the average biomass to 5.3gDWm^2.

The cause of the fluctuations in species richness and decline in aquatic flora biomass cannot be definitively deduced from the data obtained to date. Possible causes include inter-annual and seasonal changes, differences in sampling sites, deterioration in ecosystem health or a combination of these factors.

Strelow *et al.* (2011) raised concerns about the potential invasion of aquatic weeds arising from a man-made lake adjacent to Munday Swamp. The results of the 2015 survey indicate that this has not occurred as all aquatic species recorded are native.

11.7 Summary of Risk Assessment and Mitigation Measures

The NRP will result in the loss of 139.4 hectares of native vegetation that includes:

- The EPBC Act listed:
  - Banksia Woodlands of the Swan Coastal Plain community (Endangered), 41.4 hectares,
  - *Conospermum undulatum* (Vulnerable, including State listed), 206 plants, and
  - *Macarthuria keigheryi* (Endangered including State listed), 855 plants.
- The BC Act listed:
  - Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain, community (Vulnerable), 4.07 hectares,
- Eight DBCA listed Priority Species:
  - *Johnsonia pubescens* subsp. *cygnorum* (P2),
  - *Jacksonia gracillima* (P3),
  - *Ornduffia submersa* (P4),
  - *Platysace ramosissima* (P3),
  - *Schoenus benthamii* (P3),
  - *Schoenus pennisetis* (P3),
  - *Stylidium longitubum* (P4), and
  - *Verticordia lindleyi* subsp. *lindleyi* (P4).

Table 11-24 shows a summary of the impacts and mitigation measures, with residual impacts. Table 11-25 shows a summary of the overall risk assessment and the residual risks of the NRP.

Impacting Process	Impacted Matter	Mitigation Measure	Residual Impact (after implementation of mitigation measure)
Vegetation clearing	Loss of remnant vegetation.	Well-defined and rationalised clearing footprint that avoids clearing where possible.	Loss of 143 hectares of native vegetation.
	Loss of EPBC listed TEC Banksia Woodlands.		Loss of 41.4 hectares of EPBC-listed TEC Banksia Woodlands.
	Loss of State isted TEC Forests and Woodlands (SCP15).		Loss of 4 hectares of State Listed TEC (SCP15).
	Loss of habitat for EPBC-listed species of conservation significance.		
	Loss of habitat for DBCA listed flora species.		
Flora habitat fragmentation and edge effect	Change of microclimate (light, temperature, water availability).	Well-defined and rationalised clearing footprint that avoids clearing where possible.	
	Increase in pollutants (dust) affecting plant photosynthesis during construction and operation.		

Impacting Process	Impacted Matter	Mitigation Measure	Residual Impact (after implementation of mitigation measure)
Invasion of weeds and/or pest species	Introduction of weeds or pests that outcompete or devastate conservation significant species, habitat for conservation significant species or native remnant vegetation.	Hygiene Management Plan during construction. Ongoing weed management.	Negligible due to effective hygiene management.
Movement or introduction of *Phytophthora* dieback	New infestations of dieback in previously uninfested areas due to movement of soil, water of vehicles.	Hygiene management plan to be prepared to include vehicle movement and wash-down management procedures, stockpile management, active treatment if required during construction, dieback assessments and hygiene management. Imported soil to be dieback free.	Negligible due to effective hygiene management.
Plant-pollinator associations	Impairment of reproductive ability and reduction in genetic variation of both pollinator and flora.	Well-defined and rationalised clearing footprint that avoids clearing where possible.	
Bushfire regime	Changes to bushfire regime impacting vegetation.	Existing fire management regime to remain. Fire management measures during construction.	
Hydrology and groundwater impacts	Localised drawdown may impact on Munday Swamp.	CEMP to include dewatering management with acceptable trigger values.	
	Localised groundwater level increase due to vegetation clearing.	CEMP to include dewatering management with acceptable trigger values.	
	Infill of the southernmost section of Munday Swamp.	Type of fill carefully considered during the design stage. Implementation of a CEMP including: • staged development planning and installation of water quality control measures prior to construction, • regular monitoring and maintenance of water quality control and treatment measures, and • regular monitoring of surface water.	

Table 11-24 Summary of impacts and mitigation measures
Source: Perth Airport

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Vegetation clearance	Loss of EPBClisted Banksia Woodlands TEC	Construction	Restrict clearing footprint to NRP area, demarcate vegetation clearing extent and exclusion zones	Major Adverse	Almost Certain	Very High	Offsets in accordance with EPBC environmental offsets policy. Exclusion of predators, weed control. *Phytophthora* management. Fire management. Conservation significant flora and vegetation management plan.	Adverse	Almost Certain	High
	Loss of habitat for species of conservation significance (Commonwealth) (*Conospermum undulatum, Macarthuria keigheryi*)	Construction	Restrict clearing footprint to NRP area, demarcate vegetation clearing extent and exclusion zones	High Adverse to Major Adverse	Almost Certain	High	Offsets in accordance with EPBC environmental offsets policy. Collection of plants, rootstock and seedbank. Exclusion of predators, weed control. *Phytophthora* management. Fire management. Conservation significant flora and vegetation management plan.	High Adverse	Almost Certain	High
	Removal of regionally significant vegetation and loss of habitat for species of conservation significance (State)	Construction	Restrict clearing footprint to NRP area, demarcate vegetation clearing extent and exclusion zones	Moderate Adverse (all Priority listed species)	Almost Certain	High	Exclusion of predators weed control. *Phytophthora* management. Fire management. Conservation significant flora and vegetation management plan.	Adverse	Likely	Medium
Flora habitat fragmentation and edge effect	Change of microclimate (i.e. more light and higher climate in remaining habitat)	Construction and Operation	Restrict clearing footprint to NRP area Restrict tree trimming to approach lighting clearance zone	Minor Adverse	Likely	Medium	No additional mitigation measures identified	Adverse	Likely	Medium
	Increase in pollutants (dust) affecting plants photosynthesis during construction and operation	Construction and Operation	Air quality management (i.e. dust suppression during construction)	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Invasion of weeds and/or pest species	Introduction of weeds or pest that outcompete or devastate conservation significant species	Construction and Operation	Implementation of a weed and pest management and hygiene plan	Moderate Adverse	Unlikely	Low	Active weed management post-development to rehabilitate degraded areas	Minor Adverse	Unlikely	Low
Movement or introduction of dieback disease	New infestations of dieback in previously uninfested areas due to movement of vehicles, soil or water	Construction and Operation	Dieback Management Plan to be prepared to include vehicle movement and wash-down management procedures, stockpile management, active treatment if required during construction, dieback assessments and hygiene management. Imported soil to be dieback free.	Moderate to High Adverse	Possible	Medium	Location of stockpiles considered	Moderate Adverse	Unlikely	Low
Plant-pollinator associations	Impairment of reproductive ability and reduction in genetic variation of both pollinator and flora	Construction and operation	Restrict clearing footprint to NRP area, demarcate vegetation clearing extent and exclusion zones	Negligible	Unlikely	Very Low	No additional mitigation measures identified			
Bushfire regime	Changes to bushfire regime impacting vegetation	Construction and Operation	Management plans to include measures for fire management during construction. Existing fire management and suppression around the estate	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Hydrology and groundwater impacts	Localised drawdown may impact on Munday Swamp	Construction	Implement Dewatering Management Plan with acceptable trigger values.	Minor Adverse	Possible	Low	No additional mitigation measures identified			
	Localised groundwater level increase due to vegetation clearing	Construction	Implement Dewatering Management Plan with acceptable trigger values.	Minor Adverse	Unlikely	Low	No additional mitigation measures identified			
	Infill of the southernmost portion of Munday Swamp	Construction	Type of fill carefully considered during the design stage. Implementation of a CEMP including: staged development planning and installation of water quality control measures prior to construction, regular monitoring and maintenance of water quality control and treatment measures, and regular monitoring of surface water.	Minor Adverse	Possible	Low	Testing of fill chemistry undertaken prior to construction	Minor Adverse	Unlikely	Low

Table 11-25 Summary of risk assessment and residual risk
Source: Perth Airport

11.8 Proposed Offsets

With mitigation measures (summarised in Section 11.7), some unavoidable residual impacts remain. Under the EPBC Act, proponents are required to offset the residual impacts of an action. Residual impacts due to habitat loss will be offset as per the requirements of the EPBC Act Environmental Offsets Policy (DSEWPaC 2012b) and Offset Assessment Guide (DSEWPaC 2012c). Refer to section 17.9 for further detail.

11.9 Conclusions

The NRP covers an area of 293 hectares of which approximately 139.4 hectares is native vegetation. Perth Airport has undertaken a rigorous process to assess the potential impacts to the flora and vegetation values from the NRP as per the requirements of Guidelines 1.1 and 1.2 under the EPBC Act. This has included a thorough review and screening of all MNES, state listed and general flora species and communities to identify those that are present and require detailed assessment. This resulted in identification and assessment of potential impacts (direct, indirect and off site), avoidance and mitigation and significance of residual impacts for the following:

- two species of flora protected under the EPBC Act,
  - *Conospermum undulatum* and *Macarthuria keigheryi,*
- The Threatened Ecological Community protected under the EPBC Act,
  - The Banksia Woodlands of the Swan Coastal Plain,
- The Threatened Ecological Community protected under the BC Act,
  - Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain,
- Priority Flora, which is not specifically protected under the BC Act, has also been identified, with eight species listed below:
  - *Johnsonia pubescens* subsp. *cygnorum* (P2),
  - *Jacksonia gracillima* (P3),
  - *Ornduffia submersa* (P4),
  - *Platysace ramosissima* (P3),
  - *Schoenus benthamii* (P3),
  - *Schoenus pennisetis* (P3),
  - *Stylidium longitubum* (P4), and
  - *Verticordia lindleyi* subsp. *lindleyi* (P4).
- the Whole of Environment is considered through impacts associated with clearing of native remnant vegetation as per Significant Impact Guideline 1.2.

The NRP requires the clearing and development of the total NRP area to facilitate the required development of an effective runway and associated infrastructure and clearances. In doing so, impacts upon flora and vegetation are unavoidable. Where possible, Perth Airport will apply appropriate management plans and mitigation efforts, as identified in this MDP, to minimise impacts to flora and vegetation remaining habitats adjacent to the NRP.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12 Fauna

This section describes the impacts on fauna resulting from the construction and operation of the New Runway Project (NRP).

Detail is provided on the following:

- What fauna species are present in the NRP area?
- What are the potential impacts of the NRP on fauna species?
- How will the potential impacts on fauna be mitigated?
- What is the significance of potential impacts on fauna species from the NRP?

12.1 Introduction

This section describes the impacts on fauna resulting from the construction and operation of the New Runway Project (NRP).

The NRP will impact fauna as a result of:
- clearing in the NRP area, and
- the construction and operation of the runway.

An assessment of the impacts on the NRP on fauna has been undertaken. This includes numerous surveys of the fauna within the NRP area to define the existing fauna conditions, assess the potential impacts from the construction and operation of the NRP, and propose mitigation measures. Further information regarding fauna assessment methodologies in can be found in Section 12.4.

Additional information on construction of the new runway and associated infrastructure can be found in Section 6. Additional information on the proposal to offset residual impacts to fauna can be found in Sections 12.8 and 17.9.

12.2 Key Findings

Key findings from the investigations into fauna across the NRP area include potential impact to:
- approximately 135 hectares of native vegetation (woodlands and heathland), 97.0 hectares of rough grassland and 5.6 hectares of drains that provides habitat for various fauna. The balance of the area consists of cleared or degraded land that is of low value for fauna,
- three species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), being Carnaby's Black Cockatoo, Baudin's Black Cockatoo and the Forest Red-tailed Black Cockatoo. These three cockatoo species have high conservation significance and forage around the estate bushland. They do not roost or breed on the estate, and
- three Priority Species listed by the State Department of Biodiversity Conservation and Attractions (DBCA), including the Quenda (Southern Brown Bandicoot) (Priority 4, DBCA), Rakali (Water-Rat) (Priority 4, DBCA) and a native bee species (*Hylaeus globuliferus)* (Priority 3, DBCA).

12.3 Policy Context and Legislative Framework

This MDP has been developed in consideration of the following Commonwealth legislation and guidelines:
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act),
- Significant Impact Guidelines 1.1: Matters of National Environmental Significance (DoE 2013) (Guideline 1.1), and
- Significant Impact Guidelines 1.2: Actions on or impacting upon Commonwealth land and actions by Commonwealth agencies (DSEWPaC 2013a) (Guideline 1.2).

Guideline 1.2 requires that potential impacts to both EPBC Act protected fauna species (Matters of National Environmental Significance (MNES)) and non-MNES fauna species resulting from airport projects (on Commonwealth land) are assessed. This "Whole of Environment" approach to fauna requires assessment of potential impacts (direct, indirect and offsite), mitigation and significance to MNES, state listed species and other fauna in general. Guideline 1.2 is considered in conjunction with Guideline 1.1 that includes criteria considered when assessing the significance of potential impacts to a fauna species:
- lead to a long-term decrease in the size of a population,
- reduce the area of occupancy of a species,
- fragment an existing population into two or more populations,
- adversely affect habitat critical to the survival of a species,
- disrupt the breeding cycle of a population,
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline,
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat,
- introduce disease that may cause the species to decline, or
- interfere with the recovery of the species.

Biodiversity in Western Australia is protected under the Western Australian *Biodiversity Conservation Act 2016* (BC Act), which replaced the *WA Wildlife Conservation Act 1950* at the start of 2019. Fauna species listed under the BC Act are assessed as part of the "Whole of Environment" approach to fauna. To inform this the following state policy documents and guidance have been applied in assessment of potential impacts to fauna.
- EPA Position Statement No.3 - Terrestrial Biological Sureveys as an Element of Biodiversity Protection (EPA 2002b),
- EPA Guidance Statement No. 56 - Guidance Statement for Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a),
- EPA Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (Hyder et al. 2010),
- EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (Endangered) Calyptorhynchus latirostris, Baudin's Cockatoo (Endangered) *Calyptorhynchus baudinii,* Forest Red-tailed Black Cockatoo (Vulnerable) *Calyptorhynchus banksii naso* (DSWEPaC 2012a),
- Revised draft referral guideline for three threatened black cockatoo species: Carnaby's Cockatoo (Endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (Endangered) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (Vulnerable) *Calyptorhynchus banksii naso* (DEE 2017).

12.4 Impact Assessment Methodology

12.4.1 Values and Impacts Approach

Bamford Consulting Ecologists (BCE) has developed an approach to assess the significance of an area for fauna species and the potential impacts to fauna from a project based upon Guideline 1.1 and Guideline 1.2 is outlined in Figure 12-1. The environmental context identifies and describes the fauna assemblage, the occurrence of conservation significant fauna and assigns a site status for all fauna within the project area. Conservation significant fauna (CS fauna) are defined in Section 12.4.2. The fauna assemblage (i.e. "Whole of Environment" fauna) is discussed in Section 12.5.3. Vegetation and Substrate Associations (including a regional vegetation assessment), patterns of biodiversity and ecological processes are discussed in Sections 12.5.5 to 12.5.8.

The impact assessment identifies threatening processes to fauna, in particular impacts to "Regularly Present" CS fauna and "Whole of Environment" fauna and provides mitigation and avoidance measures (Figure 12-1). "Regularly Present" include those conservation significant species that are known to occur in the project area and are known or expected to be a resident or regular migrants/visitor to the area. Impact significance for "Regularly Present" CS fauna and "Whole of Environment" fauna is assessed using criteria outlined in Guideline 1.1. The assessment considers potential direct (on-site and potentially off-site) impacts, and indirect impacts due to changes in ecosystem function. Refer to BCE (2019) for further detail.

Environmental Context within the Project Area

Identify and describe Fauna Assemblage[1]

Identify occurrence of Conservation Significant Fauna within the Project Area[2]

Identify and assign a site status category for all Fauna within the Project Area

Fauna Habitat Assessment, identifying:
- Vegetation and Substrate Associations
- Patterns of Biodiversity across the landscape
- Ecological Processes

Impact Assessment

Identify Threatening Processes to Fauna

Identify broader potential and cumulative impacts to "Regularly Present" Conservation Significant Fauna	Identify broader potential and cumulative impacts to "Whole of Environment" Fauna

Identify Mitigation and Avoidance Measures to reduce broader potential impacts

Determine whether impacts to Conservation Significant Fauna (MNES and non-MNES species) are significant using Significance Criteria in Guideline 1.1[3]	Determine whether impacts to "Whole of Fauna Environment" are significant using Significance Criteria in Guideline 1.1[3]

Figure 12-1 Impact Assessment Methodology for Assessing Project Impacts to Fauna under the EPBC Act.
Source: Bamford Consulting Ecologists, 2019

1 Identified through desktop database searches, surveys and studies
2 Conservation Significant Fauna (CS fauna) includes MNES and non-MNES Fauna. Refer to Section 12.4.2 for definition of CSF.
3 Refer to Section 12.4.3 for a description of BCE's Significant Impact Criteria based on Guideline 1.1.

12.4.2 Fauna Species of Conservation Significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the EPBC Act and the BC Act. In addition, DBCA recognises and assigns priority levels. Therefore, two broad levels of conservation significance were developed and applied for the assessment (Table 12-1). Other fauna species that are not of listed conservation significance were considered under the "Whole of Environment" component of the assessment.

Conservation Significance Level	Description
CS1	Species listed under State or Commonwealth Acts
CS2	Species listed as Priority by DBCA but not under legislative acts.

Table 12-1 Levels of conservation significance.
Source: Bamford Consulting Ecologists, 2019

12.4.3 Determination of Significant Impacts

The impact assessment process involved review of the fauna values identified through desktop assessment and field investigations with respect to the project and impacting processes. Impact assessment criteria were based on the severity of impacts on the fauna assemblage and CS fauna and quantified on the basis of predicted population change. Population change can be the result of direct habitat loss and/or impacts upon ecological processes. Significant impacts may occur if:

- there is direct impact upon a Vegetation and Substrate Association (VSA) and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna,
- there is direct impact upon CS fauna, and
- ecological processes are altered, and this affects large numbers of species or large proportions of populations ("Whole of Environment" fauna), including significant species.

In the following criteria (Table 12-2), the significance of impacts is based on estimated percentage fauna population decline within the immediate area of the surroundings, and upon the effect of the decline on the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of distribution of a species derived from the extent of available habitat.

The approach is consistent with the determination of impact significance for MNES, 'non-MNES species and the environment as outlined in Guideline 1.1 (DoE, 2013) and are addressed in Section 12.6 (Impact Assessment).

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but <1 % within 12km radius. No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10 % within 12 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline >10 % within 12 km radius. No change in viability or conservation status of taxon.
Critical	Taxon extinction within 12 km radius and/or change in viability or conservation status of taxon.

Table 12-2 Assessment criteria of impacts upon fauna.
Source: Bamford Consulting Ecologists, 2019

12.5 Environmental Context

12.5.1 Background

The purpose of this section is to provide an overview of the fauna that are present or are likely to be present within the NRP, with reference to the Perth Airport estate and particular emphasis on conservation significant species. It provides:

- a description of the fauna assemblage within the NRP,
- a list of conservation significant species that exist or are likely to be present within the NRP, from this list, "Regularly Present" species have been identified. "Regularly Present" species are given specific consideration in the impact assessment in Section 12.6. This process assists in screening out those species that are not likely to be affected by the project, enabling greater focus during the impact assessment phase on more relevant species,
- a site status category for all fauna (including MNES and non-MNES species) within the NRP, and
- an examination of the fauna values within the NRP for input into the fauna habitat assessment. This includes the following:
  - overall fauna assemblage, in terms of uniqueness, completeness and richness,
  - VSAs present (that provide habitat for fauna),
  - patterns of biodiversity across the landscape, and
  - ecological processes upon which the fauna depend.

12.5.2 Sources of information

Information on fauna within the NRP was drawn from a wide range of sources. These included State and Commonwealth government databases and results of previous fauna assessments conducted on and in the vicinity of the project area, e.g. studies undertaken for the Perth Airport estate.

The fauna assemblage of the NRP and broader Perth Airport estate have been the subject of a number of studies dating back to 1994; including general fauna surveys and targeted studies on significant species.

In 2008 and 2014, trapping and bird census surveys were conducted in and adjacent to the project area as a part of a comprehensive fauna survey for the Perth Airport estate (Everard and Bamford, 2014). Fauna studies including a Black Cockatoo Habitat Assessment were also conducted for the NRP (Bamford *et al., 2017*) and updated in 2019 to inform this current assessment.

As a result, there is a considerable body of information available on the fauna assemblage of the project area. Table 12-3 lists the fauna studies undertaken in the Perth Airport estate since 1994.

Study	Title/ Survey Type	Airport Estate	NRP
ATA (1994)	Report of a Fauna Survey of the Perth Airport	X	
How (1995)	Objection Assessment of Faunal Values for Perth Airport	X	
ATA (1997)	Perth Airport Rare and Endangered Flora and Fauna	X	
Kuchling and Burbidge (1996)	Perth Airport Western Swamp Tortoise Survey	X	X
Bancroft and Bamford (2008)	Fauna of the Perth Airport: Progress Report (Autumn 2008 Survey)	X	X
Strehlow and O'Connor (2009)	Sampling of aquatic macro-invertebrates at Perth Airport	X	
Huang and Bamford (2010)	Perth Airport Graceful Sun-Moth (*Synemon gratiosa*) Survey	X	X
Strehlow *et al.* (2011)	Sampling of aquatic macro and microinvertebrates at Perth Airport	X	X
Basnett and Bamford (2012a)	Perth Airport Black Cockatoo Habitat Study – Site 2	X	
Basnett and Bamford (2012b)	Perth Airport Bushland Fauna Assessment	X	
Moore and Bamford (2013)	Perth Airport Black Cockatoo Habitat Survey	X	X
Everard and Bamford (2014)	Fauna Surveys of the Perth Airport Bushland: 2008 and 2014	X	X
Syrinx Environmental (2017)	Munday Swamp: Assessment of Northern Main Drain Diversion Works on Wetlands, Vegetation and Fauna	X	X
Bamford (2017)	Munday Swamp: Assessment of Fauna Values: Autumn 2017	X	X
Bamford *et al.* (2017)	Fauna Assessment of the New Runway Project – Perth Airport	X	X
Wetland Research and Management (2018)	Perth Airport Macroinvertebrate Study: Spring 2017	X	X
Moore *et al.* (2018)	Black Cockatoo Foraging Habitat Assessment of the Perth Airport	X	X
Bamford and Knowles (2019)	Survey for conservation significant invertebrates on the Perth Airport Estate, January 2019	X	X
Bamford and Everard (2019) (in prep)	Fauna Impact Assessment for the Perth Airport Estate. Included a re-assessment of potential nest-trees for black cockatoos across the Estate in August and September 2018.	X	X

Table 12-3 Summary of fauna investigations undertaken in the NRP and Perth Airport estate.
Source: Bamford Consulting Ecologists, 2019

Field surveys were conducted in accordance with State and Federal guidelines and have included the following:

- acoustic surveys for bats,
- aural surveys for frogs,
- level 2 fauna trapping (e.g. pitfall, funnel, cage and Elliott trapping),
- aural surveys for birds,
- assessment of VSAs/fauna habitats,
- Black Cockatoo assessment for foraging and nesting habitat and roosting sites,
- Quenda transect surveys,
- use of motion-sensitive cameras,
- searching Munday Swamp and surrounds for CS fauna, including the Water-rat (Rakali) and Western Swamp Tortoise (including trapping),
- habitat assessment for aquatic invertebrates,
- sampling for freshwater fish,
- wetland studies (e.g. water quality, habitat and macroinvertebrates),
- targeted searching for reptiles, and
- opportunistic observations.

12.5.3 Overview of the fauna assemblage

While the project footprint is the area that is physically affected by the proposed works, the study area for the fauna assessment is the region defined at an appropriate scale to capture potential and contextual impacts. The assessment thus includes the NRP area and where relevant, adjacent areas within the Perth Airport estate.

204 vertebrate species were identified as potentially occurring in the Airport Estate. These include: five fish, 12 frogs, 42 reptiles, 130 birds (six introduced) and 15 mammals (five introduced). Of these, 174 species (two fish, 11 frogs, 32 reptiles, 116 birds and 13 mammals) have been recorded in the Perth Airport estate and are considered highly likely to be present in the NRP. Refer to section 12.5.4.1 and BCE 2019 for further detail on species now considered locally extinct at the Perth Airport estate. Six bird species which have been previously recoded are now probably locally extinct, leaving a current assemblage of 168 vertebrate species (Table 12-4). Not all species listed in Table 12-4 are likely to occur in the project area, some species may be resident, while others may be regular or irregular visitors to the site as a part of an annual cycle.

	Potential	Recorded	Highly Likely	Locally extinct
Fish	5 (1 int.)	1 (1 int.)	1	1
Frogs	12	10	1	0
Reptiles	42	22	10	4
Birds	130 (6 int.)	103 (4 int.; 6 prob LE)	13 (1 int.)	1
Mammals	15 (5 int.)	12 (5 int.)	1	13
Total	**204**	**148**	**26**	**19**
		174 (168 current)		

Table 12-4 Composition of vertebrate fauna assemblage of the Perth Airport estate.
Source: Bamford Consulting Ecologists, 2019

'Potential' species are those returned from the literature review and deemed as 'likely' to occur in the vicinity of the project area. 'Recorded' species have been detected in one or more surveys; some of these are now considered to be probably locally extinct ('prob. LE'). 'Highly Likely' species are those not recorded but considered very likely to utilise the project area, at least occasionally. 'Locally extinct' species formerly occurred in the project area and Airport Estate but are now absent. The numbers of introduced ('int.') species are shown in parentheses, where relevant.

For further detail on the fauna assembly refer to BCE (2019).

12.5.4 Conservation Significant Fauna

Of the 174 species of vertebrate fauna that have been recorded, or that are highly likely to occur in the area, nine are considered to be of conservation significance (Table 12-5). Of these, only four species (two birds, two mammals) are expected to be regularly present and five species (all birds) irregularly present. These species are discussed in Section 12.5.4.2 and Section 12.6 (Impact Assessment). No listed conservation significant fish, frogs or reptiles have been recorded or are expected to occur.

In addition, database reviews returned four invertebrate species of conservation significance, however only one (a native bee, *Hylaeus globuliferus*) is highly likely to be present within the southern area of the NRP (refer Table 12-5). The following are considered locally extinct:

- The Graceful Sun-Moth *(Synemon gratiosa)*, was searched for in 2010 and it was concluded that the species was absent due to low habitat quality (Huang and Bamford 2010). It is therefore not included in Table 12-5.
- Two crickets (Priority 1) and *Austrosaga spinifer* (Priority 2), may formerly have occurred on the Perth Airport estate, but are now considered to be locally extinct following surveys in 2019. Refer to Section 12.5.4.1 for further details.

One aquatic invertebrate species endemic to the south-west was recorded from Munday Swamp; the freshwater isopod *Paramphisopus palustris* (WRM, 2018). The species appears to be a resident of Munday Swamp, having also been recorded previously by Strehlow and O'Connor (2009), and Strehlow *et al.* (2011). A number of additional south-west endemics are known from Munday Swamp but were not recorded by WRM (2018). The south-west endemic species *Perthia acutitelson* (amphipod) and *Notonecta handlirschi* (backswimmer) were reported by Strehlow and O'Connor (2009). Neither of these species have been recorded from Munday Swamp since. Another south-west endemic species previously known from Munday Swamp is the water boatman *Sigara mullaka*. *S. mullaka* was recorded by Strehlow and O'Connor (2009) but has not been recorded since. It is not known if these changes represent species loss, or if these species are present only intermittently. The backswimmer and boatman can both fly as adults and thus move between wetlands.

12.5.4.1 Conservation Significant Locally Extinct Fauna

Reptiles

The Western Swamp Tortoise, *Pseudemydura umbrina,* has been recorded alive at the Airport Estate since 1970 (~50 years). The record consisted of the capture of a single juvenile animal "at airport swamps adjacent Hardey Road" (Western Swamp Tortoise database maintained by the DBCA), leading to the suggestion that the Five Mile Swamp area in the southern part of Estate harboured a Western Swamp Tortoise population at least until the early 1970s (Burbidge *et al.* 2010). This presumed population was not monitored, and no specimens were found during surveys in 1995 (Kuchling and Burbidge 1996) and 2005 (Burbidge and Kuchling 2005). The 1995 survey was intensive, using trapping methods developed during decades of research on the species at Twin Swamps and Ellen Brook Nature Reserves. Kuchling and Burbidge (1996) also provided anecdotal accounts of the species in the Perth Airport area from several long-term residents, with dates from the early 1940s, late 1960s/early 1970s, and 1995. The latter was of a shell only.

Burbidge *et al.* (2010) note the original distribution of the species as from "near Pearce Airforce Base south to Perth Airport" but provide no detail of the Airport records. They give the current distribution of the species as Ellen Brook and Twin Swamps Reserves. The current fauna profile also supports this and provides no records from the airport (DBCA 2017). Multiple fauna surveys have been undertaken on the Estate and the tortoise has not been found (or evidence to suggest its presence), and it therefore seems improbable that the species persists there. Kuchling and Burbidge (1996) did caution that their survey was slightly delayed from the ideal seasonal timing, and that it could not be concluded that the species was extinct at the Perth Airport at the time of their survey, and that further surveys were warranted. For example, the species was thought to be 'effectively extinct' at Twin Swamps Nature Reserve in 1985, but two adult females were found in 1994 after an increase in survey effort, despite routine monitoring over the intervening decade. However, given that the species has not been observed at the Estate for 48 years, and the Five Mile Swamp area (located at the southern end of the NRP) where the species was originally recorded has since been highly developed, it seems highly unlikely that the species is still present in the area. Furthermore, hydrogeological conditions at the northern wetlands were found to be unsuitable for the species in recent years (Geo and Hydro 2014). As the species is unlikely to be present, no direct or indirect impacts are anticipated and therefore measures to avoid or mitigate impacts are not included in this assessment.

Invertebrates

Two conservation significant invertebrate species, the crickets *Throscodectes xiphos* (Priority 1) and *Austrosaga spinifer* (Priority 2), may formerly have occurred in the project area, but are now considered to be locally extinct. There is little information available on the distribution and habitat of these species; Everard and Bamford (2014) note that there are records in the general Perth region and *T. xiphos* is associated with Banksia Woodland, and *A. spinifer* is associated with Heathland. Locations where the species have been recorded in the past (Melaleuca Park Reserve) were visited to provide a habitat comparison (Bamford and Knowles 2019). Some suitable habitat is present in the project area, with approximately 65.7 hectares of Woodland and 70.0 hectares of Heathland. On-ground searching for these species, head-torching and light-trapping, was carried out in early 2019 in the NRP area and Airport Estate and neither was found (Bamford and Knowles, 2019). While a single survey cannot confirm absence, the conclusion that these species are locally extinct was made based upon the survey result, the lack of any other recent records in the broader region, and the high level of disturbance across the project area and the Perth Airport estate, including lighting which is known to cause local extinction of some invertebrate species (Rich and Longcore, 2006).

12.5.4.2 Regularly Present Conservation Significant Fauna

Regularly present species are those that are known (or expected) to occur in the project area and are known/expected to be resident or regular migrants/visitors. These are indicated in Table 12-5. They include two CS1 species (Forest Red-tailed Black Cockatoo and Carnaby's Black Cockatoo, but Baudin's Black Cockatoo may also need to be considered based on 2018 observations) and three CS2 species (Quenda, Rakali, and the native bee species. Two CS1 migratory bird species are listed as MNES (Table 12-5): the Glossy Ibis and Fork-tailed Swift. Although these two species are highly likely, they are common and widespread and will not be impacted by the development. The Blue-billed Duck, being an irregular visitor is unlikely to be impacted. Note that the Rainbow Bee-eater and Eastern Great Egret were listed as migratory under legislation until mid-2016 and are thus listed as CS1 in earlier versions of the MDP, but they have been removed from these lists and addressed under "Whole of Environment" fauna.

This list can be further refined by considering which of these species are the most susceptible to negative impacts from the development of the project. This impact assessment is presented in Section 12.6. Notes on species or groups of species of conservation significance of particular interest with respect to this impact assessment are provided below.

Black Cockatoos

The three black cockatoo species are all of high conservation significance and are known to forage in bushland within the project area and Perth Airport estate. Both Carnaby's and the Forest Red-tailed Black Cockatoos occur regularly in bushland in the northern and southern areas of the estate and forage throughout, whereas Baudin's Black Cockatoo is probably only an irregular visitor, with a single record in 2014 (Everard and Bamford, 2014), but multiple records (over a short period of time) in 2018 (M. Bamford and W. Bancroft, pers. obs.). Baudin's Black Cockatoo is less reliant on the bushland than the other two black cockatoo species, but this may be changing (as has happened with the Forest Red-tailed Black Cockatoo which was unknown on the Perth Airport estate before 2008) (DEE 2018a). See sections 12.6.1, 12.6.2, and 12.6.3 for the impact assessment for the three species.

Quenda

The Quenda was found to be abundant across the NRP and Perth Airport estate. Evidence of the species (e.g. tracks and foraging holes) have been found in all locations visited, including native vegetation, in areas where weeds provide dense cover and even in garden beds. However, animals in garden beds probably represent a very small proportion of the population and may represent displaced individuals. Fauna relocation carried out by BCE in the January to May 2016 period found Quenda to be using virtually any available shelter, even amongst the carparks and light industry south of Terminal 1 (Bamford *et al*., 2017).

Quenda population estimates for each vegetation type within the NRP boundary are based on maximum values assigned by ecologists as follows:

- Damp Heathland (70.0 hectares) – 196 individuals,
- Woodlands (65.7 hectares) - 92 individuals, and
- Grasslands (97.0 hectares) - 24 individuals.

The total Quenda population within the NRP is therefore considered to be in the order of 312 individuals. See section 12.6.4 for the impact assessment for the species.

Rakali

The Rakali is present but probably restricted to permanent wetlands along Abernethy Road, with seasonal dispersal into Munday Swamp and along the main drains which flow through the NRP area (Bamford *et al.* 2017). Drains may provide connectivity for Rakali between the Abernethy Road wetlands and the Swan River.

The only record of the Rakali is at a feeding platform in Munday Swamp, located on the northern boundary of the NRP area. As Munday Swamp is seasonal, this suggests that an animal had been present the previous winter and it was speculated that the Rakali may be an occasional visitor as individuals disperse along drains and from wetlands nearby. The creation of 'living streams' along some drains should provide Rakali with increased habitat and ability to disperse. See section 12.6.5 for the impact assessment for the species.

Native bee

There is little information available on the distribution and habitat of the native bee, *H. globuliferus*. Everard and Bamford (2014) note that there are records in the general Perth region and the species is known to forage on the flowers of Woollybush (*Adenanthos cygnorum*), which is present in Banksia Woodland of the project area. Approximately 20.6 hectares of Banksia Woodland with *A. cygnorum* occurs in the NRP.

The precautionary approach can therefore be taken that the species is present and that impacts are likely to be proportional to loss of their preferred habitat in the NRP area. Searching for the species tends to be difficult as they are highly seasonal, and thus can only be found during a short time window. Some on-ground searching for the species was carried out in Banksia Woodland in the NRP in early 2019 by Bamford and Knowles (2019) but the species was not found. The work included diurnal netting round Woollybush for the bee. The timing of these surveys was consistent with activity periods of the species determined from specimen records held by the WA Museum, although flowering of Woollybush was poor which would affect the detectability of *H. globuliferus*. It was also noted that WA Museum records suggest *H. globuliferus* may be moderately widespread. See section 12.6.6 for the impact assessment for the species.

Species		Conservation Category (MNES species)	Presence	Expected Occurrence in the Airport Estate	Expected Occurrence in the NRP	Regularly Present in the NRP
CONSERVATION SIGNIFICANCE 1						
Plegadis falcinellus	Glossy Ibis	M,S5 (MNES)	Highly likely	Irregular visitor	Irregular visitor	
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	V,S3 (MNES)	Recorded	Regular visitor	Regular visitor	*
Calyptorhynchus baudinii	Baudin's Black Cockatoo	E,S2,WR (MNES)	Recorded	Irregular visitor	Irregular visitor	
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	*E,S2,WR (MNES)*	Recorded	Regular visitor	Regular visitor	*
Apus pacificus	Fork-tailed Swift	M,S5 (MNES)	Highly likely	Irregular visitor	Irregular visitor	
Falco peregrinus	Peregrine Falcon	S7	Highly likely	Irregular visitor	Irregular visitor	
CONSERVATION SIGNIFICANCE 2						
Oxyura australis	Blue-billed Duck	P4	Highly likely	Irregular visitor	Irregular visitor	
Isoodon fusciventer	Southern Brown Bandicoot	P4	Recorded	Resident	Resident	*
Hydromys chrysogaster	Water-rat, Rakali	P4	Highly likely	Regular visitor	Regular visitor	*
Hylaeus globuliferus	A native bee species	P3	Highly likely	Regular visitor	Regular visitor	*

Table 12-5 Species of conservation significance recorded or that are highly likely to occur in the NRP.
Source: Bamford Consulting Ecologists, 2019

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory. BC Act listings: S1 to S7 = Schedules 1 to 7. DBCA Priority species: P1 to P5 = Priority 1 to 5.

Expected occurrence categories:
- Resident: species with a population permanently present in the project area (shaded),
- Regular visitor or migrant: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle (shaded),
- Irregular Visitor: species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the project area in at least moderate numbers and for some time.

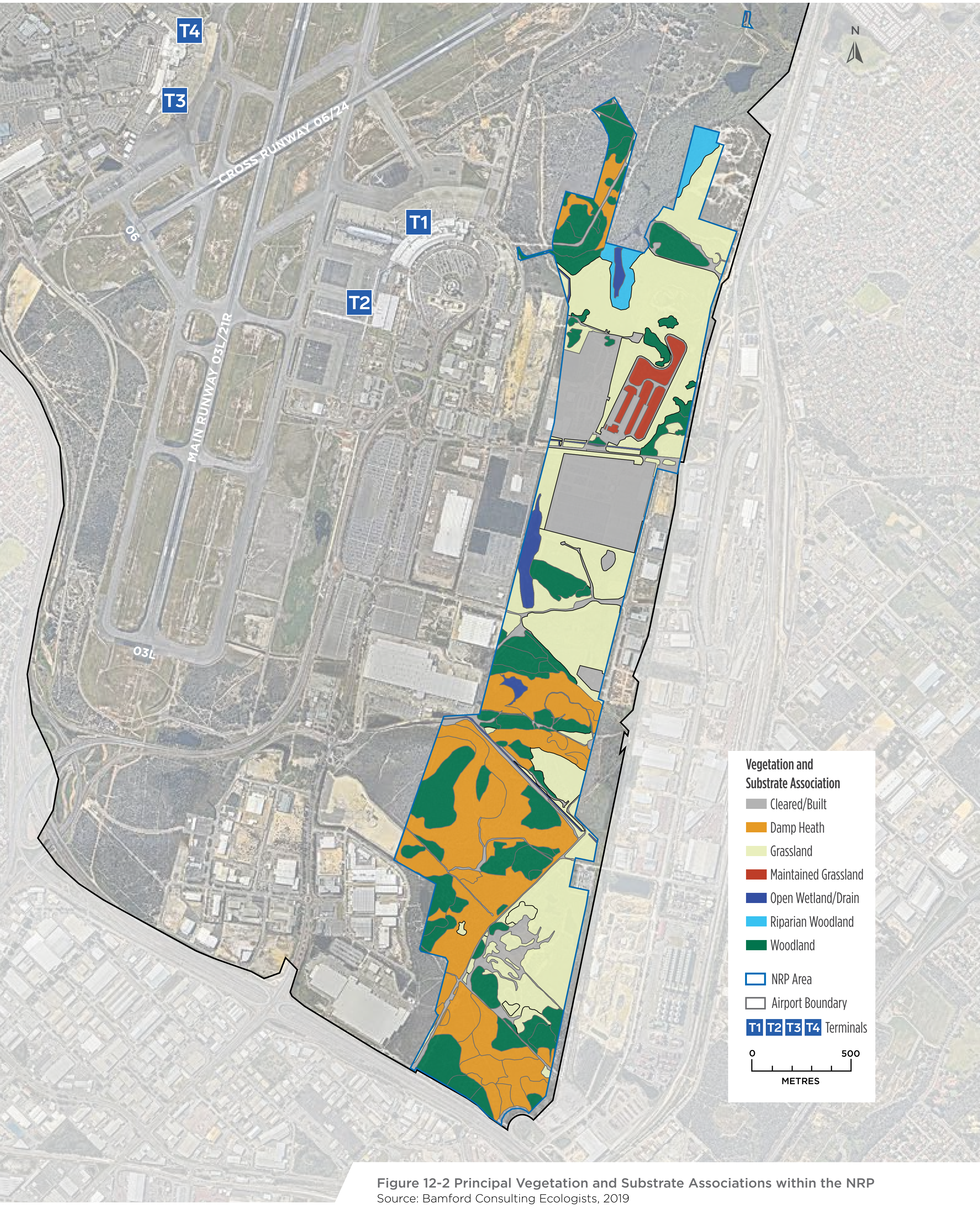


Figure 12-2 Principal Vegetation and Substrate Associations within the NRP
Source: Bamford Consulting Ecologists, 2019

12.5.5 Vegetation and Substrate Associations

Principal Vegetation and Substrate Associations (VSAs) recorded in the NRP are:

- woodland (Marri/Banksia and Riparian Woodlands) (65.7 hectares);
- damp heathland (70.0 hectares);
- grassland that is not mown and may include scattered shrubs and small trees (97.0 hectares);
- drains/wetlands (5.6 hectares); and
- cleared and built areas (including roads, infrastructure and mown grass near runways) (54.5 hectares).

Principal VSAs identified within the NRP area are presented in Figure 12-2 .

12.5.6 Regional Vegetation Assessment

To provide context of the impact, a regional vegetation assessment was conducted within a 12 km radius of the NRP (Figure 12-.3). The project area, including all roads, infrastructure and native vegetation, covers an area of 292.8 hectares. The project area is located within the Southern River Complex, as described by Heddle *et al*. (1980), and 132.0 hectares of this vegetation type remains within the NRP (Figure 12-3). This represents 16.6 per cent of the remaining extent of the Southern River Complex within a radius of 12 km (796 hectares). Only 55 hectares or 6.9 per cent of this vegetation type is managed for conservation within 12 km.

The 12 km radius covers an area of 45,239 hectares; of this, the remaining extent of all native vegetation (i.e. not just the Southern River Complex discussed above) is 8,486 hectares, or 18.8 per cent of the radius. Native vegetation extends over 45.1 per cent of the NRP; hence a higher proportion than the broader region. A total of 3,996 hectares within the 12 km region, or 8.8 per cent of lands, is managed by the DBCA (Table 12-6, Figure 12-3). This is mostly for conservation but includes small areas of State Forest, and areas for recreation and management. No land within the NRP boundary is managed by DBCA.

	Vegetation type within the radius		Vegetation extent (Jan 2018) remaining within the 12km radius		DBCA managed lands within 12km radius	
Heddle vegetation type	**Hectares**	**% of radius**	**Hectares**	**% of radius**	**Hectares**	**% of radius**
Southern River Complex†	9,452	20.9	796	1.8	55	0.1
Bassendean Complex-Central And\South†	10,272	22.7	204	0.5	107	0.2
Cannington Complex†	601	1.3	2	0.0	-	0.0
Cook Complex	43	0.1	11	0.0	-	0.0
Darling Scarp Complex	3,258	7.2	1,932	4.3	1,393	3.1
Dwellingup Complex In Medium\To High Rainfall	3,606	8.0	1,764	3.9	875	1.9
Forrestfield Complex†	4,058	9.0	576	1.3	119	0.3
Guildford Complex	4,685	10.4	360	0.8	132	0.3
Helena Complex In Low To Medium\Rainfall	1,781	3.9	1,425	3.1	699	1.5
Helena Complex In Medium To High\Rainfall	486	1.1	470	1.0	93	0.2
Karrakatta Complex-Central And\South	886	2.0	2	0.0	0	0.0
Murray And Bindoon Complex In Low\To Medium Rainfall	480	1.1	174	0.4	71	0.2
Murray Complex In Medium To High\Rainfall	63	0.1	47	0.1	17	0.0
Swan Complex	3,514	7.8	419	0.9	268	0.6
Vasse Complex	505	1.1	9	0.0	50	0.1
Yarragil Complex (Maximum Develo-\Pment Swamps) In Medium To High Rainfall	336	0.7	170	0.4	39	0.1
Yarragil Complex (Minimum Develo-\Pment Swamps) In Medium To High Rainfall	348	0.8	128	0.3	78	0.2
Excluded Areas (e.g. Rivers)	865	1.9	NA	NA	NA	NA
Total	**45,239**	**100.0**	**8,486**	**18.8**	**3,996**	**8.8**
Area of 12 km radius	**45,239**		**45,239**		**45,239**	

Table 12-6 Regional vegetation analysis - Heddle vegetation types within a 12 km radius of the NRP
Source: Bamford Consulting Ecologists, 2019

Shading indicates vegetation types that occur within the project area.
†indicates complexes that may support Banksia Woodlands.

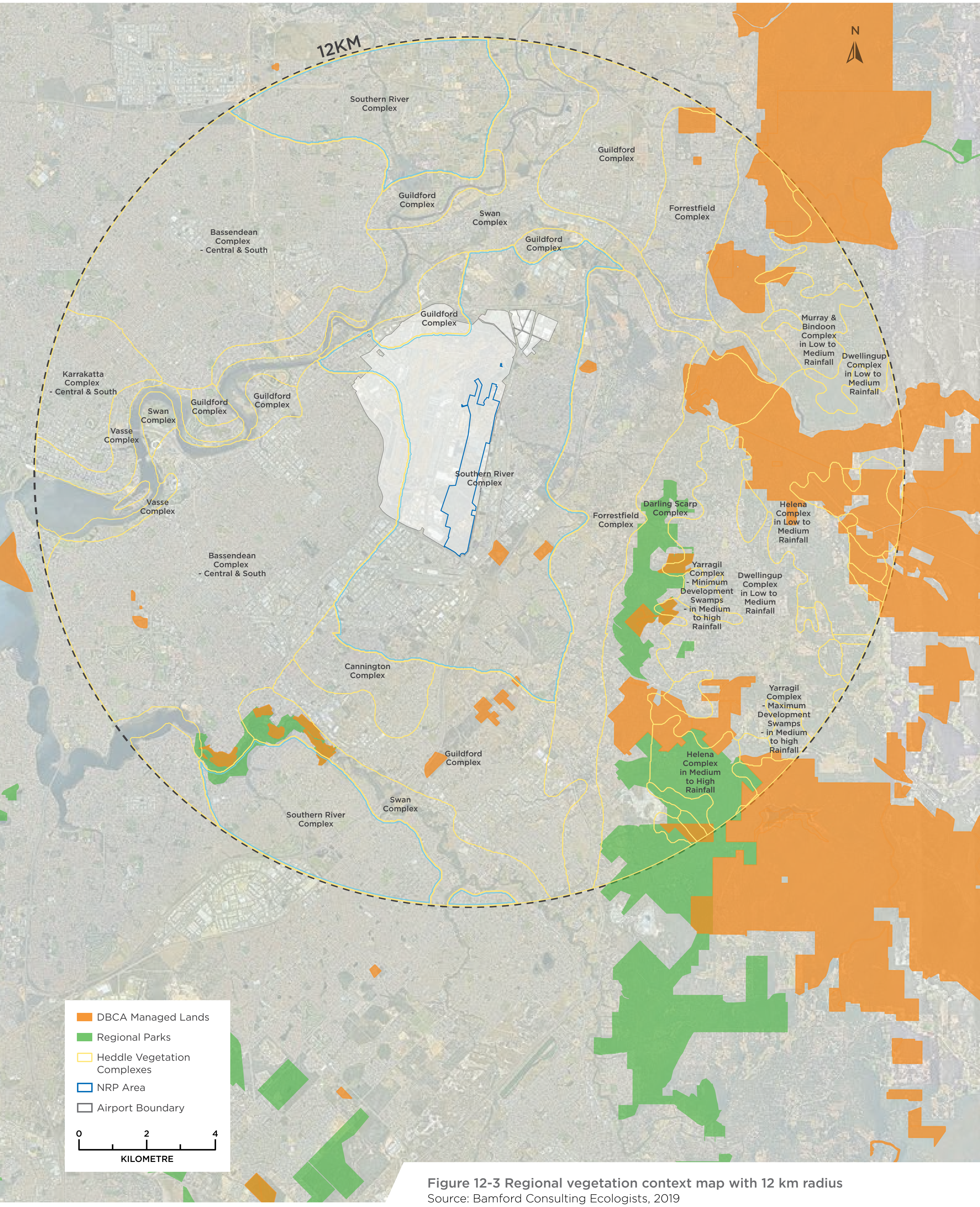


Figure 12-3 Regional vegetation context map with 12 km radius
Source: Bamford Consulting Ecologists, 2019

12.5.7 Patterns of biodiversity across the landscape

The results of systematic sampling in 2008 and 2014, and more recent targeted surveys and interpretation of VSAs with respect to the habitat requirements of fauna in 2017, make it possible to provide some broad conclusions concerning how biodiversity is organised across NRP.

Woodlands support the greatest range of reptile and bird species, including many of conservation significance. All three black cockatoo species have been recorded foraging in Woodlands; Carnaby's Black Cockatoo focusses on areas with a high proportion of Banksia, while the Forest Red-tailed and Baudin's Black Cockatoos favour Marri. The Woodlands also potentially provide nesting sites for black cockatoos. Woodlands support the Quenda and are where many of the frogs spend their non-breeding season. The conservation significant (CS2) invertebrate *H. globuliferus* is most likely to occur in woodland areas. The rich assemblage of flowering plants in Woodlands supports nectivorous fauna from birds to insects. Riparian Woodlands also provide often dense cover for species such as Quenda and Rakali, and the seasonally damp soils may support short range endemic invertebrates. A few reptile species appear to be most common in Riparian Woodlands and the Flooded Gum, *Eucalyptus rudis*, readily forms hollows that are used by a range of fauna.

Damp Heathlands provide dense cover favoured by some bird species (e.g. Splendid Fairy-wren and White-browed Scrubwren), and the persistence of these species may depend upon this sort of shelter. Quenda are also most abundant in this dense, low vegetation.

Built areas including those in the central part of the project area are of low value for fauna but allow species to move through otherwise hostile environments. Cleared areas with introduced or isolated native trees can be used for foraging by black cockatoos. Constructed drains in the project area support aquatic invertebrates, seasonal breeding by frogs, the Rakali and potentially small numbers of conservation significant waterbirds. Long-necked turtles are abundant in wetlands and some drains around the Perth Airport estate; in one sparsely-vegetated drain of about 200 m in length, 28 turtles were found in one evening in June 2014. Drains, while artificial, provide a network along which aquatic fauna, and fauna associated with riparian vegetation, can move through the landscape.

12.5.8 Ecological processes upon which the fauna depend

A number of ecological processes are likely to be asserting a strong influence upon the fauna assemblage by virtue of the project area's location and management.

Feral species are subject to some control, and the suppression of fox numbers probably explains the abundance of Quenda across the project area. Feral cats appear to be abundant which may also be a consequence of fox control, with the impact of cats virtually unknown. They can cause the extinction of reptile and bird populations in small areas (Bamford 2008; Bamford and Calver 2012) but it is not known if this effect would operate on the scale of the project area bushland. The introduced Mosquitofish is very abundant in drains and may be having an effect on aquatic fauna.

The fauna assemblage in the project area has some connection to vegetation in the north and south (within the Perth Airport estate), but limited connectivity with other areas of native vegetation and this is mainly to the east, where the vegetation and soils differ markedly to those of the project area. This emphasises the isolation. Connectivity is important in ensuring that fauna can move between fragments of native vegetation (i.e. from the project area to the Perth Airport estate and to areas outside the estate).

The NRP area is situated at the southern end of Munday Swamp and includes some low-lying areas. This creates the potential for some of the VSAs within the project are to be linked by hydrology and therefore sensitive to hydrological change that may be caused by the project. This may be important not just for those VSAs that are clearly groundwater dependent (e.g. Damp Heathlands), but also for the main woodland areas where trees such as banksias can be affected by groundwater change.

Fire can have both positive and negative effects on biodiversity. There is evidence that most fires within the Perth Airport estate have burnt only small sections, probably because of effective fire suppression and the bushland being somewhat fragmented. Such a pattern of small fires resulting in a mosaic of fire ages is likely to benefit the faunal assemblage.

12.5.9 Summary of the fauna habitat assessment

Information on fauna within the NRP area was drawn from a wide range of sources. These included State and Commonwealth government databases and the results of previous fauna assessments conducted in the NRP area and Perth Airport estate.

The faunal assemblage of the NRP area is likely to be substantially intact but is probably still losing species and is unusual because it exists in a region of extensive regional clearing and development. The NRP supports a number of significant species, including three black cockatoos (Carnaby's, Baudin's and Forest Red-tailed Black Cockatoo), Quenda, Rakali, and a native bee species (*H. globuliferus*). Approximately 81 % (238.3 ha) of the project area consists of VSAs suitable for fauna, such as Woodland, Damp Heathland, Grassland and artificial drains.

Each of the VSAs are important for different components of the assemblage. For example, *Woodland* areas support the greatest range of reptile and bird species, including many of conservation significance such as the black cockatoos and Quenda. All three black cockatoo species have been recorded foraging in the woodland in the Estate with Carnaby's Black Cockatoo occurring in areas with a high proportion of tree *Banksia* spp., and Baudin's and Forest Red-tailed Black Cockatoos favouring Marri woodland. The conservation significant native bee species, *H. globuliferus*, is also most likely to occur in woodland areas, and the rich assemblage of flowering plants in Woodlands supports nectivorous fauna (from birds to insects). *Damp Heathlands* and *Grasslands* are also likely to support populations of Quenda and some bird species. *Drains*, while artificial, may be important for facilitating fauna movements (e.g. Rakali) through the landscape.

12.6 Impact Assessment

This section provides details on the potential impacts (as outlined in Section 12.4.1) that may occur as a result of the project, taking into account all elements and project phases. Impacts to Regularly Present MNES and non-MNES species, and "Whole of Environment" fauna are assessed against the definition of significance in Guideline 1.1 (DoE, 2013). Refer to Section 12.4 (Impact Assessment Methodology) for the approach to assessing impacts to fauna, and to definitions of impact classes.

For the purposes of this assessment, direct impacts are discussed in terms of vegetation clearing and the direct loss of habitat leading to population declines. Other impacting processes specific to the development of the project area include population fragmentation, habitat degradation due to weeds, species interactions, changes to hydrology and fire regimes, and disturbance from dust, light, vibration and noise.

Impacts are considered for the following species that are known (or expected) to occur within or adjacent to the NRP area:

- Regularly Present Conservation Significant Fauna that are also MNES (as identified in Table 12-5), including:
  - Carnaby's Black Cockatoo,
  - Baudin's Black Cockatoo (while categorised as an Irregular Visitor, recent observations of this species within the Airport Estate have led it to be included here on a precautionary basis), and
  - Forest Red-tailed Black Cockatoo.
- Regularly Present Conservation Significant Fauna that are non-MNES (as identified in Table 12-5), including:
  - Quenda,
  - Water-rat (Rakali), and
  - Native bee (*H. globuliferus*).
- The "Whole of Environment" on Commonwealth Land (Section 12.6.7). This includes locally significant fauna species.

Note, the Rainbow Bee-Eater and Eastern Great Egret have been delisted from the Commonwealth EPBC Act Migratory Species List, although the Bee-eater remains listed on the Marine Species List. Neither are protected by State legislation and will now be addressed under "Whole of Environment" fauna.

This section also summarises the proposed avoidance and mitigation measures to reduce impacts to these matters and assesses the proposed impacts in relation to guidance notes, conservation advice and recovery plans, where relevant.

12.6.1 Carnaby's Black Cockatoo

12.6.1.1 Overview

Carnaby's Black Cockatoo is the most abundant of the black cockatoos on the Perth Airport estate and on the coastal plain in the Perth region generally. It is normally a non-breeding migrant (but with a few pairs breeding on the coastal plain in recent years), being most abundant from late summer to mid-winter. The species is present on the Perth Airport estate in large numbers, with flocks of several hundred observed (typically in the autumn) and is likely to visit the project area. Threatening processes affecting the ongoing survival and management actions needed to support the recovery of the species are outlined in the Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (DPaW, 2013).

Foraging habitat for Carnaby's Black Cockatoo was recorded in the project area (Bamford, 2019)). Approximately 232.7 hectares provide foraging value for Carnaby's Black Cockatoo with a foraging value score of between one (negligible to low foraging value) to six (high foraging value). 45.9 hectares of this is moderate to high foraging habitat (score 4 to 6). The distribution of foraging habitat for the species in the project area is shown in Figure 12-5. This area is larger than that of native vegetation within the NRP as Black Cockatoos also feed on non-native vegetation such as grasslands.

Carnaby's Black Cockatoo does not currently breed in the project area or the Perth Airport estate but limited suitable habitat is present and the species does breed elsewhere on the coastal plain in small numbers. The nearest possible (but unconfirmed breeding) is in the Bushmead Rifle ranges approximately four kilometres to the north-east. Breeding is more likely beyond the escarpment with breeding possible within a 12 km radius. The Black Cockatoo Habitat Assessment documented 103 Marri trees and 30 Jarrah trees that met the basic criterion of 500 mm Diameter at Breast Height (DBH), but only seven Marri and five Jarrah were given a rank of 3 (potentially suitable hollow). Refer to BCE, 2019 for detailed descriptions of tree rankings. Thus, 12 trees had hollows that might presently be useful to the species (or other species that require large hollows). Potential nest tree locations are provided in Figure 12-4. No roosting sites or roosting activity was recorded in the Perth Airport estate, although there are some known roost sites in the region from the Great Cocky Count (Peck *et al*. 2017).

12.6.1.2 Direct Impacts

The development of the NRP will result in the loss of 232.7 hectares of foraging habitat for Carnaby's Black Cockatoo (Table 12-7). Vegetation scores range from one (Negligible Foraging Value) to six (High Foraging Value). Impact areas are calculated using vegetation scores one to six only. The consequence (impacts) of this loss of foraging habitat is discussed in Table 12-8.

Project	Impact Areas (hectares) per foraging habitat vegetation score						Total Impact Area
	1	2	3	4	5	6	
New Runway Project	170.0	12.0	4.8	16.5	27.7	1.7	**232.7**

Table 12-7 Impact areas per foraging habitat vegetation score for Carnaby's Black Cockatoo in the NRP
Source: Bamford Consulting Ecologists, 2019

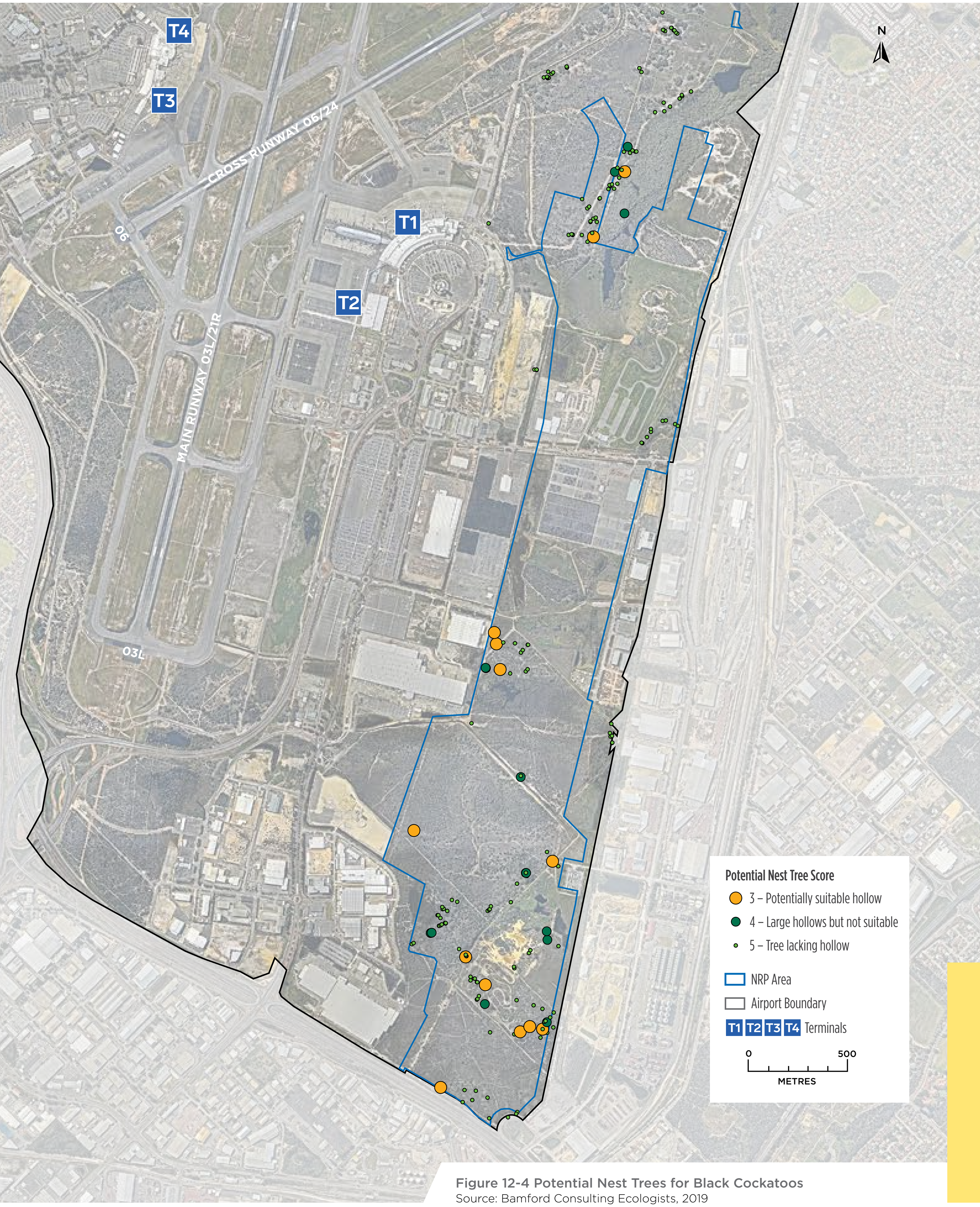


Figure 12-4 Potential Nest Trees for Black Cockatoos
Source: Bamford Consulting Ecologists, 2019

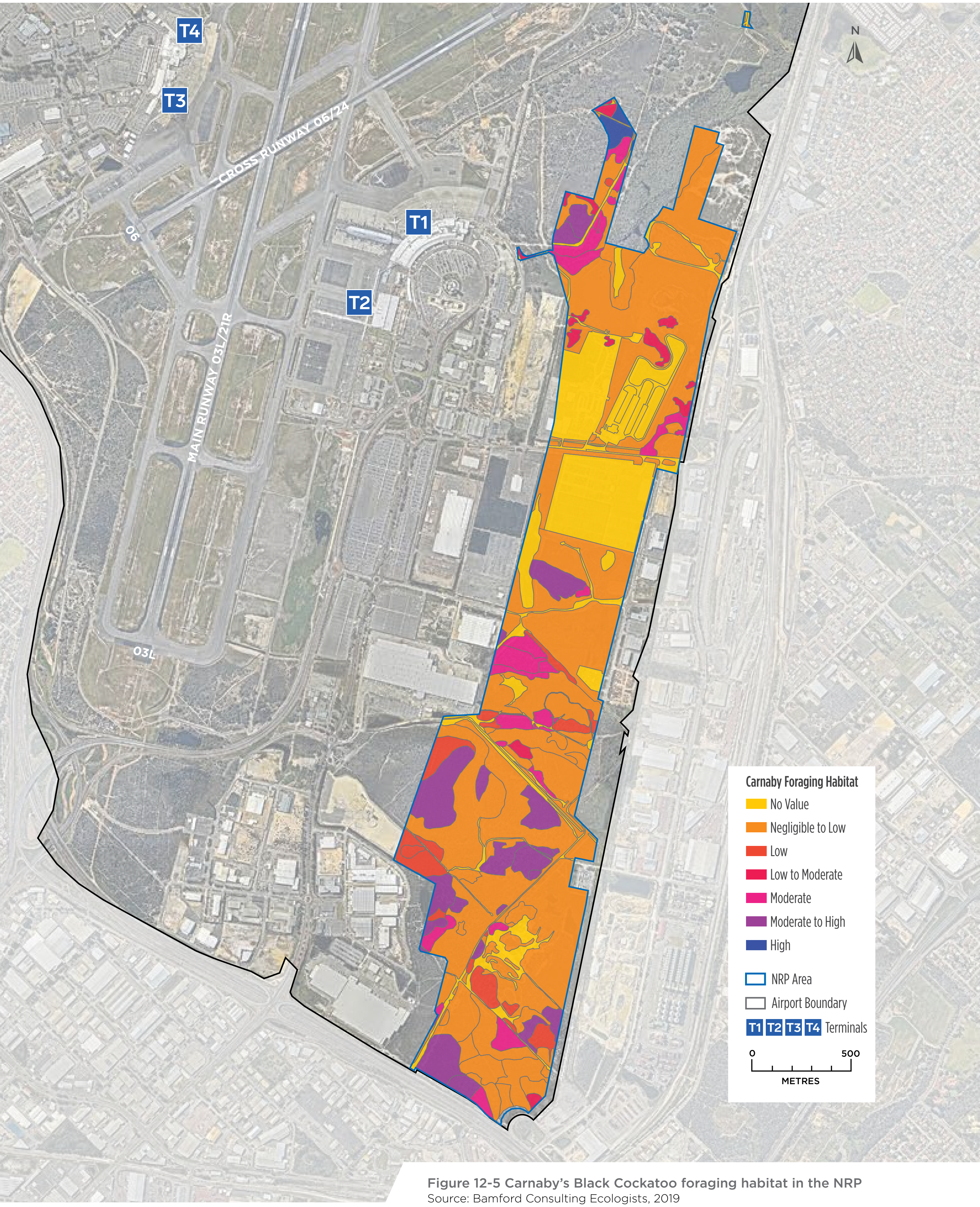


Figure 12-5 Carnaby's Black Cockatoo foraging habitat in the NRP
Source: Bamford Consulting Ecologists, 2019

12.6.1.3 Indirect Impacts

A summary of indirect impacts (as defined in Section 12.4.1) on Carnaby's Black Cockatoo and proposed mitigation measures are discussed in Table 12-8. Detailed descriptions of the impacting processes can be found in BCE (2019).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline /local extinction	Moderate (<10 per cent decline in carrying capacity within 12 km).	Loss of 232.7 hectares of Carnaby's foraging habitat (Scores 1-6 only) will occur as a result of the NRP. Foraging habitat remaining within 12 km radius: 8,486 hectares (all Heddle veg complexes). This is a decline of 2.7 per cent in carrying capacity within that region.	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible. Retain gardens and verges. Plant with foraging species suitable for Carnaby's Black Cockatoo. Replant degraded areas.
Indirect (ecosystem function)	Population fragmentation	Negligible	The Carnaby's Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the project area is unlikely to result in fragmentation of existing populations.	Replanting to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the Perth Airport estate due to weed invasion	Negligible	The development of the project area will result in all native vegetation being cleared from the site. Therefore surrounding remnant native vegetation, within the Perth Airport estate (e.g. vegetation around Munday Swamp, located to the north of the NRP and vegetation to the south of the NRP) may be impacted by weeds. However, impacts are likely to be negligible and can be managed with existing weed management protocols. No offsite impacts as a result of weed invasion are expected.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Negligible	Ongoing mortality can occur during project operations; for example, from birds colliding with approaching and departing planes (runway adjacent to the project area) and from vehicle strike. Birdstrike may decrease due to removal of vegetation from the project area.	Avoid black cockatoo forage trees along high-speed roads.
Indirect (ecosystem function)	Species interactions	Negligible	Not relevant to Carnaby's Black Cockatoo. However, existing feral management procedures need to be continued.	Not applicable.
Indirect (ecosystem function)	Changes to hydroecology	Negligible	There may be a risk to habitat used by Carnaby's Black Cockatoo due to altered hydrology (such as increased surface water runoff), although with standard management procedures, the risk is considered low. There could be some off-site hydrological change but this would also not affect habitat for the species.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change.
Indirect (ecosystem function)	Changes to fire regime	Negligible	Not relevant to Carnaby's Black Cockatoo given the lack of foraging and nesting habitat that will be retained in the project area. Surrounding habitat (outside of the project area, but within the Estate) can be managed with existing fire management protocols.	Existing fire management and suppression around the Perth Airport estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Negligible	Not relevant to Carnaby's Black Cockatoo as the species is very tolerant to noise and light in urban environments.	Legal environmental limits.

Table 12-8 Summary of potential impacts to Carnaby's Black Cockatoo and proposed mitigation measures.
Source: Bamford Consulting Ecologists, 2019

12.6.1.4 Significance of Residual Impacts

An assessment of the potential impacts to Carnaby's Black Cockatoo using Guideline 1.1 is summarised in Table 12-9.

Significance Criteria under Guideline 1.1	Likelihood and Rationale Carnaby's Black Cockatoo
Lead to a long-term decrease in the size of a population[1] (or an important population[2]).	**Likely to occur.** Carnaby's is a regular non-breeding migrant to the project area and Perth Airport estate. Native vegetation within the project area does provide some foraging habitat (232.7 hectares of varied value, from low to high), and approximately 2.7 per cent of foraging habitat within 12 kilometres. The impact is likely to be a shift in the local distribution and abundance of the species in the project area. It is uncertain if this represents a decline in an important population, but there will be a decline in the number of the species, or their period of occupancy, at a regional level (12 kilometres). At present, breeding does not occur in the project area, but there may be some breeding within 12 kilometres to the east.
Reduce the area of occupancy of the species (or an important population).	**Likely to occur.** Loss of the native vegetation will alter the local distribution and abundance of the Carnaby's Black Cockatoo, resulting in a reduction in their local abundance. They are likely to still occur in the immediate region and remain as visitors (but in reduced numbers) to the Perth Airport estate.
Fragment an existing population (or important population) into two or more populations.	Unlikely to occur. No barrier to movement. The Carnaby's Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the NRP is unlikely to result in fragmentation of existing populations.
Adversely affect habitat critical to the survival of a species[3]	Unlikely to occur. Native vegetation within the project area does provide some low to high foraging habitat (232.7 hectares). The impact is likely to be a shift in the local distribution and abundance of the species but is not critical to the survival of the species.
Disrupt the breeding cycle of a population (or important population).	Unlikely to occur. Some loss of potential nest-trees at a localised scale but breeding not confirmed within the project area. Breeding of the Carnaby's Black Cockatoo may occur within 12 kilometres, and thus a small loss of foraging habitat of a few breeding pairs may occur; this would represent a very small part of the foraging range of those pairs.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. Localised loss of foraging habitat (232.7 hectares) will occur with development of native vegetation within the project area. The loss of foraging habitat will lead to a decline in abundance at the local scale but is not critical to the survival of the species. Offsets through rehabilitation within the Perth region are proposed to ensure there will be no overall loss of foraging habitat.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral bees, cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. Localised impacts. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the project area or Perth Airport estate. The project is unlikely to interfere with the recovery of the species provided that vegetation clearing is offset.

Table 12-9 Carnaby's Black Cockatoo assessed as per Guideline 1.1.
Source: Bamford Consulting Ecologists, 2019

[1] A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area (includes a geographically distinct regional population, or collection of local populations, or a population, or collection of local populations, that occurs within a particular bioregion). Pertains to endangered and vulnerable species.

[2] An 'important population' is a population that is necessary for a species' long-term survival and recovery (includes populations identified as such in recovery plans, and/or key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species range). Pertains to vulnerable species.

[3] 'Habitat critical to the survival of a species' refers to areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species or ecological community. Pertains to endangered and vulnerable species.

It is expected that two of the nine EPBC significance criteria (Table 12-9) will be triggered for the Carnaby's Black Cockatoo. The proposed action will result in some residual impact to the Carnaby's Black Cockatoo, through the direct and permanent removal of up to 232.7 hectares of (low to high quality) foraging habitat. Twelve potential nest-trees that have hollows and 121 potential nest-trees (i.e. trees >500mm DBH that currently have no hollows) are within the project area. This impact is unavoidable due to the removal of vegetation and subsequent construction of airport infrastructure. There is likely to be an impact to Carnaby's Black Cockatoo at the local- (major impact within the project area and surrounding Perth Airport estate) and regional- (moderate impact within 12 kilometres) scales through the loss of foraging habitat and a potentially altered local distribution of the species, but this is not expected to have a significant impact at the species-scale.

12.6.2 Baudin's Black Cockatoo

12.6.2.1 Overview

Baudin's Black Cockatoo is primarily a species of tall eucalypt forests of the South-West and Perth is at the northern limit of its range. It is present, and breeds, in the forests of the escarpment east of Perth. Surveys have previously concluded that the species is probably only an irregular visitor, with a single record in 2014. Surveys by BCE conducted in August and September 2018, however, recorded recent and intermediate foraging evidence (chewed Marri nuts) in 14 locations in the north, west and south of the Airport Estate. Foraging evidence was recorded in the central region of the project area as well. Birds were also seen actively foraging in Marri trees in the north of the project area and elsewhere within the Airport estate. It is not known if these records are indicative of a movement of the species onto the coastal plain or was only an infrequent event that might not happen again.

Prior to 2018, it was considered that the Perth Airport estate was so little-used by Baudin's Black Cockatoo that it was not considered in impact assessment and that at such a low level of usage, the impact would be negligible (Bamford *et al.*, 2017). However, recent surveys suggest that the species may forage within the project area and in the northern area of the Airport estate more often than previously thought but is still likely to be an irregular visitor.

Foraging habitat for Baudin's Black Cockatoo was recorded in the project area (Figure 12-6). Approximately 63.9 hectares provides some foraging value for Baudin's Black Cockatoo with a foraging value score of between one (negligible to low foraging value) to five (moderate to high foraging value), out of a possible total score of six. There are 12.0 hectares of moderate to high foraging habitat (score four and five) for this species within the project area. Approximately 78 per cent (228.9 hectares) of the project area had no foraging value (Score of zero) for the species. The distribution of foraging habitat for the species in the project area is shown in Figure 12-6.

Baudin's Black Cockatoo does not currently breed in the project area or the Airport estate and it seems unlikely it will do so. However, there are documented 103 Marri trees and 30 Jarrah trees within the Perth Airport estate that met the basic criterion of 500 mm DBH, but only seven Marri and five Jarrah were given a rank of 3 (potentially suitable hollow). Thus, 12 trees had hollows that might presently be useful to the species (or other species that require large hollows). Potential nest tree locations and habitat assessment mapping are provided in Figure 12-4. No roosting sites or roosting activity was recorded in the Perth Airport estate, although there are some known roost sites in the region from the Great Cocky Count (Peck *et al*. 2017).

12.6.2.2 Direct Impacts

The development of the NRP will result in the loss of 63.9 hectares of varying quality foraging habitat for Baudin's Black Cockatoo. Vegetation scores range from one (Negligible Foraging Value) to six (High Foraging Value). Impact areas are calculated using vegetation scores one to six only. (Table 12-10). The consequence (impacts) of this loss of foraging habitat is discussed in Table 12-11.

Project	Impact areas (hectares) per foraging habitat vegetation score						Total Impact Area
	1	2	3	4	5	6	
New Runway Project	31.0	10.0	10.9	8.4	3.6	0.0	**63.9**

Table 12-10 Impact areas per foraging habitat vegetation score for Baudin's Black Cockatoo in the NRP.
Source: Bamford Consulting Ecologists, 2019

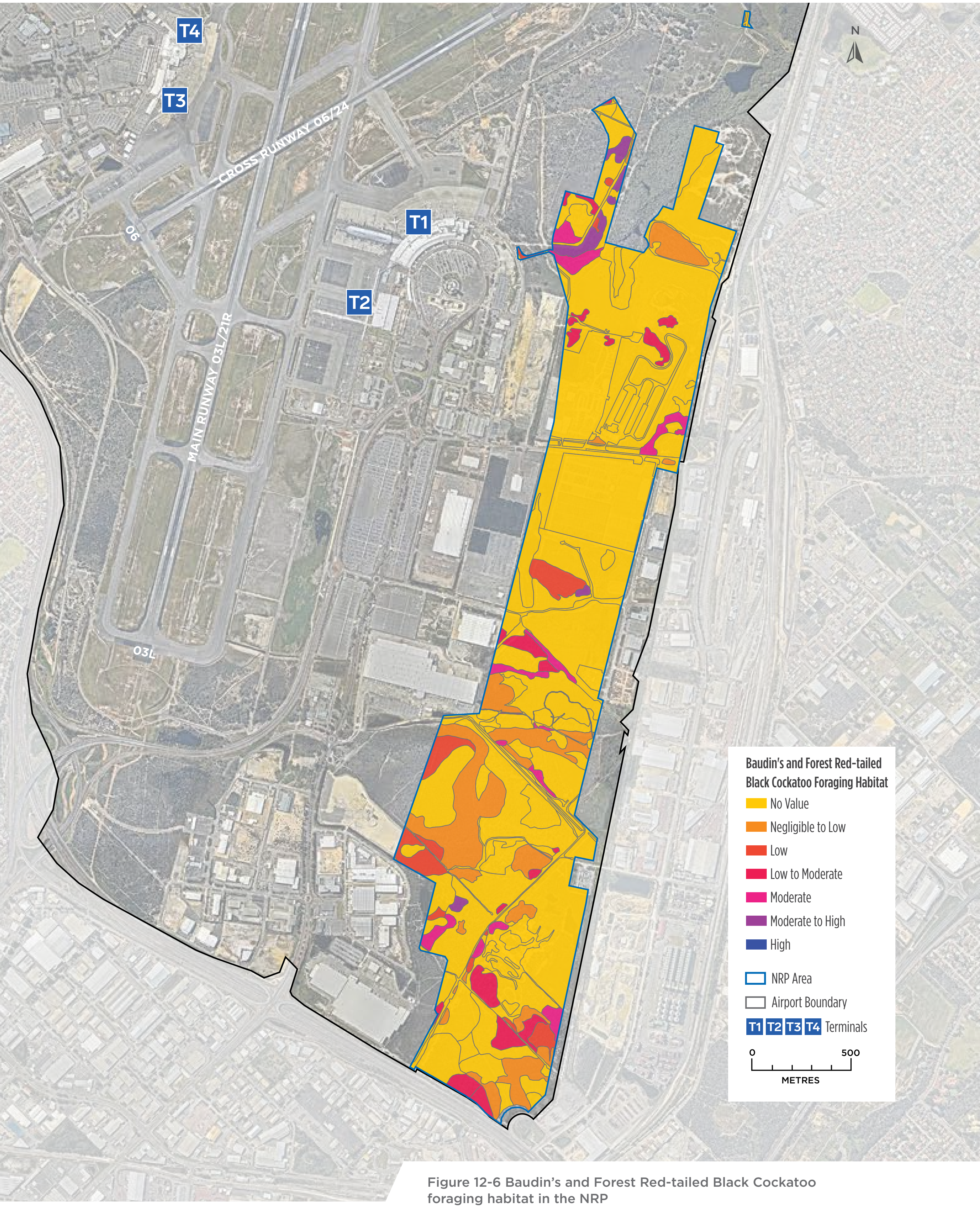


Figure 12-6 Baudin's and Forest Red-tailed Black Cockatoo foraging habitat in the NRP
Source: Bamford Consulting Ecologists, 2019

12.6.2.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on Baudin's Black Cockatoo are discussed in Table 12-11 (below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline /local extinction	Minor	Loss of 63.9 hectares of foraging habitat (Scores 1-6 only) will occur as a result of the proposed project, but on current knowledge this is used irregularly. Foraging habitat remaining within 12 km radius: 8,486 hectares (all Heddle vegetation complexes). This is a decline of 0.8 per cent in carrying capacity that could occur, but because the habitat in the project area is not used consistently, the value to the species would be less than this.	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible. Retain gardens and verges. Plant with foraging species suitable for Baudin's Black Cockatoo. Replant degraded areas.
Indirect (ecosystem function)	Population fragmentation	Negligible	Baudin's Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the project area is unlikely to result in fragmentation of existing populations.	Replanting to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the Airport estate due to weed invasion	Negligible	The development of the project area will result in all native vegetation being cleared. Therefore surrounding remnant native vegetation (e.g. vegetation around Munday Swamp) will be sensitive to weed invasion.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Negligible	Ongoing mortality can occur during project operations; for example, from birds colliding with approaching and departing planes (runway adjacent to the project area) and from vehicle strike. Birdstrike may decrease due to removal of vegetation from the project area.	Avoid black cockatoo forage trees along high-speed roads.
Indirect (ecosystem function)	Species interactions	Negligible	Not relevant to Baudin's Black Cockatoo. However, existing feral management procedures need to be continued.	Not applicable.
Indirect (ecosystem function)	Changes to hydroecology	Negligible	There may be a risk to habitat used by Baudin's Black Cockatoo due to altered hydrology (such as increased surface water runoff), although with standard management procedures the risk is considered low. There could be some off-site hydrological change but this would also not affect habitat for the species.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change
Indirect (ecosystem function)	Changes to fire regime	Negligible	Not relevant to Baudin's Black Cockatoo given the lack of foraging and nesting habitat that will be retained in the project area. Surrounding habitat (outside of the project area, but within the Perth Airport estate) can be managed with existing fire management protocols.	Existing fire management and suppression around the Perth Airport estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Negligible	Not relevant to Baudin's Black Cockatoo as the species is very tolerant to noise and light in urban environments.	Legal environmental limits.

Table 12-11 Summary of potential impacts to Baudin's Black Cockatoo and proposed mitigation measures
Source: Bamford Consulting Ecologists, 2019

12.6.2.4 Significance of Residual Impacts

An assessment of the potential impacts to Baudin's Black Cockatoo using Guideline 1.1 (DoE 2013) significance criteria is summarised in Table 12-12.

Significance Criteria Under Guideline 1.1	Likelihood and Rtionale
	Baudin's Black Cockatoo
Lead to a long-term decrease in the size of a population (or an important population).	Unlikely to occur. Native vegetation within the project area does provide some foraging habitat (63.9 hectares of varied value, from low to high), and 0.8 per cent of foraging habitat within 12 km. The impact is likely to be a shift in the local distribution and abundance of the species but not to result in a population decline. At present breeding does not occur in the project area but there may be some breeding within 12 km to the east. Despite the proportion of foraging habitat in the project area, on current observations the species is an irregular foraging visitor and therefore actual impact from loss of foraging habitat on the local population is expected to be negligible.
Reduce the area of occupancy of the species (or an important population).	Unlikely to occur. Loss of the native vegetation may alter the local distribution and abundance of the Baudin's Black Cockatoo, but on current behaviour of the birds they are irregular visitors, so the impact will be a reduction in the frequency with which birds visit the project area.
Fragment an existing population (or important population) into two or more populations.	Unlikely to occur. No barrier to movement. The Baudin's Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the project area is unlikely to result in fragmentation of existing populations.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. The project area is not situated in primary nesting or foraging habitat for this species. Very minor loss of preferred foraging habitat used only infrequently. Adjacent foraging habitat available outside the project area.
Disrupt the breeding cycle of a population (or important population).	Unlikely to occur. Some loss of potential nest-trees at a localised scale, but breeding not confirmed within the project area. Breeding of the Baudin's Black Cockatoo may occur within 12 km, and thus a small loss of foraging habitat of a few breeding pairs may occur.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. Localised loss of foraging habitat (63.9 hectares) will occur with development of native vegetation within the project area, but it is currently used only irregularly by the species. Offsets will to some degree minimise long term impacts associated with vegetation clearing.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral bees, cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. Localised impacts. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the project area or Perth Airport estate. The project is unlikely to interfere with the recovery of the species provided that vegetation clearing is offset.

Table 12-12 Baudin's Black Cockatoo assessed as per Guideline 1.1.
Source: Bamford Consulting Ecologists, 2019

It is not expected that any EPBC significance criteria (Table 12-12) will be triggered for the Baudin's Black Cockatoo. The proposed action will result in some residual impact to the Baudin's Black Cockatoo, through the direct and permanent removal of up to 63.9 hectares of (low to high quality) foraging habitat (considered to be used irregularly by the species). Twelve potential nest-trees that presently have hollows and 121 potential nest-trees that might be of future use to the species (i.e. trees >500mm DBH that currently have no hollows) are within the project area. This impact is unavoidable due to the removal of vegetation and subsequent construction of airport infrastructure. There is likely to be an impact to Baudin's Black Cockatoo at the local- (moderate impact within the project area and surrounding Airport Estate) and regional- (minor impact within 12 km) scales through the loss of foraging habitat and a potentially altered local distribution of the species, but this is not expected to have a significant impact on the local population (or at the species-scale).

12.6.3 Forest Red-tailed Black Cockatoo

12.6.3.1 Overview

The Forest Red-tailed Black Cockatoo has undergone a recent (since about 2010) influx onto the coastal plain in the Perth area; it was not recorded on the Perth Airport estate in early surveys but has been regular since 2008. Bamford *et al*. (2017) concluded that it is now a regular visitor to the project area and Airport Estate. Small numbers of Forest Red-tailed Black Cockatoos occur around the Airport Estate more or less consistently, with flocks of two to five birds seen daily around Brearley/ Dunreath Avenue intersection while BCE personnel were conducting fauna relocation in May 2016.

The Forest Red-tailed Black Cockatoo has similar foraging requirements to Baudin's Black Cockatoo, relying heavily on Marri and to a lesser extent on Jarrah, but it also forages on a suite of exotic plants both within the Airport Estate and in surrounding suburbs. The amount of quality native foraging habitat within the project area and Airport Estate is small, so the presence of the species is probably supported by exotic plants within and outside the area.

Foraging habitat for the Forest Red-tailed Black Cockatoo was recorded in the project area. Approximately 63.9 hectares provides some foraging value for the Forest Red-tailed Black Cockatoo with a foraging value score of between one (negligible to low foraging value) to five (moderate to high foraging value), out of a possible total score of six. There are 12.0 hectares of moderate to high foraging habitat (score four and five) for this species within the project area. Approximately 78 per cent (228.9 hectares) of the project area had no foraging value (Score 0) for the species. The distribution of foraging habitat in the project area is shown in Figure 12-6.

The Forest Red-tailed Black Cockatoo does not currently breed in the project area or Perth Airport estate but limited suitable habitat is present and the species does breed elsewhere on the coastal plain in small numbers. It also breeds nearby (within 12 kilometres) in forests along the Escarpment. The nearest possible (but unconfirmed) breeding is in the Bushmead Rifle Range area, approximately four kilometres to the east.

There were 103 Marri trees and 30 Jarrah trees documented that met the basic criterion of 500mm Diameter at Breast Height (DBH), but only seven Marri and five Jarrah trees were given a rank of three (containing a potentially suitable hollow). Thus, 12 trees (seven Marri and five Jarrah) had hollows that might be useful to the species (or other species) in the future. Potential nest tree locations are provided in Figure 12-4. No roosting sites or activity was recorded in the project area or Perth Airport estate, although there are some known roost sites in the region from the Great Cocky Count (Peck *et al.* 2017).

12.6.3.2 Direct Impacts

The development of the NRP will result in the loss of 63.9 hectares of varying quality foraging habitat for the Forest Red-tailed Black Cockatoo. Vegetation scores range from '1' (Negligible Foraging Value) to '6' (High Foraging Value). Impact areas are calculated using vegetation scores one to six only. (Table 12-13). The consequence (impacts) of this loss of foraging habitat is discussed in Table 12-14.

Project	Impact areas (hectares) per foraging habitat vegetation score						Total Impact Area
	1	2	3	4	5	6	
New Runway Project	31.0	10.0	10.9	8.4	3.6	0.0	**63.9**

Table 12-13 Impact areas per foraging habitat vegetation score for the Forest Red-tailed Black Cockatoo in the NRP.
Source: Bamford Consulting Ecologists, 2019

12.6.3.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on the Forest Red-tailed Black Cockatoo are discussed in Table 12-14 (below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline /local extinction	Minor	Loss of 63.9 hectares of foraging habitat (Scores 1-6 only) will occur as a result of the proposed project. Foraging habitat remaining within 12 kilometre radius: 8,486 hectares (all Heddle vegetation complexes). This is a decline of 0.8 per cent in carrying capacity.	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible. Retain gardens and verges. Plant with foraging species suitable for the Forest Red-tailed Black Cockatoo. Replant degraded areas.
Indirect (ecosystem function)	Population fragmentation	Negligible	The Forest Red-tailed Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the project area is unlikely to result in fragmentation of existing populations.	Replanting to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the Estate due to weed invasion	Negligible	The development of the project area will result in all native vegetation being cleared. Therefore, surrounding remnant native vegetation (e.g. vegetation around Munday Swamp) will be sensitive to weed invasion.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Negligible	Ongoing mortality can occur during project operations; for example, from birds colliding with approaching and departing planes (runway adjacent to the project area) and from vehicle strike. Birdstrike may decrease due to removal of vegetation from the project area.	Avoid black cockatoo forage trees along high-speed roads.
Indirect (ecosystem function)	Species interactions	Negligible	Not relevant to Forest Red-tailed Black Cockatoo. However, existing feral management procedures need to be continued.	Not applicable.
Indirect (ecosystem function)	Changes to hydroecology	Negligible	There may be a risk to habitat used by the Forest Red-tailed Black Cockatoo due to altered hydrology (such as increased surface water runoff), although with standard management procedures the risk is considered low. There could be some off-site hydrological change but this would also not affect habitat for the species.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change
Indirect (ecosystem function)	Changes to fire regime	Negligible	Not relevant to the Forest Red-tailed Black Cockatoo given the lack of foraging and nesting habitat that will be retained in the project area. Surrounding habitat (outside of the project area, but within the Estate) can be managed with existing fire management protocols.	Existing fire management and suppression around the Airport Estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Negligible	Not relevant to the Forest Red-tailed Black Cockatoo as the species is very tolerant to noise and light in urban environments.	Legal environmental limits.

Table 12-14 Summary of potential impacts to the Forest Red-tailed Black Cockatoo and proposed mitigation measures.
Source: Bamford Consulting Ecologists, 2019

12.6.3.4 Significance of Residual Impacts

An assessment of the potential impacts to the Forest Red-tailed Black Cockatoo using Guideline 1.1 is summarised in Table 12-15.

Significance Criteria Under Guideline 1.1	Likelihood and Rationale
	Forest Red-tailed Black Cockatoo
Lead to a long-term decrease in the size of a population (or an important population).	**Likely to occur.** The Forest Red-tailed Black Cockatoo is a regular non-breeding visitor to the project area and Perth Airport estate. Native vegetation within the project area does provide some foraging habitat (63.9 hectares of varied value, from low to high), and 0.8 per cent of foraging habitat within 12 kilometres. The impact is likely to be a shift in the local distribution and abundance of the species but not to result in a population decline. At present breeding does not occur in the project area, but there may be some breeding within 12 kilometres to the east.
Reduce the area of occupancy of the species (or an important population).	**Likely to occur.** Loss of the native vegetation of the Estate will alter the local distribution and abundance of the Forest Red-tailed Black Cockatoo resulting in a reduction in their local abundance. They are likely to still occur in the immediate region and remain as visitors (but in reduced numbers) to the Airport Estate.
Fragment an existing population (or important population) into two or more populations.	Unlikely to occur. No barrier to movement. The Forest Red-tailed Black Cockatoo is a strong-flying species known to cross large areas of open land and to move through built environments to access feeding areas. Development of the project area is unlikely to result in fragmentation of existing populations.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. Native vegetation within the project area does provide some low to high foraging habitat (63.9 hectares). The impact is likely to be a shift in the local distribution and abundance of the species but is not critical to the survival of the species.
Disrupt the breeding cycle of a population (or important population).	Unlikely to occur. Some loss of potential nest-trees at a localised scale but breeding not confirmed within the project area. Breeding of the Forest Red-tailed Black Cockatoo may occur within 12 kilometres, and thus a small loss of foraging habitat of a few breeding pairs may occur.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. Localised loss of foraging habitat (63.9 hectares) will occur with development of native vegetation within the project area. The loss of foraging habitat will lead to a decline at a localised scale but is not critical to the survival of the species. Offsets will to some degree minimise long term impacts associated with vegetation clearing.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral bees, cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. Localised impacts. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the project area or Perth Airport estate. The project is unlikely to interfere with the recovery of the species provided that vegetation clearing is offset.

Table 12-15 Forest Red-tailed Black Cockatoo assessed as per Guideline 1.1.
Source: Bamford Consulting Ecologists, 2019

It is expected that two of the nine EPBC significance criteria (Table 12-15) will be triggered for the Forest Red-tailed Black Cockatoo. The proposed action will result in some residual impact to the Forest Red-tailed Black Cockatoo, through the direct and permanent removal of up to 63.9 hectares of (low to high quality) foraging habitat (considered to be used irregularly by the species). Twelve potential nest-trees that presently have hollows and 121 potential nest-trees that might be of future use to the species (i.e. trees >500mm DBH that currently have no hollows) are within the project area. This impact is unavoidable due to the removal of vegetation and subsequent construction of airport infrastructure. There is likely to be an impact to Forest Red-tailed Black Cockatoo at the local- (moderate impact within the project area and surrounding Airport Estate) and regional- (minor impact within 12 km) scales through the loss of foraging habitat and a potentially altered local distribution of the species, but this is not expected to have a significant impact at the species-scale.

12.6.4 Quenda

12.6.4.1 Overview

The Quenda is listed as Priority 4 by the DBCA. The species was found to be abundant in the project area and Perth Airport estate. Evidence of the species (e.g. tracks and foraging holes) was found in all locations visited, including native vegetation, in areas where weeds provide dense cover and riparian vegetation. Population estimates of Quenda for each of the three broad vegetation types were:

- damp heathland – 196 individuals,
- woodland – 92 individuals, and
- grassland – 24 individuals.

The total Quenda population within the NRP is therefore considered to be in the order of 312 individuals. This represents 31 per cent of the population estimated to occur on the entire estate (based on 193 hectares of dampland heaths, 299 hectares of Woodlands and 233 hectares of Grasslands). Quenda habitat mapping in the project area is provided in Figure 12-7.

There are about 8,000 hectares of native vegetation within a 12km radius of the project area, with most of it woodland and some areas (approximately 200 hectares) of damp heath. The Quenda densities within the Perth Airport estate are high due to long-term fox control. Densities outside the Perth Airport estate are likely to be much lower than within the Perth Airport estate due to foxes. If an average density of 0.14/ hectares is assumed (based upon Thomas's (1990) lowest density), then the Quenda population within 12km of but outside the estate is approximately 1,100 animals This gives a total Quenda population within the 12km radius of about 2,000, about 50 per cent of the regional population within the estate, and 15 per cent within the NRP.

12.6.4.2 Direct Impacts

The development of the NRP will result in the loss of 232.7 hectares of Quenda habitat (Table 12-16). A further 54.5 hectares of cleared/built areas and 5.6 hectares of artificial drains are present in the project area.

Vegetation type	Impact area/ hectares
Damp Heathland	70.0
Woodland	65.7
Grassland	97.0
Total impact area	**232.7**

Table 12-16 Impact areas per vegetation type within the NRP.
Source: Bamford Consulting Ecologists, 2019

Figure 12-7 Quenda Habitat (Woodland, Damp Heathland and Grassland) in the NRP
Source: Bamford Consulting Ecologists, 2019

12.6.4.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on the Quenda are discussed in Table 12-17 (below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline/local extinction	Major (Estimated 15 % population decline across a 12 km radius).	Loss of up to 232.7 hectares of Quenda habitat will occur as a result of the proposed project. The project area currently has an approximate population of 312 individuals, thus the loss of habitat and resultant population decline within the project area could result in a population decline in the order of 15 per cent across a 12 kilometre radius.	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible. Retain gardens and verges. Replant degraded areas and if possible, connect remnants and re-plantings with corridors of native vegetation. Translocate animals prior to clearing.
Indirect (ecosystem function)	Population fragmentation	Moderate	The Quenda population within the project area provides connectivity with populations in the northern area of the Perth Airport estate and into the broader region. The loss of individuals from the project area will reduce connectivity and further fragment remaining populations.	Replanting to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the Perth Airport estate due to weed invasion	Minor	The development of the project area will result in the loss of up to 232.7 hectares of Quenda habitat, but some native vegetation will be retained elsewhere on the Perth Airport estate. Retained areas such as Munday Swamp to the north will be at increased risk of weed invasion and the carrying capacity of these areas could be reduced as a result, although Quenda will utilise degraded vegetation.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Major	Ongoing mortality from vehicle strike can occur during project operations and is a concern for the proposed project.	Provide signage and reduce road speeds in areas of high fauna activity. Implement wildlife underpasses if suitable locations can be identified.
Indirect (ecosystem function)	Species interactions	Major	Impacts due to species interactions (i.e. predation by feral cats) are likely to increase due to habitat loss and fragmentation.	Existing control of feral species. Extend fox control to include cats. Dieback Management.
Indirect (ecosystem function)	Hydroecology	Negligible	Offsite impacts due to hydrological change are likely to be negligible as modifications to surface water hydrology will be strictly managed onsite. It is unlikely that Quenda habitat surrounding the project area would be impacted by hydrological change, although Quenda will utilise many different vegetation types.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change
Indirect (ecosystem function)	Changes to fire regime	Negligible	Not relevant to the Quenda given the lack of habitat that will be retained in the project area. Surrounding habitat (outside of the project area, but within the Perth Airport estate) can be managed with existing fire management protocols.	Existing fire management and suppression around the Airport Estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Negligible	Not relevant to Quenda as the species is tolerant to noise and light in urban environments.	Legal environmental limits.

Table 12-17 Summary of potential impacts to Quenda and proposed mitigation measures.
Source: Bamford Consulting Ecologists, 2019

12.6.4.4 Significance of Residual Impacts

An assessment of the potential impacts to Quenda using Guideline 1.1 is summarised in Table 12-18.

Significance Criteria Under Guideline 1.1	Likelihood and Rationale
	Quenda
Lead to a long-term decrease in the size of a population (or an important population).	**Likely to occur.** Approximately 232.7 hectares of native vegetation (comprising of woodland, damp heathland and grassland) will be impacted as a result of the project, leading to a decrease in the size of the local population.
Reduce the area of occupancy of the species (or an important population).	**Likely to occur.** Loss of 232.7 hectares of native vegetation from the project area will alter the local distribution and abundance of the Quenda resulting in a significant reduction in local abundance. They are likely to still occur in bushland to the north and other areas of the Perth Airport estate (e.g. in gardens, and verges).
Fragment an existing population (or important population) into two or more populations.	**Likely to occur.** The proposed clearing of 232.7 hectares of Quenda habitat within the project area is likely to result in further fragmentation of existing local populations.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. Quenda are widespread across the Swan Coastal Plain and Perth hills. Although 232.7 hectares of Quenda habitat will be removed, the habitat within the project area is not critical to the survival of the species and some adjacent habitat is available within and outside the Perth Airport estate.
Disrupt the breeding cycle of a population (or important population).	**Likely to occur.** Breeding will be disrupted within the project area but may continue (albeit at a much reduced rate) after the construction phase as some individuals move back into gardens and verges within the project area. It is expected that breeding outside the project area and Perth Airport estate will continue undisrupted.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. Localised loss of Quenda habitat (232.7 hectares) will occur with development of native vegetation within the project area. While localised declines will occur, impacts will not lead to a decline of the species.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. Localised impacts. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the project area or Perth Airport estate.

Table 12-18 Quenda assessed as per Guideline 1.1.
Source: Bamford Consulting Ecologists, 2019

It is likely that four of the nine significance criteria under Guideline 1.1 will be met for Quenda (Table 12-18). Based on the assessment above, approximately 232.7 hectares of Quenda habitat will be permanently removed for the construction of airport infrastructure. This represents all of the Quenda habitat within the NRP area. Remnant patches of native vegetation will be retained outside the project area, located to the north, and the species can exist in planted gardens. Therefore, there will be substantial and permanent population decline but a small population may return to areas of planted gardens and verges. There is likely to be a major impact to Quenda within the project area, surrounding Perth Airport estate and regionally through the loss of foraging habitat and a potentially altered local distribution of the species, but this is not expected to have a significant impact at the species-scale. Pre-clearing trapping and relocation to a suitable release site will reduce direct mortality and the remaining population can be assisted through a revegetation program designed to create interconnected habitat through the built landscape. The regional (within 12 kilometres) population will persist.

12.6.5 Rakali

12.6.5.1 Overview

The Rakali (Water-rat) is listed as Priority 4 by DBCA. The species is present in the area but probably restricted to permanent wetlands along Abernethy Road (e.g. Ollie Worrell Reserve) and the Swan River, with seasonal dispersal into Munday Swamp and along the main drains which flow through the NRP area (Bamford *et al.,* 2017) (Figure 12-8). Drains may provide connectivity for Rakali between the Abernethy Road wetlands and the Swan River (located to the west of the project area).

The only record of the Rakali is a feeding platform in Munday Swamp located on the northern boundary of the NRP area (Bamford *et al.,* 2017) (Figure 12-8). As Munday Swamp is seasonal, this suggests that an animal had been present the previous winter. It was speculated as individuals disperse along drains and from wetlands nearby, the Rakali is likely only an occasional visitor to Munday Swamp and given that only a small section of the swamp is part of the NRP area the impact would be considered minimal.

12.6.5.2 Direct Impacts

The development of the NRP will result in the loss of 5.6 hectares of Rakali habitat and includes existing artificial drains used by the species to move through the project area and Perth Airport estate. However, the programme of converting drains into “living streams” may benefit the species by providing improved connectivity and more permanent wetland habitat.

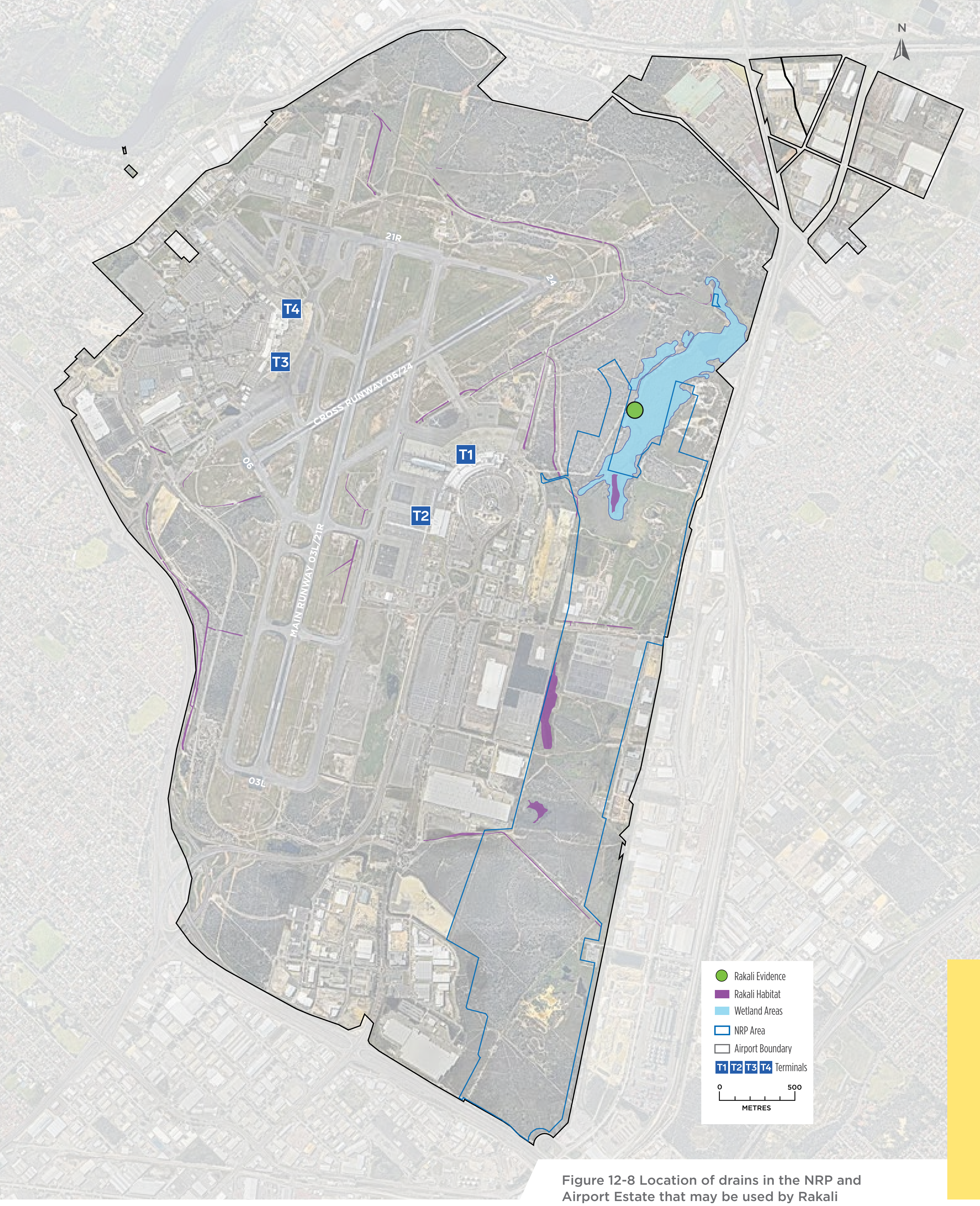


Figure 12-8 Location of drains in the NRP and Airport Estate that may be used by Rakali
Source: Bamford Consulting Ecologists, 2019

12.6.5.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on the Rakali are discussed in Table 12-19(below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline/ extinction	Negligible	The removal or modification of key habitat (5.6 hectares of existing drains) will occur as a result of the proposed project.	Well-defined and rationalised clearing footprint that avoids Rakali habitat (i.e. drains) where possible. Replanting drains to replace/ enhance habitat and connectivity.
Indirect (ecosystem function)	Population fragmentation and survival	Minor	The removal or modification of 5.6 hectares of drains from within the NRP may reduce the ability for Rakali to move through the area, e.g. between wetlands located east of the project area through to the Swan River (west of the project area). Although other drains occur to the north of the project area which may be used by the Rakali.	Clearing designed to retain drains/linkage where possible. Replanting drains (as a part of the Living Streams program) to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the Airport estate due to weed invasion	Negligible	Impacts from weed invasion are expected to be negligible with standard weed management procedures	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Minor	Ongoing mortality from vehicle strike can occur during project operations and is a concern for the NRP. Impacts to Rakali are considered minor as the species usually moves through the landscape via drains.	Provide signage and reduce road speeds in areas of high fauna activity. Implement wildlife underpasses if suitable locations can be identified.
Indirect (ecosystem function)	Species interactions	Minor	Impacts from species interactions assumed to be minor as the species persists in areas where feral species are present. Existing controls on feral species may be of assistance.	Existing control of feral species. Extend fox control to include cats.
Indirect (ecosystem function)	Hydroecology	Minor assuming controls	The Rakali is sensitive to hydrological change but both surface and sub-surface hydrology will be managed within the NRP area, across the Perth Airport estate and off-site. The Perth Airport currently has a program of converting drains into 'living streams' and this may benefit the Rakali.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change. Replant drains (as a part of the Living Streams program).
Indirect (ecosystem function)	Changes to fire regime	Negligible/ Minor	Vegetated drains and wetland areas provide key habitat for the Rakali. While vegetation in these can burn, the impact upon the Rakali is expected to be slight as it is partly aquatic.	Existing fire management around the Perth Airport estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Negligible	Not relevant to Rakali as the species is very tolerant to noise and light in urban environments.	Legal environmental limits.

Table 12-19 Summary of potential impacts to Rakali and proposed mitigation measures
Source: Bamford Consulting Ecologists, 2019

12.6.5.4 Significance of Residual Impacts

An assessment of the potential impacts to Rakali using Guideline 1.1 is summarised in Table 12-20.

Significance Criteria Under Guideline 1.1	Likelihood and Rationale
	Rakali
Lead to a long-term decrease in the size of a population (or an important population).	Unlikely to occur. Artificial drains provide key habitat, and the species is likely to use these to move through the project area and Airport Estate. Approximately 5.6 hectares of drains will be removed or modified as a part of the project. While there will be some removal and modification of existing drains, other drains will be created and replanted, providing some suitable habitat and net benefit for the Rakali. Furthermore, only as small section of Munday Swamp will be impacted by the project and there will be controls in place to ensure that there are no adverse impacts due to surface water or groundwater changes. Munday Swamp will therefore continue to provide an important refuge for the species (outside the project area). It is unlikely that the development of the project will lead to a long-term decrease in the size of the population.
Reduce the area of occupancy of the species (or an important population).	Unlikely to occur. If present, the modification of some drains (currently 5.6 hectares) within the project area may temporarily alter the distribution and abundance of the Rakali, but with new drains being created and planted it is unlikely to reduce the area of occupancy. Most records of the species are located along the Swan River (located approximately 3.5 km west of the project area).
Fragment an existing population (or important population) into two or more populations.	Unlikely to occur. The modification of some drains within the project area may alter the local movement of the species. The proposed project is unlikely to result in fragmentation of existing local populations as newly created and planted drains will provide some corridors for the species to move through the landscape.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. Rakali are widespread across the Swan Coastal Plain and Perth hills. Although some drains will be modified, the habitat within the project area is not critical to the survival of the species and adjacent habitat is available outside the project area e.g. vegetated drains located within the Perth Airport estate, Ollie Worrell Reserve and the Swan River.
Disrupt the breeding cycle of a population (or important population).	Unlikely to occur. It is unlikely that the development of the project will disrupt the breeding cycle of a population. There is no evidence that Rakali are breeding in the project area or Perth Airport estate. Some disturbance may occur during the construction phase until the drains are reinstalled. It is expected that breeding outside the project area (e.g. along the Swan River) will continue undisrupted.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely to occur. While the proposed project may modify some of the available habitat, it is unlikely that the species will decline.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. No active, direct recovery measures are currently undertaken in the project area, Perth Airport estate or region.

Table 12-20 Rakali assessed as per Guideline 1.1
Source: Bamford Consulting Ecologists, 2019

It is not expected that any EPBC significance criteria (Table 12-20) will be triggered for the Rakali. The proposed action will result in the disturbance of up to 5.6 hectares of drains. While there will be some modification to existing drains to accommodate the construction of airport infrastructure, other drains will be created and replanted, providing key habitat and potentially a net benefit for the Rakali. Revegetated drains will aid in the movement of the species across the built landscape. Impacts are expected to range from negligible to minor (Table 12-21). There is likely to be an impact to Rakali at the local scale through temporary disruption of movement through the landscape, but this is not expected to have a significant impact at either the regional or species scale. The proposed action is unlikely to result in a significant residual impact to the Rakali.

12.6.6 Native bee

12.6.6.1 Overview

The native bee, *H. globuliferus* (DBCA Priority 3) is known to occur in the region and from habitats represented on the project area and Perth Airport estate. There is little information available on the distribution and habitat of *H. globuliferus*. Records from the DBCA database show that the species has been recorded from the Perth Swan Coastal plain north up to Jurien Bay and Eneabba. The species has also been recorded at several locations between Lake Grace and the Fitzgerald River National Park (southwest of Ravensthorpe).

The species is known to forage on the flowers of Woollybush (*Adenanthos cygnorum*) and *Banksia attenuata*, which are both present in Banksia Woodland of the project area. The vegetation type (VT) is mapped as VT13 by Woodman Environmental (2019) and presented in Figure 12-9. Field investigations carried out within the NRP in early 2019 did not locate the species, but some likelihood of presence remains (Bamford and Knowles, 2019), and advice from the WA Museum is that the species may be more widespread and common than realised.

It is difficult to ascertain the availability of suitable *H. globuliferus* habitat within the region, however approximately 1,577 hectares of the remaining vegetation extent within a 12 km radius may contain patches of suitable vegetation (Bassendean, Cannington, Forrestfield and Southern River vegetation complexes) (see Table 12-6). If the proportion of suitable bee habitat in these regional areas is similar to that of the project area (approximately 16 per cent; 20.6 hectares out of 132.0 hectares) then approximately 246 hectares of regional habitat may be present. The project area therefore contains approximately 8.4 per cent of the regional habitat.

12.6.6.2 Direct Impacts

The native bee is likely to be a regular visitor to the project area and Airport estate. The development of the NRP will result in the loss of approximately 20.6 hectares of VT13 (Banksia Woodland) and *H. globuliferus* habitat. Impacts to the species are likely to be proportional to loss of their preferred foraging habitat across the project area and are likely to be significant at a local scale due to the lack of suitable habitat in close proximity to the project area.

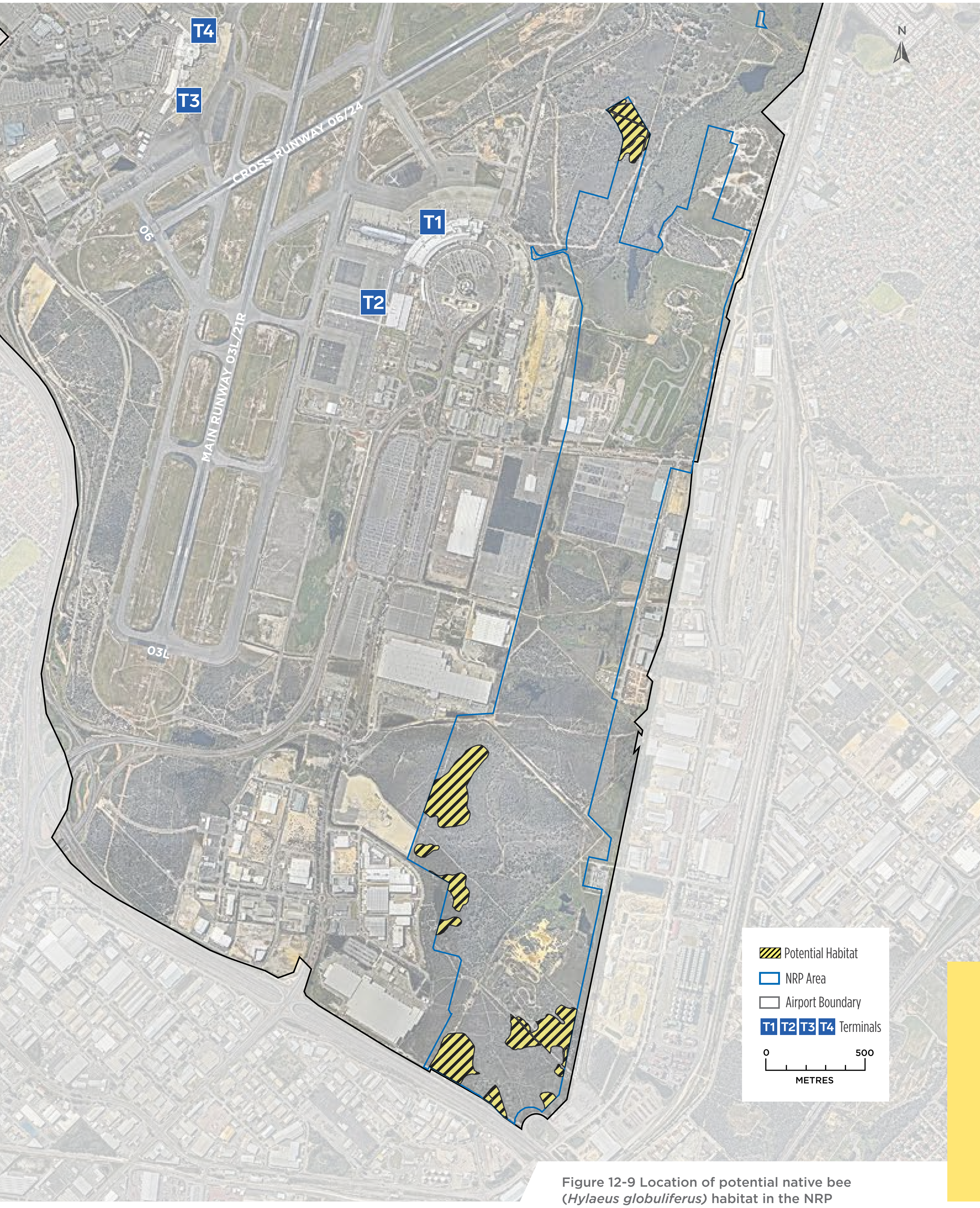


Figure 12-9 Location of potential native bee (*Hylaeus globuliferus)* habitat in the NRP
Source: Bamford Consulting Ecologists, 2019

12.6.6.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on the native bee species are discussed in Table 12-21 (below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline/local extinction	Major	Loss of up to 20.6 hectares of foraging habitat (Banksia Woodland with *Adenanthos cynorum, Woollybush)* may occur as a result of the proposed project and is significant due to the scarcity of habitat for the species in a 12 kilometre radius (approximately 8.4 per cent of the estimated 246 hectares of regional habitat).	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible. Plant gardens and verges with foraging species suitable for the native bee e.g. *A. cygnorum.* Replant degraded areas if possible, with species preferred by the native bee.
Indirect (ecosystem function)	Population fragmentation and survival	Minor	The loss of up to 20.6 hectares of Banksia Woodland is likely to result in further fragmentation of the local population.	Clearing designed to retain corridors/linkage where possible. Replanting to replace/ enhance connectivity.
Indirect (ecosystem function)	Degradation of surrounding habitat within the estate due to weed invasion	Minor	Impacts from weed invasion are expected to be negligible with standard weed management procedures. Woollybush is a native plant species that actually responds well to some disturbance.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas.
Direct	Ongoing mortality	Minor	Ongoing mortality during project operations is uncertain, but if a population is present, the proportion at risk from mortality such as that due to roadkill is probably very small.	Not applicable.
Indirect (ecosystem function)	Species interactions	Negligible	Not relevant to the native bee.	Not applicable.
Indirect (ecosystem function)	Hydroecology	Negligible	Probably not relevant to the native been assuming local hydrology is managed to prevent any significant changes.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change
Indirect (ecosystem function)	Changes to fire regime	Negligible - Minor	Not relevant to the native bee given the lack of habitat that will be retained in the project area. Surrounding habitat (outside of the project area, but within the Perth Airport estate) can be managed with existing fire management protocols. Fire events that occur in native bee habitat outside of the project area may impact the species at a local level.	Existing fire management and suppression around the Estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Minor	Impacts of dust, light, vibration and noise are not well known. The species must be tolerant to some degree, as it is present in the urban environment.	Legal environmental limits.

Table 12-21 Summary of potential impacts to the native bee species and proposed mitigation measures
Source: Bamford Consulting Ecologists, 2019

12.6.6.4 Significance of Residual Impacts

An assessment of the potential impacts to the native bee species using Guideline 1.1 is summarised in Table 12-22.

Significance Criteria Under Guideline 1.1	Likelihood and Rationale
	Native Bee
Lead to a long-term decrease in the size of a population (or an important population).	**Likely to occur.** The native bee is likely to be a regular visitor to the project area. Banksia Woodland (with *A. cygnorum*) is present within the project area and provides foraging habitat for the species. Approximately 20.6 hectares of habitat will be impacted as a result of the project (8.4 per cent of estimated habitat area within 12 kilometres). This is considered significant due to the lack of suitable habitat for the species in the region (12 kilometre radius). The impact is likely to be a shift in the local distribution and abundance of the species and a permanent decline in the population at the project area.
Reduce the area of occupancy of the species (or an important population).	**Likely to occur.** Loss of Banksia Woodland at the project area will alter the local distribution and abundance of the native bee resulting in a significant reduction in their local abundance. They may still occur in gardens, verges and the immediate region, but will be reduced due to the loss of key habitat within the project area.
Fragment an existing population (or important population) into two or more populations.	**Likely to occur.** The proposed clearing of 20.6 hectares of foraging habitat within the project area is likely to result in fragmentation of existing local populations if present.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. The native bee has been recorded on the northern Swan Coastal Plain, south-eastern wheatbelt and south coast of Western Australia. Although 20.6 hectares of foraging habitat will be removed, the habitat within the project area is not likely to be critical to the survival of the species.
Disrupt the breeding cycle of a population (or important population).	**Likely to occur.** It is unknown if the native bee is breeding at the project area. If the species is, then breeding will be disrupted. It is expected that breeding outside the project area will continue undisrupted.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Likely to occur.** Localised loss of native bee habitat (20.6 hectares) will occur as a result of the development of the project. Removal of habitat will lead to a decline of the species at the project level.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures. Feral species are unlikely to impact the native bee.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. Localised impacts. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the project area, Perth Airport estate or region.

Table 12-22 The native bee species assessed as per Guideline 1.1
Source: Bamford Consulting Ecologists, 2019

It is likely that five of the nine significance criteria under Guideline 1.1 will be met for the native bee species (Table 12-22). If present in the project area, there will be a permanent local population decline due to habitat loss. Approximately 20.6 hectares of Banksia Woodland with *A. cygnorum* will be permanently removed for construction of the project and represents a significant portion of bee habitat within the local area. There is likely to be an impact to *H. globuliferus* at the local- (major impact within the project area and surrounding Perth Airport estate) and regional- (major impact within 12 kilometres) scales through the loss of habitat and a potentially altered local distribution of the species, but this is not expected to have a significant impact at the species-scale. Standard mitigation measures and proposed additional management measures will reduce impacts to some degree but the proposed action is likely to result in a significant residual impact to the native bee. A decline in the abundance and some localised loss of the species is expected.

12.6.7 Whole of Environment Fauna

12.6.7.1 Overview

A detailed description of the "Whole of Environment" fauna within and adjacent to the NRP area is provided in Section 12.5 and summarised below.

The fauna assemblage of the project area is substantially intact but probably still losing species and is unusual because it exists in a region of extensive regional clearing and development. The desktop study identified 204 vertebrate species as potentially occurring in the project area: five fish, 12 frogs, 42 reptiles, 130 birds (six introduced) and 15 mammals (five introduced). Several species that may have occurred within the project area historically are now considered to be locally extinct, leaving a current assemblage of approximately 168 vertebrate species.

The assemblage includes a suite of common species from the Swan Coastal Plain and also some conservation significant species; the most notable being the three species of black cockatoo, Quenda, Rakali, and the native bee species (*H. globuliferous*). The assemblage is supported by a range of VSAs which are important for different components of the assemblage. Woodlands support the greatest range of reptile and bird species, including many of conservation significance. Woodlands are particularly notable for supporting black cockatoos, and heathlands for supporting Quenda. All three black cockatoo species have been recorded in and around the woodlands of the NRP and Perth Airport estate; Carnaby's Black Cockatoo focusses on areas with a high proportion of Banksia, while the Forest Red-tailed and Baudin's Black Cockatoos favour Marri woodland. The assemblage is notable for a suite of species (particularly sedentary birds and reptiles) that have declined in the Perth area but persist in large tracts of native vegetation, although some of these seem to have become locally extinct on the Perth Airport estate during the last decade.

Grassland and Damp Heathlands are also likely to support populations of common reptile and bird species. Quenda are also abundant in this dense, low vegetation. Constructed drains in the project area while artificial, may be important for facilitating fauna movements through the landscape and support seasonal breeding by frogs, aquatic invertebrates, the Rakali and potentially small numbers of conservation significant waterbirds, such as Blue-billed Duck.

It should also be recognised that the invertebrate assemblage in general is poorly documented and species-rich groups such as micro-wasps are likely to be present and may include undescribed species. The field investigations (Bamford and Knowles 2019) did record a suite of invertebrate species suggesting that the invertebrate assemblage is substantially intact. No conservation significant species were detected but almost all species found are likely to be reliant upon native vegetation, and thus can be expected to be at risk within the project area due to habitat loss. Several of the species were noted as being of interest on the Swan Coastal Plain, as they are better-known from landscapes further east, which reflects the location of the project area close to the escarpment.

Ecological processes of particular importance with respect to the fauna assemblage include feral species and changes to hydrology.

Previous assessments of NRP fauna (e.g. Bamford *et al*., 2017) included the Rainbow Bee-eater, but this species has been delisted as a threatened native species Migratory species (under the EPBC Act) and is no longer considered a conservation concern for the NRP project. Listed, or otherwise, the development will not permanently impact on this species at the local, regional or species scale. While it forages (aerially) over and on the fringes of native vegetation, it nests in burrows in open areas including road verges, un-reticulated mown grass and de-stocked paddocks. It will nest in the cleared margins of, but not within, native vegetation. The Rainbow Bee-eater is regionally widespread.

The Rainbow Bee-eater is regionally widespread. It is a regular spring or sumer visitor that breeds in open areas on the Perth Airport Estate. Munday Swamp itself is not suitable for breeding, as it is too densely-vegetated, but adjacent old paddocks both east and west of the swamp are suitable. It has been recorded in the NRP area (1994, 1995 and 2008) and is likely to breed on cleared land in this area. Rainbow Bee-eaters do show some fidelity to breeding sites but will also move from year to year in response to changing conditions such as an increase in vegetation density (Higgins, 1999).

12.6.7.2 Direct Impacts

The impacts to the "Whole of Environment" fauna resulting from the NRP was assessed against Guidelines 1.1. The results of this assessment are summarised in Table 12-23 below. Note, impacts to non-MNES species such as Quenda, Rakali and the native bee species, including mitigation measures, are provided in Sections 12.6.4.3, 12.6.5.3 and 12.6.6.3 respectively.

The development of the NRP will result in the loss of several VSA types including Woodland (65.7 hectares), Damp Heathland (70.0 hectares), Grassland (97.0 hectares) and artificial drains (5.6 hectares), a total area of 238.3 hectares. A further 54.5 hectares of already cleared/built lands (negligible to no value for fauna) are also within the project area.

12.6.7.3 Indirect Impacts

These impacts (as defined in Section 12.4.1) on the "Whole of Environment" fauna are discussed in Table 12-23 (below).

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Direct	Habitat loss leading to population decline/ extinction	Major	Loss of 238.3 hectares of various VSAs will result in population declines at a local level for a wide suite of native fauna species, including common and conservation significant species. This would be of concern to a number of species (e.g. sedentary, insectivorous birds such as fairy-wrens, thornbills, scrubwrens, robins, whistlers and shrike-thrush and some reptile and mammal species e.g. Quenda).	Well-defined and rationalised clearing footprint that avoids habitat where possible. Pre-clearing trapping and relocation (e.g. reptiles). Replant degraded areas. Establish gardens with native vegetation. Identify and avoid direct impact on active nests of the Rainbow Bee-eater
Indirect (ecosystem function)	Population fragmentation and survival	Moderate	The project area is situated in a highly urbanised and fragmented landscape. Loss of 238.3 hectares in the project area would affect local movement patterns of some bird and mammal species such as the Quenda which at present may rely on native vegetation for the persistence of local populations. Obstructions associated with the project areas, such as runways, roads and drainage channels may also affect movement of small, terrestrial species.	Clearing designed to retain corridors/linkage where possible. Replanting to replace/ enhance connectivity. Creating biodiverse gardens. 'Living stream' approach to drains to create wildlife corridors.

Impact Type	Threatening Process	Significance	Discussion	Proposed Avoidance/ Mitigation Measure
Indirect (ecosystem function)	Degradation of surrounding habitat within the Perth Airport estate due to weed invasion	Minor to Major	Weed invasion of the project area is currently high in parts of the native vegetation and weed invasion will be a risk in the native vegetation that is retained. Weeds are likely to be managed intensively in gardens and living streams in the future and will need to be managed in retained native vegetation.	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas and throughout.
Direct	Ongoing mortality	Moderate	Direct mortality of common species during clearing and construction is unavoidable but can be minimised for some species (e.g. Bobtail, Quenda) through pre-clearing trapping and relocation. Increased mortality can occur during project operations; for example, from roadkill, animals striking infrastructure and entrapment in trenches. Some species, however, will be vulnerable to increased and ongoing mortality such as from roadkill; these would include mammals and reptiles that will persist in greatly reduced and fragmented populations, such as Bobtail and Quenda.	Pre-clearing fauna relocation. Install wildlife underpasses for Quenda and some other fauna if suitable locations can be identified.
Indirect (ecosystem function)	Species interactions	Major, but reduced to Minor assuming feral animal control is practiced.	Feral species are a conservation concern for some native fauna, and at present the control of foxes is believed to have contributed to the flourishing Quenda population in the project area. Control of foxes and cats will be even more important with reduced populations of bird, mammals and reptile species.	Existing control of feral species. Extend fox control to include cats to reduce predation pressure on small mammals and birds.
Indirect (ecosystem function)	Hydroecology	Negligible - Minor	In the future scenario, fauna will be heavily reliant on managed landscapes where hydrology will probably be managed with drains to ensure vegetation and wetlands are protected. Therefore, fauna species that rely on wetlands and wetland-vegetation (e.g. fish, frogs and some bird species are likely to be protected from adverse impacts due to hydrological change. The Perth Airport currently has a program of converting drains into 'living streams' and this may benefit several fauna species.	Understand and manage local hydrology. Ensure standard approaches minimise hydrological change. Replant drains (as a part of the Living Streams program).
Indirect (ecosystem function)	Changes to fire regime	Moderate to Major	In the future scenario, intensive management may result in the virtual exclusion of fire as all native vegetation in the project area will be removed. Although 'living streams' could be subject to infrequent and possibly intense fires. Species that occur at low densities would be vulnerable to such fires.	Existing fire management around the Perth Airport estate.
Indirect (ecosystem function)	Dust, light, vibration, noise	Minor	Impacts of dust, light, vibration and noise upon fauna are difficult to predict. Given the current setting of native vegetation in the project area, fauna is already exposed to high levels of noise, light and vibration. Separation distances will be reduced, and this may be a concern for some invertebrates, but the consequences are largely unknown. Mobile species such as birds may leave the area to avoid high levels of noise and vibration.	Legal environmental limits. Direct lighting away from retained native vegetation where possible within relevant standards.

Table 12-23 Summary of potential impacts to the "Whole of Environment" fauna and proposed mitigation measures
Source: Bamford Consulting Ecologists, 2019

12.6.7.4 Significance of Residual Impacts

An assessment of the potential impacts to "Whole of Environment" fauna using Guideline 1.1 (DoE 2013) significance criteria is summarised in Table 12-24.

Significance Criteria Under Guideline 1.1	Likelihood and Rationale
	Whole of Environment fauna
Lead to a long-term decrease in the size of a population (or an important population).	**Likely to occur.** Loss of 238.3 hectares of vegetation (and drains) in the project area will result in permanent population declines at a local level for a wide suite of native fauna species, including common and some conservation significant species (e.g. Quenda). Some birds (not MNES or Priority) vulnerable to habitat loss and fragmentation may become locally extinct.
Reduce the area of occupancy of the species (or an important population).	**Likely to occur.** The removal of 238.3 hectares of vegetation (and drains) will reduce the area of occupancy for a wide suite of native fauna species.
Fragment an existing population (or important population) into two or more populations.	Unlikely to occur. The removal of 238.3 hectares of vegetation (and drains) and the construction of airport infrastructure will alter the local movement of some native fauna species. Mobile species such as birds may vacate the area for more favourable habitats. Some species such as the Rakali may still be able to move through the landscape provided that drains within the project area are planted with native vegetation.
Adversely affect habitat critical to the survival of a species.	Unlikely to occur. Common native fauna species found within the project area are widespread across the Swan Coastal Plain. Although 238.3 hectares of vegetation (and drains) will be cleared, the habitat within the project area is not critical to the survival of many of the species. Conservation significant species are discussed in Sections 12.6.1 to 12.6.6
Disrupt the breeding cycle of a population (or important population).	Unlikely to occur. The development of the project will affect some populations rather than breeding cycles per se.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Likely to occur.** Localised loss of 238.3 hectares will occur as a result of the development of the project. Removal of native vegetation and drains will result in population declines at a local level for a wide suite of native fauna species.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	Unlikely to occur. Feral species and other competitors (e.g. feral cats and foxes) are likely to be present in the region but can be managed with onsite environmental procedures.
Introduce disease that may cause the species to decline.	Unlikely to occur. Hygiene management plan will be implemented.
Interfere with the recovery of the species.	Unlikely to occur. No active, direct recovery measures are currently undertaken in the project area, Airport Estate or region.

Table 12-24 "Whole of Environment" fauna assessed as per Guideline 1.1
Source: Bamford Consulting Ecologists, 2019

It is likely that three of the nine significance criteria under Guideline 1.1 will be met for the "Whole of Environment" fauna (Table 12-24). There will be permanent population declines at a local level due to habitat loss in the project area. Approximately 238.3 hectares of vegetation (and drains) will be permanently removed for the construction of airport infrastructure and represents a significant portion of habitat within the local area.

Standard mitigation measures and proposed additional management measures will reduce impacts to some degree, which are expected to range from negligible to major (Table 12-24). The proposed action is likely to result in a significant residual impact to local populations for some species of birds and reptiles. A decline in the abundance and localised loss of the species is expected, although some bird and mammal species will exist in planted gardens. Some species will remain and can be assisted through a revegetation program designed to create interconnected habitat through the built landscape (e.g. Rakali in planted drains).

Although residual impacts at a local level are expected to be permanent and significant, many common species present within the project area are widespread across the Swan Coastal Plain and therefore at a species level, are at low risk from the proposed action.

12.7 Summary of Risk Assessment and Mitigation Measures

A summary of the proposed mitigation measures and residual impacts for each impacting process for the NRP is provided in Table 12-25.

Applicable Threatening/ Impacting Process	Fauna Matter	Mitigation/Avoidance Measure	Residual Impact (after implementation of mitigation/ avoidance measure)
Habitat loss leading to population decline /local extinction	Carnaby's Black Cockatoo	Well-defined and rationalised clearing footprint that avoids habitat where possible. Management of remnant vegetation and use of food plants in gardens.	Loss of 232.7 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Forest Red-tailed Black Cockatoo		Loss of 63.9 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Baudin's Black Cockatoo		Loss of 63.9 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Quenda	Well-defined and rationalised clearing footprint that avoids habitat where possible. Replant degraded areas.	Loss of 232.7 hectares of Quenda habitat.
	Rakali	Development of gardens as habitat. Munday Swamp (located outside the project area) and several artificial drains within the project area will be retained and replanted.	Loss of 5.6 hectares of Rakali habitat (artificial drains).
	Native Bee	Well-defined and rationalised clearing footprint that avoids native bee habitat where possible. Plant gardens and verges with foraging species suitable for the native bee e.g. *A. cygnorum*. Replant degraded areas if possible, with species preferred by the native bee.	Loss of 20.6 hectares of native bee habitat.
	"Whole of Environment" fauna	Well-defined and rationalised clearing footprint that avoids habitat where possible. Replant degraded areas and drains. "Fauna friendly" gardens.	Loss of 238.3 hectares of native vegetation and drainage areas.

Applicable Threatening/ Impacting Process	Fauna Matter	Mitigation/Avoidance Measure	Residual Impact (after implementation of mitigation/ avoidance measure)
Habitat loss leading population fragmentation	Carnaby's Black Cockatoo	Clearing designed to retain corridors/linkage where possible. Replanting to replace/ enhance connectivity. Creating biodiverse gardens. Replant drains (as a part of the Living Streams program) to create wildlife corridors.	Loss of 232.7 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Forest Red-tailed Black Cockatoo		Loss of 63.9 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Baudin's Black Cockatoo		Loss of 63.9 hectares of low to high value foraging habitat. Loss of 12 potential nest-trees that currently bear hollows.
	Quenda		Loss of 232.7 hectares of Quenda habitat.
	Rakali		Loss of 5.6 hectares of Rakali habitat (artificial drains).
	Native Bee		Loss of 20.6 hectares of native bee habitat.
	"Whole of Environment" fauna		Loss of 238.3 hectares of native vegetation and drainage areas.
Degradation of surrounding habitat within the Perth Airport estate due to weed invasion	Carnaby's Black Cockatoo	Weed management during earthworks. Active weed management post-development to rehabilitate degraded areas and throughout remnant native vegetation.	Negligible due to effective weed management.
	Forest Red-tailed Black Cockatoo		
	Baudin's Black Cockatoo		
	Quenda		
	Rakali		
	Native Bee		
	"Whole of Environment" fauna		
Ongoing mortality	Carnaby's Black Cockatoo	Provide signage and reduce road speeds in areas of high fauna activity. Install wildlife underpasses for fauna (e.g. Quenda) if suitable locations can be identified. Conduct trench inspections during construction phase.	Some ongoing mortality of fauna (e.g. Quenda, Bobtail) as a result of roadkill.
	Forest Red-tailed Black Cockatoo		
	Baudin's Black Cockatoo		
	Quenda		
	Rakali		
	Native Bee		
	"Whole of Environment" fauna		
Species interactions, including predation and competition	Carnaby's Black Cockatoo	Existing control of feral species. Extend fox control to include cats to reduce predation pressure on small mammals and birds (e.g. Quenda and Rakali).	Some ongoing predation is likely to occur.
	Forest Red-tailed Black Cockatoo		
	Baudin's Black Cockatoo		
	Quenda		
	Rakali		
	Native Bee		
	"Whole of Environment" fauna		

Applicable Threatening/ Impacting Process	Fauna Matter	Mitigation/Avoidance Measure	Residual Impact (after implementation of mitigation/ avoidance measure)
Changes to hydroecology	Carnaby's Black Cockatoo Forest Red-tailed Black Cockatoo Baudin's Black Cockatoo Quenda Rakali Native Bee "Whole of Environment" fauna	Understand and manage local hydrology especially in areas around Munday Swamp. Ensure standard approaches minimise hydrological change. This is particularly important in key areas such as the damp heathlands and Munday Swamp. Replant drains (as a part of the Living Streams program).	Negligible due to effective hydrology management.
Changes to fire regime	Carnaby's Black Cockatoo Forest Red-tailed Black Cockatoo Baudin's Black Cockatoo Quenda Rakali Native Bee "Whole of Environment" fauna	Existing fire management around the project area and Perth Airport estate.	Ongoing risk of unplanned fire.
Dust, light, vibration, noise	Carnaby's Black Cockatoo Forest Red-tailed Black Cockatoo Baudin's Black Cockatoo Quenda Rakali Native Bee "Whole of Environment" fauna	Legal environmental limits. Dust, light, noise, vibration suppression measures during construction. Direct lighting away from retained native vegetation during operations wherever practicable.	Some impacts remain unable to be quantified.

Table 12-25 Summary of mitigation measures for the NRP
Source: Bamford Consulting Ecologists, 2019

A summary of the impacts of fauna and an impact risk assessment, including residual impact assessment, is provided in Table 12-26.

Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Initial Assessment: Significance/ Consequence	Initial Assessment: Likelihood	Initial Assessment: Initial Risk	Residual Assessment: Additional Mitigation	Residual Assessment: Significance	Residual Assessment: Likelihood	Residual Assessment: Residual Risk
Loss of habitat	Decline in population survival	Construction	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible Trapping and translocation of species where possible	Moderate Adverse	Almost Certain	High	Offsets in accordance with EPBC offset policy	Moderate Adverse	Possible	Medium
Loss of habitat	Population fragmentation	Construction and Operation	Restrict clearing footprint to NRP area Minimise edge effects through air quality (dust) and weed management	Moderate Adverse	Almost Certain	High	If areas are available, revegetate to establish or re-establish connectivity	Moderate Adverse	Likely	Medium
Weed invasion	Degradation of habitat leading to population decline	Operation	Implementation of a weed and pest management and hygiene plan	Minor Adverse	Possible	Low	Active weed management post-development to rehabilitate degraded areas	Minor Adverse	Unlikely	Low
Loss of habitat	Increased mortality	Operation	Wildlife Management Plan in place	Minor Adverse	Likely	Medium	Avoid black cockatoo foraging trees along high-speed roads	Minor Adverse	Possible	Low
Species interactions	Predation and competition leading to population decline	Operation	Existing control of feral species as per Perth Airport's estate-wide plan. Dieback management	Moderate Adverse	Likely	Medium	Extend fox control to target feral cats	Moderate Adverse	Possible	Medium
Loss of habitat	Changes to hydro-ecology resulting in changes to groundwater level and chemistry, affecting fauna habitat	Construction and Operation	Design to maintain hydrological conditions where feasible	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Fire	Less frequent, intense fires resulting in adverse impacts to mammals and short-range endemics	Operation	Management plans to include measures for fire management during construction Existing fire management and suppression around the estate	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Dust, light, noise and vibration	Impacts to predator-prey interactions, changes to mating and nesting behaviour, increased competition and predation within and between invertebrates, frogs, birds and mammals	Construction and operation	Management plans to incorporate measures to manage dust, light, noise and vibration in accordance with legal environmental limits	Moderate Adverse (invertebrates)	Likely	Medium	CEMP to include requirement to direct construction lighting away from retained native vegetation Further macroinvertebrate surveys/ monitoring during and after construction	Moderate Adverse	Possible	Medium

Table 12-26 Summary of impacts, risks and mitigation measures
Source: Perth Airport

12.8 Proposed Offsets

With mitigation and avoidance measures (summarised in Section 12.7), some unavoidable residual impacts remain (Table 12-26). Under the EPBC Act, proponents are required to offset the residual impacts of an action. Residual impacts due to habitat loss will be offset as per the requirements of the EPBC Act's Environmental Offsets Policy (DSEWPaC 2012b) and Offset Assessment Guide (DSEWPaC 2012c).

Refer to Section 17.9 for further detail.

12.9 Conclusions

The NRP covers an area of 293 hectares of which approximately 135 hectares is native vegetation (woodlands and heathland), 97.0 hectares is rough grassland and 5.6 hectares is drains that provides habitat for various fauna. Perth Airport has undertaken a rigorous process to assess the potential impacts to fauna from the NRP as per the requirements of Guidelines 1.1 and 1.2 under the EPBC Act. This has included a thorough review and screening of all MNES, state listed and general fauna species to identify those that are present and require detailed assessment. This resulted in identification and assessment of potential impacts (direct, indirect and off site), avoidance and mitigation and significance of residual impacts for the following.

- three species of black cockatoos protected under the EPBC Act,
- three species listed under the BC Act including the Quenda (Southern Brown Bandicoot) (Priority 4, DBCA), Rakali (Water-rat) (Priority 4, DBCA) and a native bee species (*Hylaeus globuliferus)* (Priority 3, DBCA), and
- the general fauna assemblage that meets the requirement of "Whole of Environment" fauna within Guideline 1.2.

The NRP requires the clearing and development of the total NRP area in order to facilitate the provision of an effective runway and associated infrastructure and clearances. In doing so, impacts upon the fauna assemblage are inevitable. Where possible, Perth Airport will apply appropriate management plans and mitigation efforts, as outlined in this MDP, to minimise impacts to fauna located in remaining habitats adjacent to the NRP.

13 Ground-Based Noise

This section describes the impact of noise from ground-based sources during construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What is ground-based noise and how is it measured?
- How will ground-based noise change during construction and operation of the new runway?
- How will the impacts of ground-based noise be mitigated during construction?

13.1 Introduction

This section describes the impacts of noise from ground-based sources on the community resulting from the construction and operation of the New Runway Project (NRP).

The NRP will generate ground-based noise as a result of:
- construction of the new runway,
- ground running of aircraft engines for maintenance purposes,
- changes in road traffic volumes in the area surrounding the airport,
- aircraft' use of Auxiliary Power Units (APUs), and
- taxiing of aircraft.

A study was undertaken to quantify existing noise levels at and around Perth Airport followed by the modelling of future noise levels to identify potential impacts and appropriate mitigation measures.

Additional information on construction of the new runway can be found in Section 6 and additional information on ground transport is provided in Section 18.

Noise generated by aircraft in flight or when taking off or landing is addressed in Section 22.

13.2 Key Findings

Key findings from investigations into ground-based noise include:
- The impacts from ground-based noise as a result of the NRP are naturally mitigated by the distance between operations on the airport and the nearest sensitive receivers.
- In the areas to the west of the airport, the comparison of noise levels with and without the new runway are within a few decibels for the worst-affected sensitive receivers. The difference is only just enough for a sensitive human ear to detect. To the east, sensitive receivers will experience an increase in noise, though well below the 75 dB criterion set out in the Airports (Environment Protection) Regulations 1997 (the AEPR) and consistent with the background noise level experienced in an average suburb.
- Aircraft taxiing noise will be audible in the areas adjoining the eastern boundary of the estate. However, the noise levels would be relatively low in comparison to other noise associated with operation of the airport, such as aircraft arrivals and departures.
- Changed vehicle traffic volumes as a result of the NRP will result in a noise level increase of less than one decibel during the peak hour, which is well below what is detectable by the human ear.
- As airborne noise is the dominant noise source, the cumulative impact of air and ground-based noise, when considered together will not exceed that of aircraft noise when considered in isolation.

13.3 Policy Context and Legislative Framework

13.3.1 Ground-Based Operational Noise

Ground-based operational noise at airports is regulated by the AEPR. The AEPR include specific limits for certain activities at certain times of the day. They also provide other more general principles to avoid offensive noise that intrudes on individual, community or commercial amenity.

The AEPR do not apply to noise generated by an aircraft in flight or when landing, taking off or taxiing at an airport. Noise emissions associated with these activities are regulated under other Commonwealth regulations. However, for noise assessment purposes, noise generated by aircraft taxiing is addressed in this section even though it is not considered part of the ground-based noise regulatory framework. This also reflects the general division of responsibility for noise management between Airservices and Perth Airport.

The AEPR do not directly identify applicable criteria for engine operational noise emissions. Therefore, to provide a basis for the assessment of relevant NRP noise impacts, specific noise criteria have been developed based on the Western Australian Environmental Protection (Noise) Regulations 1997 (the EPNR). While the EPNR have no application to the regulation of Commonwealth-leased airports, it does provide a basis for assessing potential noise impacts in specific circumstances, particularly as these policies address community reaction. It is important to recognise in setting these criteria that the character of noise from ground-based activities at an airport is different from the character of noise from many other developments, such as industrial developments. It is not intended that these criteria would be used for future regulation of the activities considered in this assessment.

Further, it is also important to distinguish between ground-based noise and aircraft overflight noise. When aircraft fly over a location, the resultant noise is often relatively high in level but short in duration (typically ten to 20 seconds). In contrast, taxiing is relatively continuous at a lower noise level and engine ground running occurs only occasionally, but up to 15 minutes on high power at a time. The methods of assessing ground-based noise are therefore quite different from those for overflight noise, largely because of the different human perceptions of these noise types. In Western Australia, descriptors such as L_{A10} over a period of up to four hours is primarily used. Other descriptors such as L_{A1} and L_{Amax} are also relevant. These metrics are described in Table 13-2.

13.3.2 Road Traffic Noise

There is no policy or specific noise regulation that applies to the noise impact of additional traffic on an existing Primary Regional Road or Other Regional Road in Western Australia, except where (amongst other criteria) that road is subject to a major redevelopment (State Planning Policy 5.4 – Road and Rail Noise). The NRP does not involve a major redevelopment of a regional road and therefore does not trigger assessment under State Planning Policy 5.4. However, road traffic noise has been assessed using the methodology described in Section 13.4.

13.3.3 Construction Noise and Vibration

The AEPR state that noise generated from construction, maintenance, or demolition of a building or other structure at an airport should not exceed 75 dBA $L_{10,15min}$ at the site of a sensitive receptor.

Although the AEPR apply to airport construction noise, these regulations do not fully describe the impact of the noise at potentially affected residences and on other users.

The EPNR do not assign noise levels for construction, however it recommends adoption of the following:

For noise emitted from a construction site as a result of construction work carried out between 7.00 am and 7.00 pm on any day which is not a Sunday or public holiday that the regulation does not apply provided that:

a. *the construction work was carried out in accordance with control of environmental noise practices set out in Section 4 of Australian Standard 2436-2010 Guide to noise and vibration control on construction, maintenance, and demolition sites; and*
b. *the equipment used on the premises was the quietest reasonably available; and*
c. *if the occupier was required to prepare a noise management plan under subregulation (4) in respect of the construction site —*

   i. *the noise management plan was prepared and given in accordance with the requirement, and approved by the CEO; and*
   ii. *the construction work was carried out in accordance with the noise management plan, excluding any ancillary measure.*

In the absence of an applicable Australian Standard in potential building vibration, damage is often assessed against the German Standard DIN 4150-3: 1999(R5). This standard recommends guideline values which are frequency dependent. The lowest and most conservative values of peak component particle velocity, measured in millimetres per second, are normally adopted, as shown in Table 13-1.

Type of Structure	Guideline Value, Peak Component Particle Velocity (millimetres per second)
Dwellings and buildings of similar design	5
Vibration-sensitive buildings (heritage)	3

Table 13-1 Vibration damage guideline values
Source: German Standard 1999

13.4 Methodology

13.4.1 Measurement of Noise

The volume of a sound depends on its sound pressure level, which is expressed in decibels (dB).

A-weighted decibels (dBA) are generally used for the purposes of assessment. They approximate the loudness of a sound by accounting for the varying sensitivity of the human ear to different frequencies of sound. While machines are able to measure different frequencies the same way, the human ear has a greater response to some frequencies over others. The A-weighting takes what a machine has measured and then applies different weightings to the frequencies that make up that sound. Therefore, the measurement will more strongly correlate with how the human ear responds to that sound.

Figure 13-1 shows indicative dBA noise levels for a range of situations that many people are familiar with. The figure also includes reference distances for items such as a jet departure or a passenger car. It's important to consider these when rationalising reported noise levels because sound decays with distance.

Most sounds we hear in our daily lives have sound-pressure levels in the range of 30 to 90 dBA. The sound level in a typical residential home at daytime is about 40 dBA. The average noise level of conversation is about 60 to 65 dBA. Typical levels for listening to music at home are about 70 to 75 dBA, and in a public bar 80 to 90 dBA while a loud rock concert would produce noise levels for the audience of about 110 dBA.

The difference between a sound pressure and a sound power should be noted. Sound power, also expressed in dB, is the sound level at the source of the sound. Sound pressure takes into account distance from the sound source (as well as other parameters that affect the propagation of sound such as temperature, pressure and topography). In some instances, measured sound powers were used as inputs to model the sound pressure that would be experienced by nearby sensitive receivers of noise.

In terms of long-term sound perception, two to three dBA is the minimum change in sound level that most people can detect and every 10 dBA increase in sound level is perceived as a doubling of loudness. However, individuals may perceive the same sound differently and be more or less affected by a particular sound. For example, experience shows many factors can influence an individual's response to noise, including:

- the specific characteristics of the noise, including the frequency, intensity and duration of noise events, and the time of day noise events occur,
- personal circumstances and expectations about the number, frequency, loudness and timing of noise events,
- individual sensitivities and lifestyle, such as whether they spend a lot of time outdoors or sleep with a window open,
- reaction to a new noise source (in the case of a new runway) or to changed airport operational procedures,
- understanding of whether the noise is avoidable and their notions of fairness, and
- attitudes towards the source of the noise (e.g. general views about aviation activities and airports).

When communicating the impact of noise, specific metrics are used to account for the fact that the decibel level, not just decibel only describes the intensity of noise. To describe noise in a way that is more relevant to affected communities, it is necessary to consider how often a particular decibel level occurs as well as the duration of a noise event. This is achieved by the metrics described in Table 13-2.

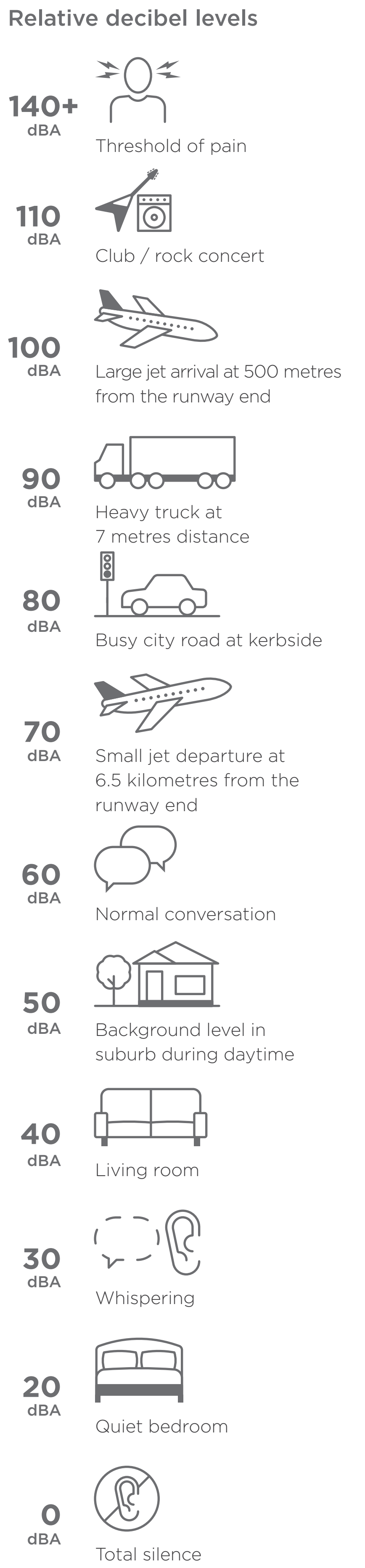


Figure 13-1 Indicative A-weighted decibel noise levels in typical situations
Source: Wilkinson Murray

Noise Metric	Description
L_{A1}	The decibel level exceeded for one per cent of the time. As this noise level is only exceeded one per cent of the time it is indicative of the maximum noise level that can be expected due to an individual noise event such as the occasional pass-by of a heavy vehicle. This metric is often used for assessment of sleep disturbance.
L_{A10}	The decibel level exceeded for ten per cent of the representative sample time.
$L_{A10,15min}$	The decibel level exceeded for ten per cent over a 15-minute sample time.
L_{A90}	The decibel level exceeded for 90 per cent of the representative sample time. This is normally taken as the background noise level.
L_{Aeq}	When a noise varies over time, the L_{Aeq} is the equivalent, constant sound which would contain the same sound energy as the time-varying sound. Sounds in the real world are complex, with huge fluctuations in frequency, amplitude and timbre over time. The L_{Aeq} provides a way to describe these sounds in terms of a simpler, more easily conceived sound.
L_{Amax}	The absolute highest decibel level recorded during the representative sample time. This is similar to, but distinct from, the L_{A1} in that this noise level may only occur for an arbitrarily short amount of time, regardless of the duration of the representative sample period.

Table 13-2 Noise metrics
Source: Wilkinson Murray

Figure 13-2 shows a typical graph of sound pressure level versus time with the above metrics annotated.

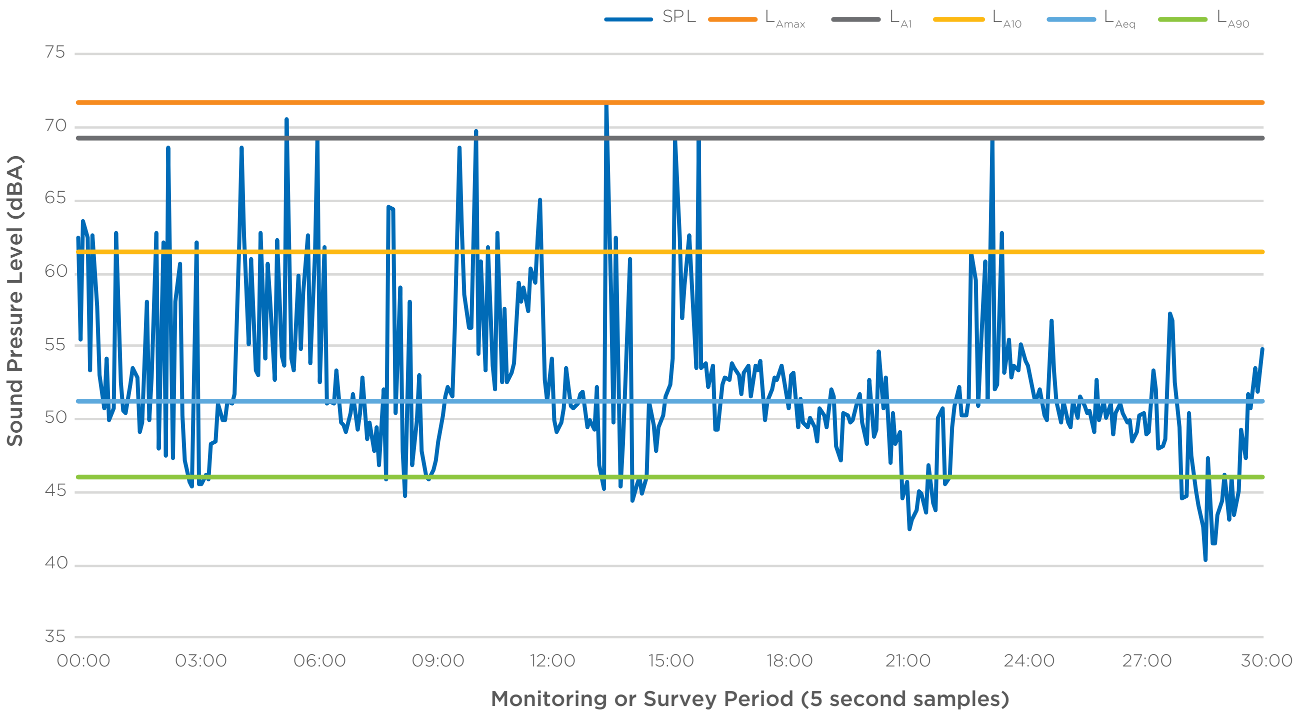


Figure 13-2 Typical graph of sound pressure versus time
Source: Wilkinson Murray

13.4.2 Significance Criteria

Significance criteria have been used to assess the potential impacts that may arise from the project with respect to ground-based operational, construction and road-traffic noise associated with the new runway. The significance criteria in Table 13-3 have been derived from the generic criteria provided in Section 8.

Magnitude description	Specialist Criteria
Major Adverse	Not applicable.
High Adverse	Operational and construction noise levels are predicted to regularly exceed established noise criteria by more than ten dBA. Mitigation measures may ameliorate some of the impacts on receivers, however mitigation of any form is unlikely to remove all adverse effects.
Moderate Adverse	Operational and construction noise levels are predicted to exceed established noise criteria by between five to ten dBA or occasionally by more than ten dBA. Exceedances of this magnitude will require careful management by implementation of procedures included in the Operational Management Plan and, where practical, physical noise control. Mitigation measures may ameliorate some of the impacts on receivers.
Minor Adverse	Operational and construction noise levels are predicted to exceed established noise criteria by up to five dBA. Exceedances of this magnitude may be manageable by implementation of procedures included in the Operational Management Plan.
Negligible	Operational and construction noise levels are not predicted to exceed established criteria. Minimal impact on sensitive receivers.
Beneficial	The project results in improvement to current noise exposure of catchment areas.

Table 13-3 Significance criteria – ground-based and construction noise
Source: Wilkinson Murray

13.4.2.1 Ground-Based Operational Noise

While the AEPR provide a regulatory approach for the management of ground-based operational noise they are not intended to provide a basis for the assessment of the impact caused by such noise. Nor do they set criteria for aircraft engine noise or other ground-based operational noise. Specific noise criteria for this assessment were developed based on the EPNR.

The EPNR stipulate the allowable noise levels at any noise-sensitive premises from other premises. Tending to be more holistic in nature, the regulations address the potential for multiple noise sources to contribute to the overall noise impact on any one premises. The allowable noise level is determined by the calculation of an influencing factor (IF), which is added to the baseline criteria set out in the EPNR. The baseline assigned noise levels are listed in Table 13-4.

Premises Receiving Noise	Time of Day	Assigned Level (dBA)		
		$L_{A\,10}$	$L_{A\,1}$	$L_{A\,max}$
Noise sensitive premises	7.00 am – 7.00 pm Monday to Saturday	45 + IF	55 + IF	65 + IF
	9.00 am – 7.00 pm Sunday and Public Holidays	40 + IF	50 + IF	65 + IF
	7.00 pm – 10.00 pm all days	40 + IF	50 + IF	55 + IF
	10.00 pm on any day to 7.00 am Monday to Saturday and 9.00 am Sunday and Public Holidays	35 + IF	45 + IF	55 + IF
Commercial premises	All Hours	60	75	80
Industrial premises	All hours	65	80	90

Note IF = Influencing factor

Table 13-4 Baseline assigned outdoor noise levels
Source: Environmental Protection (Noise) Regulations 1997

It is a requirement of the EPNR that received noise be free of the annoying characteristics set out in Regulation 9. These characteristics are tonality, modulation and impulsiveness. They have highly technical definitions; though it is sufficient to know that their presence can exacerbate the impact of noise beyond merely the dBA level. Where these characteristics are present and cannot be practicably removed, the adjustments as shown in Table 13-5 are made to the measured or predicted level at other premises.

Where tonality is present	Where modulation is present	Where impulsiveness is present
+ 5 dB	+ 5 dB	+ 10 dB

Table 13-5 Adjustments for annoying characteristics (Influencing Factors)
Source: Environmental Protection (Noise) Regulations 1997

The assigned outdoor noise levels for sensitive residential receivers and receivers such as school classrooms, hospital wards and places of worship in each catchment area are shown in Table 13-6.

These are based on the receivers that are nearest the airport in each Noise Catchment Area (NCA) and are located adjacent to transport or commercial/industrial areas from which annoying characteristics may arise.

The influencing factors (IF) described above are incorporated into these levels.

Refer to Figure 13-3 for the location of catchment areas.

Receiver NCA	Influencing Factor (IF)	Time of Day	Assigned Level (dBA)* Outdoor Noise Level for Sensitive Receivers		
			L_{A10}	L_{A1}	L_{Amax}
CA1	8	Day	53	63	73
		Sunday / Public Holiday day period	48	58	73
		Evening	48	58	63
		Night	43	53	63
CA2	10	Day	55	65	75
		Sunday / Public Holiday day period	50	60	75
		Evening	50	60	65
		Night	45	55	65
CA3	17	Day	62	72	82
		Sunday / Public Holiday day period	57	67	82
		Evening	57	67	72
		Night	52	62	72
CA4	0	Day	45	55	65
		Sunday / Public Holiday day period	40	50	65
		Evening	40	50	55
		Night	35	45	55
CA5	6	Day	51	61	71
		Sunday / Public Holiday day period	46	56	71
		Evening	46	56	61
		Night	41	51	61
CA6	13	Day	58	68	78
		Sunday / Public Holiday day period	53	63	78
		Evening	53	63	68
		Night	48	58	68
CA7	7	Day	52	62	72
		Sunday / Public Holiday day period	47	57	72
		Evening	47	57	62
		Night	42	52	62
CA8	9	Day	47	57	67
		Sunday / Public Holiday day period	42	52	67
		Evening	42	52	57
		Night	37	47	57
CA9	9	Day	54	64	74
		Sunday / Public Holiday day period	49	59	74
		Evening	49	59	64
		Night	44	54	64

* The representative assessment period means a period of time of not less than 15 minutes, and not exceeding four hours, determined by an inspector or authorised person to be appropriate for the assessment of a noise emission, having regard to the type and nature of the noise emission.

Table 13-6 Assigned outdoor noise levels (nearest sensitive receivers in catchment areas)
Source: Environmental Protection (Noise) Regulations 1997 and Wilkinson Murray

Sensitive receivers inside the catchment areas that are not adjacent to transport, commercial or industrial areas would have an assigned level where the IF is zero. The night time noise criteria are generally the most stringent criteria for the airport ground-based operational noise because ambient noise levels will generally be lower than those during the day and evening and the applicable noise criteria for a given noise-generating event will also be lower. These criteria vary according to the location and are currently in the range 35 to 53 dBA.

The EPNR also recommend assigned outdoor noise criteria for other receiver types potentially affected by ground-based noise from the NRP. The external criteria for these other receiver types are shown in Table 13-7 and apply during normal use, that is generally at daytime only, but also at night in the case of areas such as hospital wards.

In addition, EPNR Regulation 7 subregulation 1 states:
Noise emitted from any premises or public place when received at other premises –
(a) must not cause, or significantly contribute to, a level of noise which exceeds the assigned level.

For the purposes of subregulation (1)(a), a noise emission is taken to significantly contribute to a level of noise if the noise emission as determined under subregulation (3) exceeds a value which is five dB below the assigned level at the point of reception.

Therefore, if noise from the airport received at a premises is five dBA or more below the assigned noise level, then noise received at that premises is considered to be not 'significantly contributing' and deemed to comply with the requirements of the EPNR regardless of any other noise received at that premises from other sources.

The assigned noise levels discussed above apply to relatively continuous L_{A10} descriptor noise, such as that produced by taxiing and APU operation. In addition, noise objectives for intermittent noise as described by the L_{A1} and L_{Amax} are defined in the regulations. However, given the nature of operations and the distance between the taxiways and aprons to surrounding sensitive receivers, it is the L_{A10} assigned noise levels that are of relevance when assessing noise impact of ground operations.

13.4.3 Modelling

Noise levels from the ground-based sources have been forecast using the Environmental Noise Model (ENM). ENM is the widely used and accepted computer-based, environmental noise model which allows calculation of noise levels from a series of noise sources into the surrounding area. It considers the noise level of the noise sources, distance attenuation, air absorption, ground effects, shielding by intervening buildings and topography, and the effects of specific weather conditions. For this assessment, the model was prepared to incorporate the topography surrounding the airport, the expected final landform of the estate, and future buildings on the estate.

Newer generation aircraft, such as the Boeing 787 and the Airbus A350, generate less noise than traditional aircraft. However, to ensure all predictions are conservative, no allowance has been made for any potential reduction in aircraft-noise levels over time. The predictions discussed are based on known aircraft noise levels.

13.4.3.1 Validation and Calibration

To validate and calibrate the ENM computer model, real-time noise loggers were placed in six locations around the estate to record the existing level of noise. This also allowed a baseline noise level that the predicted noise levels can be compared to. Noise loggers were hosted in nearby residences in their front or backyards.

Noise loggers were placed at free-field locations on the side of the house or building towards the new runway location. This is so the loggers are not recording a noise level that has been attenuated by a structure in between itself and the airport. A free-field location is one where no sound reflections occur so the noise is recorded as it is received directly from the source. This generally means the recording equipment was placed on surfaces that absorb sound fairly well; grass, sand etc. This means that reflected noise is not recorded, thereby overestimating the noise in the environment. The noise-monitoring equipment used for these measurements consisted of environmental noise loggers set to A-weighted (see Section 13.4.1), fast response, and continuous monitoring over 15-minute sampling periods and remained in-situ for approximately one week. This equipment is capable of remotely monitoring and storing noise-level descriptors for later detailed analysis. The equipment was calibrated before and after the survey to ensure the accuracy of observations. No significant drift in the level of noise was noted, indicating that the loggers measured noise levels consistently and accurately.

For the locations of the noise loggers and the outcome of these measurements see Section 13.5.3.

Type of Receiver NCA	Time of Day	Assigned Level (dBA)		
		L_{A10}	L_{A1}	L_{Amax}
Commercial	All hours	60	75	80
Industrial	All hours	65	80	90

Table 13-7 Assigned outdoor noise level for other receiver types
Source: Environmental Protection (Noise) Regulations 1997

13.4.3.2 Baseline Airport Operations

To determine a baseline, aircraft movements for 2016 were used to model the noise impact associated with the current level of operations. This provides a reference to compare the forecast noise exposure in future years to. Although this data refers to landing and taking off, the amount of aircraft taxiing can be inferred from this because the routes from aircraft parking position to runway end are well understood. For the modelling of engine ground running actual data was available.

To predict future levels of ground-based noise, forecast aircraft movements up to 2045 were used. Separate forecasts were provided for both the with and without the runway scenarios. Without the new runway, the capacity of the airfield will be constrained and the separate forecasts reflect this. For this reason, the without runway scenario was only modelled for 2025 and not 2045. By comparing the two scenarios, the ground-based noise impact that is directly attributable to the new runway can be measured.

13.4.3.3 Weather Effects

Forecasting of ground-based noise involves assessment under acoustically neutral and typical worst-case conditions that exacerbate the noise impact on nearby sensitive receivers. This includes assessment of the typical worst case 15-minute period; in those cases where the noise level varies with time, and assessment under worst-case meteorological conditions. Worst-case meteorological conditions consider what is known as a temperature inversion.

Normally, hot air will cool as it rises and then fall back down. This can lead to layers of air in the lower atmosphere at different temperatures. The warmer the air, the faster the sound travels. When a sound wave moves from a warm layer of air to a higher, colder layer of air it can be bent (refracted) away from the earth as it slows down.

Under a temperature inversion, the warmer layer of air is situated above the colder layer of air and sound waves are instead bent towards the earth. This results in a higher level of noise, further away than would normally be experienced. It is under these conditions that the environmental noise model was prepared.

13.4.3.4 Modelling Assumptions - Ground-Based Operational Noise

Aircraft Taxiing

Aircraft taxiing has been assumed to be a function of the total aircraft movements for a year.

A typical weekday and typical weekend was calculated based on the average number of movements on each individual taxiway over a one year period. The number of movements on each taxiway was based on existing operational data for 2016 and forecast operational data for the year 2025 and 2045. Again, to be conservative it is assumed each aircraft taxis from its assigned terminal to the furthest point of the runway and vice versa. However, in reality, aircraft can choose an intersection departure or arrival, where they enter or exit the runway earlier than the runway end.

Sound power levels were assigned to each movement based on the type of aircraft. The average sound power level per meter for each taxiway was applied as a line source along its full length. The sound power levels assigned to various aircraft were arrived at through research, testing and observations at Brisbane Airport. Measurement involved the recording of maximum noise levels as aircraft taxied past the measurement location. This was then used to calculate the sound power level of the moving source.

Table 13-8 shows the measured results of the highest energy mean level that was adopted for each aircraft type. Other aircraft were grouped into these five categories based on similar size, engine type and configuration. Although there are no Boeing 747 operations at Perth Airport large long-haul aircraft are all categorised into this group.

APU Usage

An Auxiliary Power Unit (APU) is a turbine that is used to produce electricity for an aircraft when a fixed ground-power unit (fGPU) is not available. It is fundamentally the same machine as a jet engine used for flight, but the movement is used to create electricity rather than thrust. They also provide the electricity used to start jet engines.

APU noise has been calculated based on the worst case one hour period for morning, afternoon, and evening.

In the case of APUs, a sound power level of 118 dBA was used. This was based on noise measurements at Brisbane Airport. This considers a total of ten aircraft standing at each point over the period with one being a Boeing 767 at 125 dBA and the rest being Boeing 717's at 115 dBA. Table 13-9 presents these levels.

The modelling assumed future APU sites and taxiways as shown in Figure 13-3.

Aircraft Type	Sound Power Level, dBA	
	Individual Measurement	Energy Mean
Boeing 747 (all types)	137, 134, 136, 142	138
Boeing 737 (all types)	126, 126, 139	135
Boeing 717	120	120
Airbus A330	129	129
Boeing 777	132	132

Table 13-8 Taxiing sound power levels
Source: Wilkinson Murray

Aircraft Type	Composite Sound Power Level, dBA
Boeing 767	125
Boeing 717	115
All others	119

Table 13-9 Auxiliary power unit sound power levels
Source: Wilkinson Murray

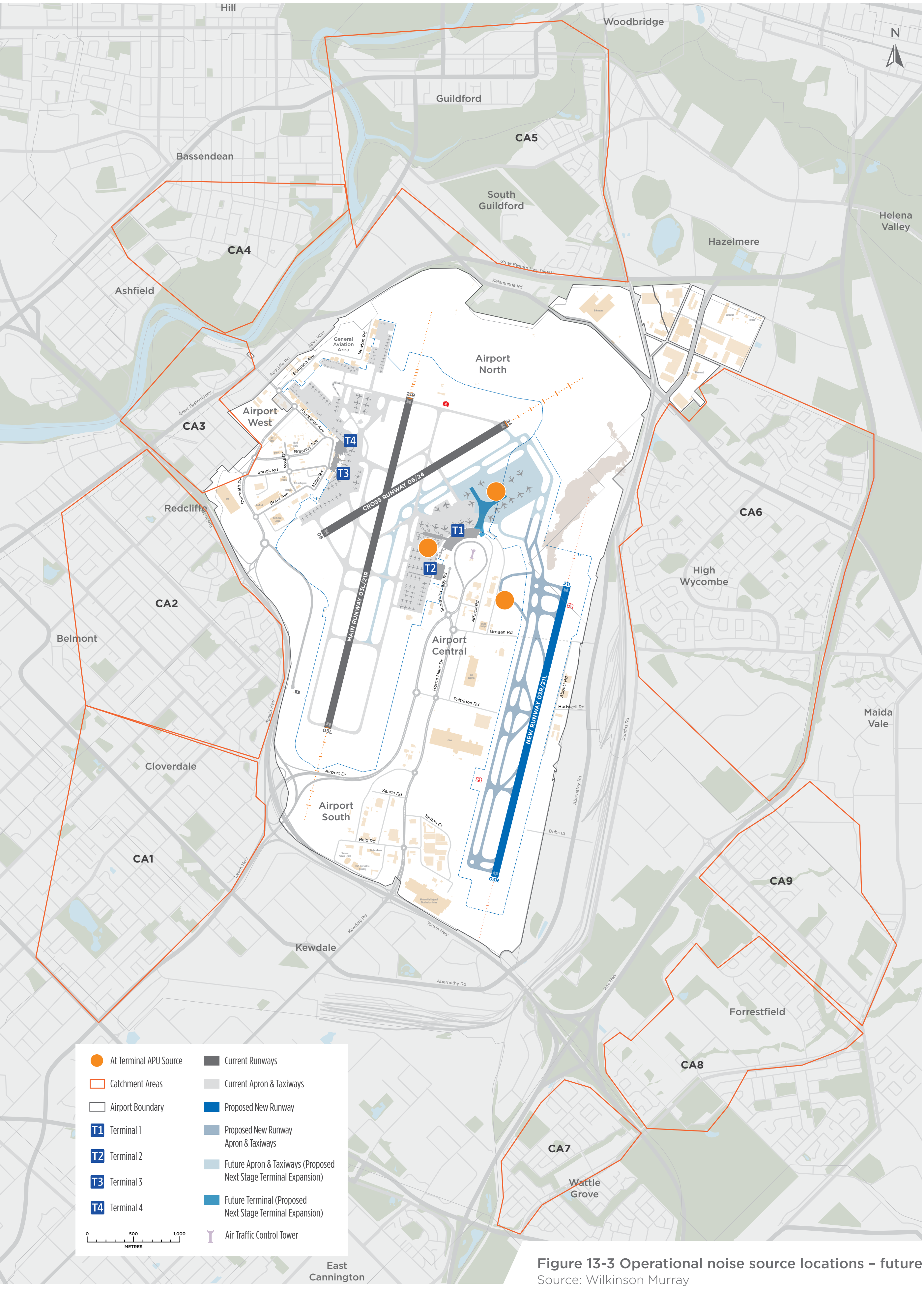


Figure 13-3 Operational noise source locations – future
Source: Wilkinson Murray

Engine Ground Running

An essential safety measure following maintenance of aircraft is to perform ground-based engine testing, known as Engine Ground Running (EGR). For modelling purposes, it was assumed that a high-power engine run would occur for no more than 15 minutes in any night.

Relocation of the primary EGR location is not proposed as part of this MDP.

Taking a conservative approach to allow for a range of orientations, it has been assumed for modelling purposes that the noise source would be omnidirectional.

To present an envelope of potential noise impact, typical L_{A10} noise levels from EGR at surrounding residential receivers were modelled for the Dash 8-300 (DH8C) and Fokker 100 (F100). These are two of the most common and representative aircraft used in EGR at Perth Airport.

It is noted that currently there is no EGR of large aircraft at Perth, this situation is not expected to change in the future.

The sound pressure levels at 110 metres away for each aircraft are presented in Table 13-10 (based on analysis of EGR measurements and audio recordings). They were used as starting points to model the noise impact for nearby catchment areas. Catchment areas are discussed in Section 13.5.

Aircraft Type	Octave Band Frequency Hertz								
	63	125	250	500	1000	2000	4000	8000	A
Fokker F100	90	92	86	79	86	83	86	78	91
Dash 8-300	86	87	84	81	81	78	79	72	86

Table 13-10 Typical Perth engine ground running L_{A10} sound pressure levels at 110 metres dBA
Source: Wilkinson Murray

Table 13-10 breaks the noise down into its amplitudes at various pitches (frequencies). The "A" column indicates how loud the noise would appear to the human ear.

The ENM modelled the impact of this noise on surrounding catchment areas.

Weather Conditions

Ground-based noise levels were forecast for both acoustically neutral and adverse weather conditions that exacerbate the noise impact on nearby sensitive receivers. Adverse weather conditions assume either that there will be a temperature inversion in the atmosphere around Perth Airport or a given noise catchment area will be downwind of the noise source, whichever is worst.

In reality, the noise level that is forecast for adverse weather conditions will only occur for a small percentage of the time. The percentage of time that each catchment area would be downwind of a ground-based noise source is demonstrated in Table 13-11.

Catchment Areas	Occurrence of Downwind Conditions				
	Annual (per cent)	Summer (per cent)	Autumn (per cent)	Winter (per cent)	Spring (per cent)
CA1	5	3	6	9	5
CA2	3	2	3	3	3
CA3	3	2	4	3	4
CA4	5	4	7	4	7
CA5	5	4	6	3	6
CA6	2	1	2	2	2
CA7	2	1	3	3	2
CA8	1	1	2	2	1
CA9	1	0	1	1	1

Table 13-11 Percentage of night time hours under downwind conditions
Source: Wilkinson Murray

Temperature inversions are far more common during night time hours than during the day. The noise levels modelled for a temperature inversion can be expected to occur around Perth Airport for approximately 30 per cent of night time hours.

13.4.3.5 Modelling Assumptions - Road Traffic Noise

Data on traffic volumes from WA Main Roads was correlated with data from the survey of the existing noise environment.

Noise levels at the façade of residences has been forecast using the Calculation of Road Traffic Noise (CORTN) traffic-noise prediction technique.

The predicted L_{A10} traffic noise levels were calculated based on the following assumptions:

- facade reflection is a maximum of 2.5 dBA,
- road surface is composed of open grade asphalt, and
- average vehicle speed is 70 kilometres per hour.

13.4.3.6 Modelling Assumptions - Construction Noise and Vibration

The exact details of each construction stage would be established by the successful construction contractors. However, a broad construction methodology was generated and, based on this information, appropriate construction scenarios have been developed.

For construction noise and vibration impacts, an assessment has been made on the assumption of a four-year construction period with six months of commissioning. The majority of the work being completed six days a week between 7.00 am and 7.00 pm.

There are two acoustically significant stages of construction assumed for this assessment:

- bulk earthworks, and
- paving construction.

The bulk earthworks stage is expected to be the noisiest. Table 13-12 provides a summary of typical sound power levels (at source) of the plant which may be used during this stage. Sound pressure levels at seven metres away are also provided. These nominal levels were measured in previous experiments.

Plant	Sound Power Levels (dBA) – Noise at Source	Sound Pressure Levels (dBA) at Seven Metres
Caterpillar 657 Scraper	118	93
Caterpillar 825 Compactor	108	83
Caterpillar 966 Loader	114	89
Caterpillar D11 Bulldozer	120	95
Caterpillar D8 Bulldozer	110	85
30,000 litre Water Truck	103	78
200 tonne Excavator	117	92
30 tonne Excavator	105	80
Dump Truck	105	80
Moving Floor Truck	105	80
B-double Truck	105	80
Concrete Truck	105	80
16' Grader	111	86
14' Grader	109	84
Bobcat	103	78
Pad Foot Roller	104	79
Smooth Drum Roller	105	80
Multi-tyre Roller	100	75
Gravel Paver	109	84
Asphalt Paver	109	84
Paver Train	110	8
Concrete Cutting	115	90
Concrete Batch Plant	110	85
Asphalt Batch Plant	114	89

Table 13-12 Typical construction sound-power levels and sound-pressure levels
Source: Wilkinson Murray

The likely fleet of equipment required for the bulk earthworks phase of construction is shown in Table 13-13 and for the paving phase in Table 13-14

Description	Equipment	Quantity
Bulk Earthworks • North-West Sector • Central Sector • South-West Sector	Caterpillar 657 Scrapper	8
	D11 Bulldozer	4
	200 tonne Excavator	3
	50 tonne Dump Truck	15
	Caterpillar 825 Compactor	7
	30,000 litre Water Cart	7
	16 foot Grader	7
	Pad Foot Roller	7
	Smooth Drum Roller	7

Table 13-13 Construction noise scenario for bulk earthworks
Source: Wilkinson Murray

Description	Equipment	Quantity
Paving Works • North-West Sector • Central Sector • South-West Sector	Paving machine Asphalt	2
	Paving machine Concrete	1
	Saw Cutter	2
	Dump Trucks	13 (25 tonne), 24 (Tippers)
	Pug Mills	1
	Concrete Plant	1
	Asphalt Plant	1
	Rollers	4
	Bulldozer	7
	Loaders	10
	Excavators	6
	Water Trucks	7
	Concrete and asphalt trucks	11
	Graders	10

Table 13-14 Construction noise scenario for paving construction
Source: Wilkinson Murray

For the purposes of this assessment, it is assumed that bulk earthworks and paving would occur in three areas of the NRP area in summer and winter times: north-west sector, central sector and south-west sector. The equipment shown in Table 13-13 and Table 13-14 has been assumed to operate in one sector at a time.

The ENM was used to predict construction noise levels in the surrounding catchment areas. In the case of construction noise, a tenth percentile noise level for summer and winter periods was used. The tenth percentile is the construction noise level that is exceeded for ten per cent of the time taking weather conditions into account. Calculations were based on ten years of one-hourly weather data to ensure the predictions are specific and accurate for the actual conditions expected for each site.

13.5 Existing Condition

13.5.1 Ground-Based Operational Noise

The source of existing ground-based noise are:

- engine ground running,
- use of auxiliary power units, and
- aircraft taxiing.

13.5.1.1 Engine Ground Running

Perth Airport does not have major airline-maintenance facilities and so has less ground running than other major airports such as Sydney, Brisbane and Melbourne. There is, however, a continuing requirement for airlines to carry out EGR at Perth Airport.

A typical EGR consists of a period of running the engine at idle power: a short full power run of the engine; or a combination of both. When possible, aircraft are oriented into the wind to mitigate the noise impact on downwind receptors. Perth Airport has in place an EGR Management Plan that sets out the rules and procedures established to reflect the characteristics of Perth Airport and limit the impacts of engine testing. The plan also outlines restrictions on the power setting and the time period of an EGR, details regarding locations, time of day and duration; as well as the approval process for an EGR to occur. There is currently one primary EGR location identified at Perth Airport as shown in Figure 13-4. Extensive records are kept of each EGR including the date of the run, the type of aircraft, the site of the running, the aircraft heading, the number of engines running, the time of each running and the power settings used.

Historically, the EGR Management Plan has been successful, with Perth Airport receiving very few noise complaints that can be attributed to a recorded instance of EGR. All EGR are recorded at Perth Airport in line with the EGR Management Plan.

The two most common aircraft that undergo EGR at Perth Airport are the Dash 8-300 and Fokker F100. Current EGR noise generally occurs intermittently during the night.

13.5.1.2 APU and Aircraft Taxiing

Most aircraft operating at Perth Airport will have an APU, though fGPU is available at most bays.

APUs are sometimes preferred by airlines. Additionally, fGPU is not available at stand-off bays. The existing location of APUs is shown in Figure 13-5.

The existing ground-based noise situation was modelled based on movements from 2016 and can be visualised in Figure 13-6 and Figure 13-7.

13.5.2 Road Traffic Noise

There are no specific noise regulations or criteria in Western Australia that address the noise impact of additional traffic on an existing highway. As such, there is no data from road traffic-noise monitoring for the major roads in the vicinity of the airport.

Road-traffic noise contributes to the overall ambient noise.

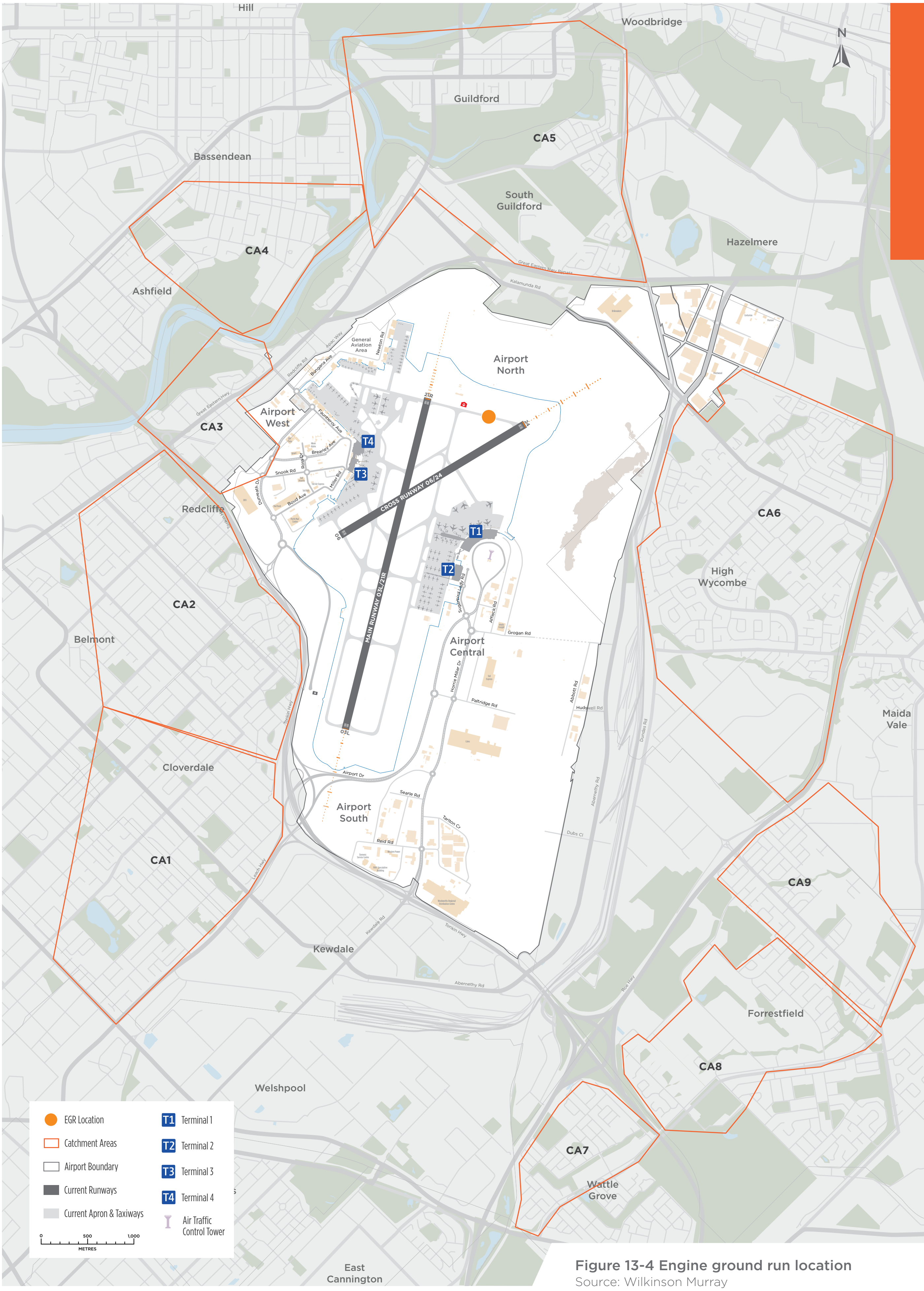


Figure 13-4 Engine ground run location
Source: Wilkinson Murray

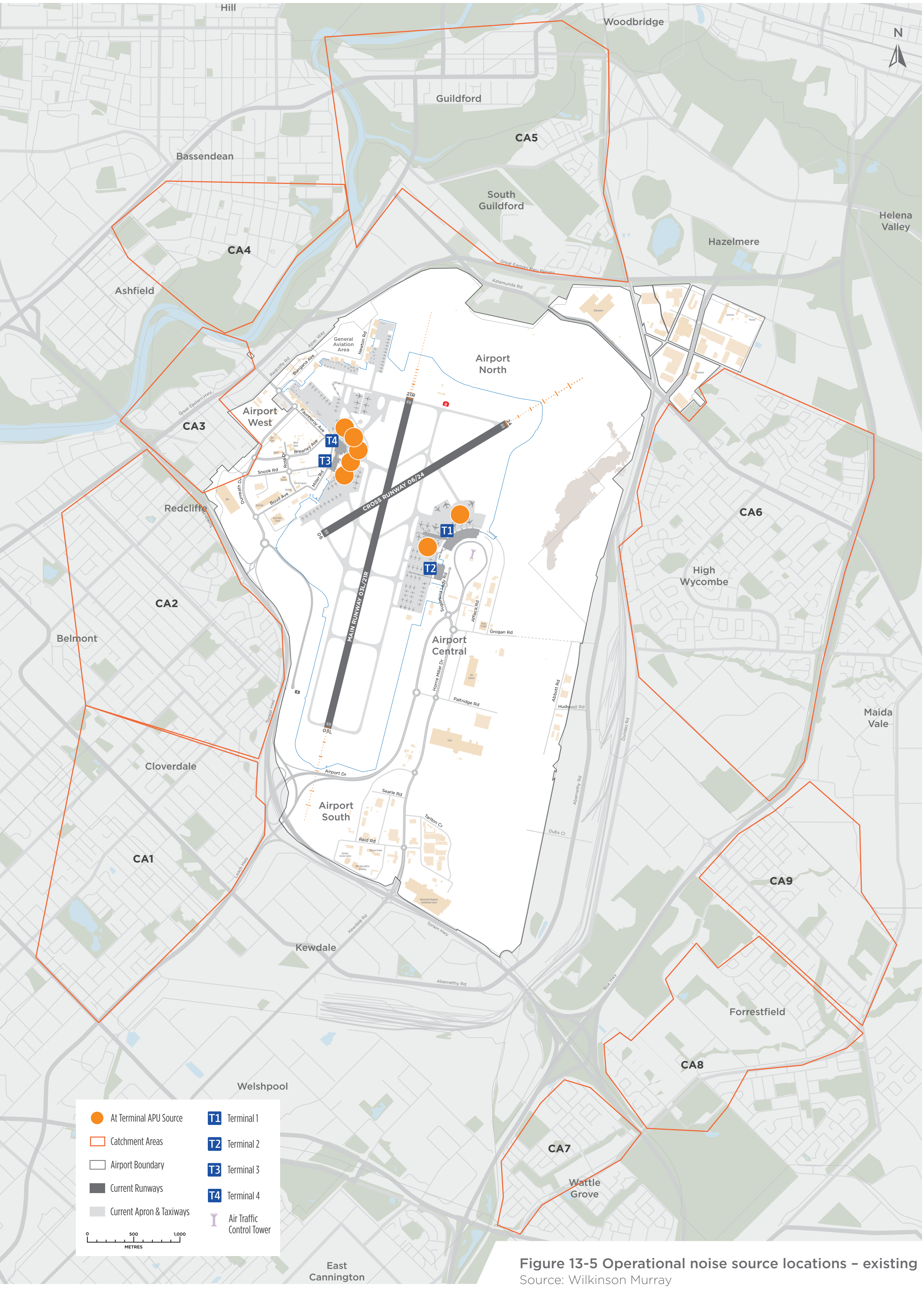


Figure 13-5 Operational noise source locations – existing
Source: Wilkinson Murray

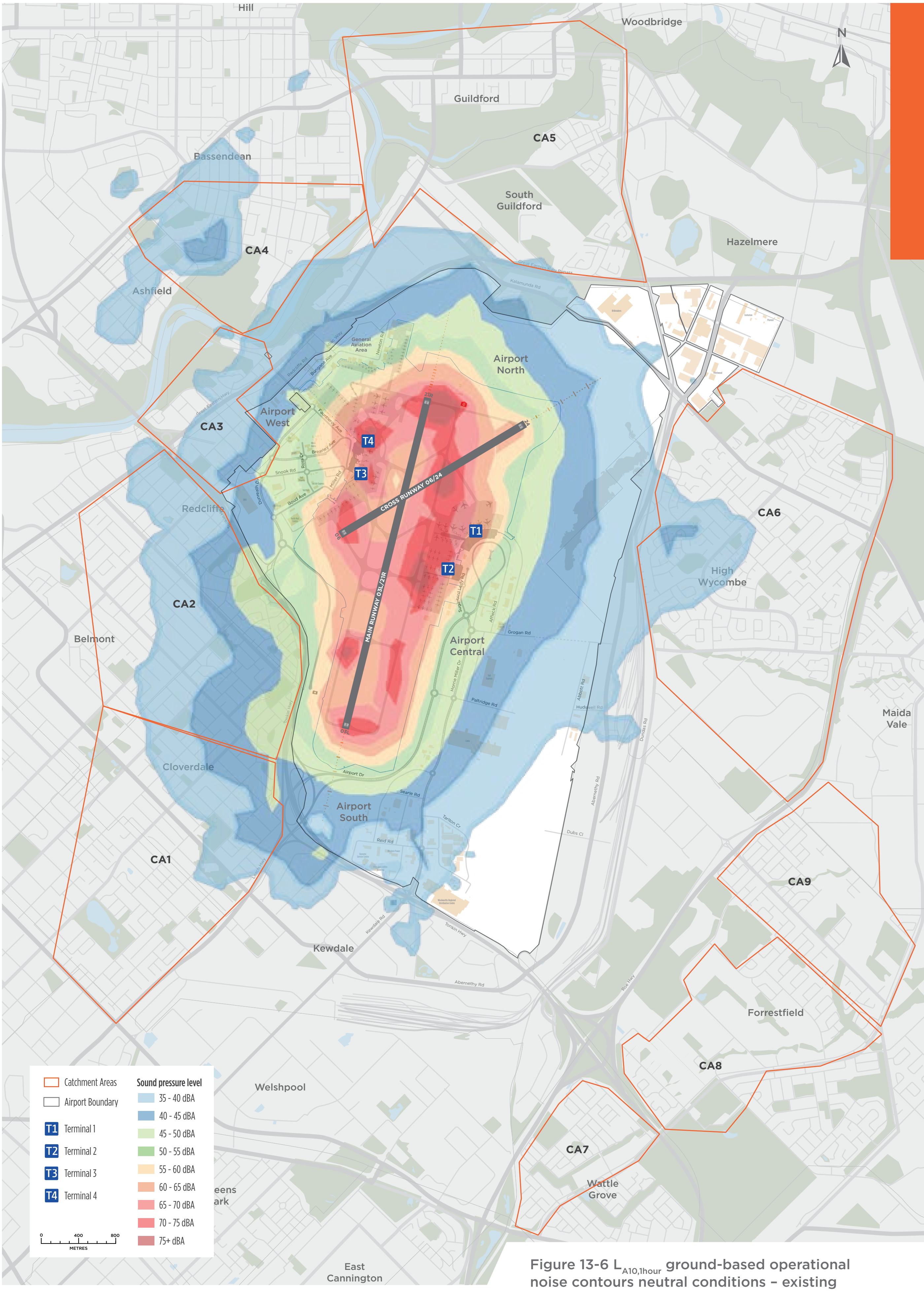


Figure 13-6 $L_{A10,1hour}$ ground-based operational noise contours neutral conditions – existing
Source: Wilkinson Murray

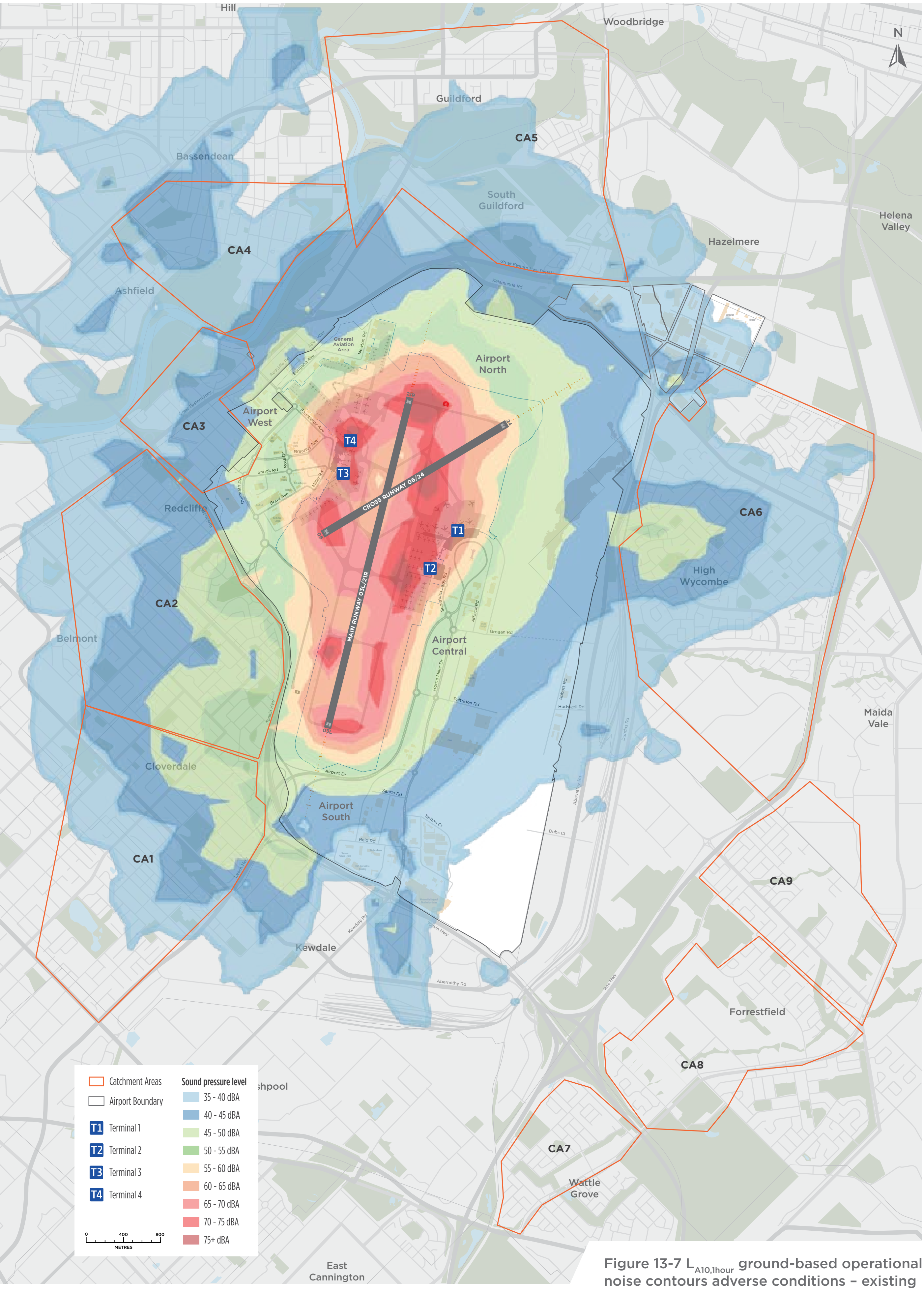


Figure 13-7 $L_{A10,1hour}$ ground-based operational noise contours adverse conditions – existing

Source: Wilkinson Murray

13.5.3 Ambient Noise

Ambient, or background, noise levels have been measured at a number of locations around the site. In March 2015 at four locations; and in June 2017 at one repeat location and three additional locations. The 2017 measurements were conducted to the north and east of the NRP area. The locations are shown in Figure 13-8. These measurements were carried out in accordance with Australian Standard 1055:1997. For details of how the noise measurements were deployed see Section 13.4.3.1.

Potentially noise-sensitive receivers such as residences have been grouped in nine catchment areas; CA1 to CA9. These areas have been defined to cover the large range of areas of receivers around the estate. The catchment areas are described in Table 13-15 and shown in Figure 13-8. M3 and M5 are the same location measured two years apart. By comparing these two measurements it was ensured that the noise loggers' measurements are reproducible.

Catchment areas were based on current residential and other noise sensitive land uses. Information about the exposure of future residential and noise sensitive land uses to ground-based noise has not been calculated for this MDP, though the impact can be inferred from the relevant noise heatmaps.

Noise levels that exceed the criteria in Table 13-6 by more than 10 dBA were measured in CA4 (Bassendean) and CA5 (South Guildford). Under the definition in Table 13-3 this would be considered highly adverse. It should be noted that the criteria this is based on arises from the EPNR, which do not apply to Commonwealth-leased airports. Additionally, the influencing factor for these two catchment areas is minimal or zero in the case of Bassendean due to the absence of industrial or commercial sites in the area. This leads to more stringent criteria. Noise events in this area may also be correlated with aircraft noise from overflight, which is addressed in Section 22.

Noise levels that exceed the criteria in Table 13-6 by more than 5 to 10 dBA were measured in CA1 (Cloverdale), CA2 (Redcliffe/Belmont), and CA8 (Forrestfield), though only for the night period. Under the definition in Table 13-3 this would be considered moderately adverse.

Noise Catchment Area	Direction from Airport	Description	Noise Monitoring Location
CA1	South-West	Cloverdale residential area bounded by the Tonkin Highway	M1, M2
CA2	West	Redcliffe and Belmont residential area bounded by the Tonkin Highway	M1, M2
CA3	North-West	Redcliffe residential area bounded by the Tonkin Highway	M1, M2
CA4	North-West	Bassendean bounded by the Swan River	M3, M4, M5
CA5	North	South Guildford bounded by the Great Eastern Highway Bypass	M3, M4, M5
CA6	East	High Wycombe bounded by Abernethy Road	M6, M7
CA7	South	Wattle Grove bounded by the Tonkin and Roe Highways	M8
CA8	South-East	Forrestfield bounded by the Roe Highway	M8
CA9	South-East	Forrestfield bounded by the Roe Highway	M8

Table 13-15 Noise catchment areas
Source: Wilkinson Murray

The results of the noise logging were processed to determine ambient L_{A10} (see Table 13-16) and L_{A90} (see Table 13-17) noise levels for each period of the day.

The L_{A10} noise levels can be considered typical maximum noise levels, while the L_{A90} noise level is representative of background noise levels during each period of the day.

Monitor	Day (7.00 am – 7.00 pm)	Evening (7.00 pm – 10.00 pm)	Night (10.00 pm – 7.00 am)
M1	55	52	52
M2	56	50	49
M3	59	58	55
M4	58	55	51
M5	60	54	54
M6	48	49	44
M7	47	44	45
M8	50	46	43

Table 13-16 Measured L_{A10} (average) noise levels dBA
Source: Wilkinson Murray

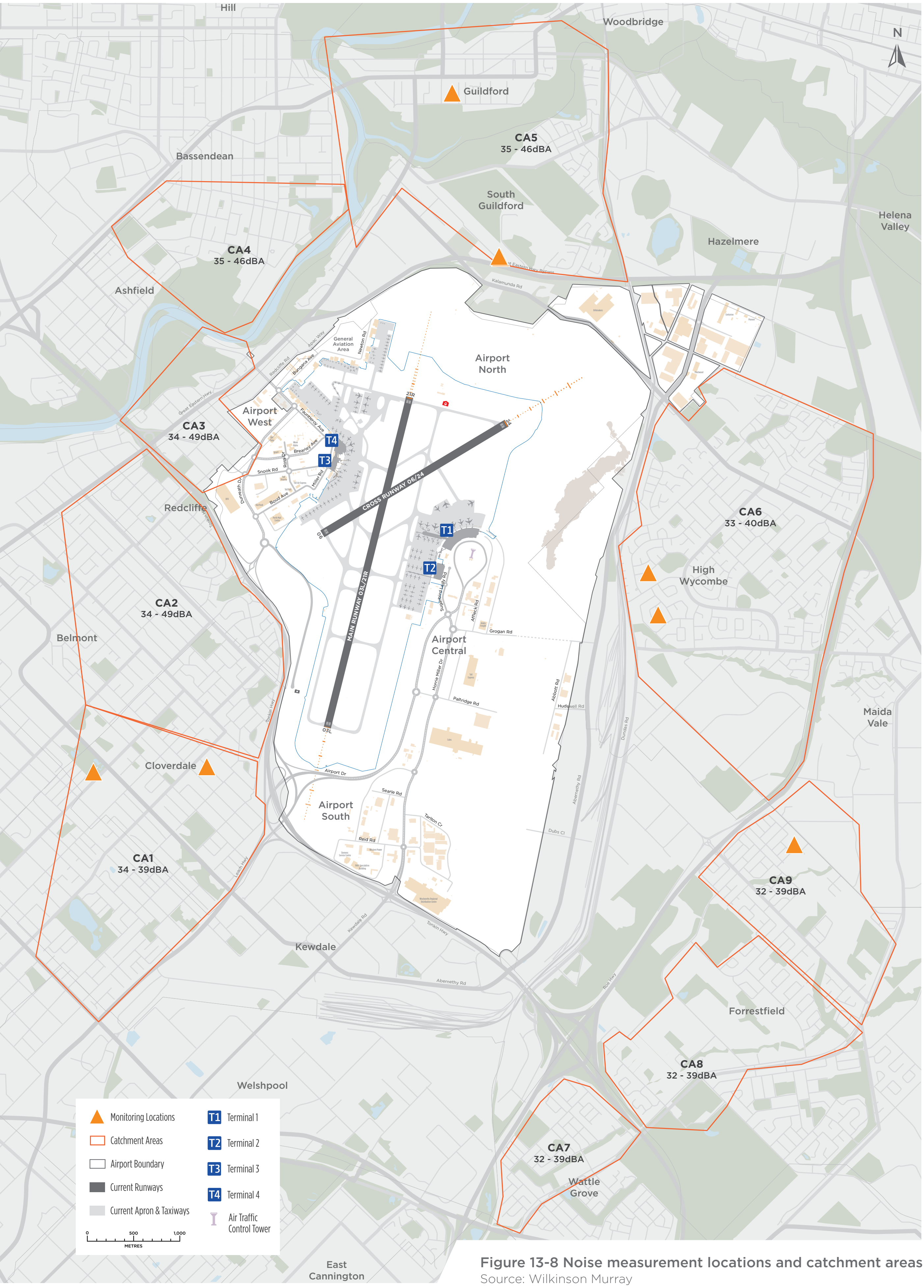


Figure 13-8 Noise measurement locations and catchment areas

Source: Wilkinson Murray

Note: Background noise level indicated for each catchment area

These noise levels can be put into context through comparison to the assigned noise levels as per the EPNR found in Table 13-6. Although these criteria, derived from the EPNR, are exceeded in most cases, it is most often only a minor impact, see Table 13-3.

Monitor	Day (7.00 am – 7.00 pm)	Evening (7.00 pm – 10.00 pm)	Night (10.00 pm – 7.00 am)
M1	49	49	48
M2	38	37	34
M3	45	46	38
M4	46	42	35
M5	44	46	38
M6	38	40	35
M7	36	37	33
M8	39	38	32

Table 13-17 Measured L_{A90} (background) noise levels dBA
Source: Wilkinson Murray

The EPNR cannot be used to set noise criteria for the L_{A90} metric. However, this measure is useful to gain some understanding of the background noise level that is usually present. By reference to Figure 13-1, it can be seen that the quietest measured L_{A90} above are comparable to whispering, while the loudest is comparable to the background noise level of the average Australian suburb.

13.6 Impact Assessment

Noise levels from ground-based operations have been calculated for the future periods both with and without the NRP:
- 2025 (opening year) – with and without the NRP, and
- 2045 – with the NRP.

The amount of noise directly attributable to the new runway can be identified by comparing the with and without scenarios in 2025. The without scenario was not assessed for 2045 as the current airfield will be constrained and well over capacity by this stage without the new runway.

13.6.1 Ground-Based Operational Noise

13.6.1.1 Engine Ground Running

Table 13-18 presents the highest noise levels at surrounding catchment areas for EGR under neutral or adverse weather conditions (wind in the day and temperature inversions at night). Levels are shown as bold where they exceed the Assigned Outdoor Noise Level. These levels can be visualised in Figure 13-9 to Figure 13-12 .

EGR Scenario		Sensitive Receiver Catchment Areas								
		CA1	CA2	CA3	CA4	CA5	CA6	CA7	CA8	CA9
Fokker F100	Max	37	**47**	43	**50**	**51**	**53**	21	23	30
	Min	20	28	33	**38**	31	27	20	18	22
Fokker F100	Max	**46**	**56**	50	**56**	**59**	**64**	33	31	38
(Adverse Weather)	Min	27	35	41	**42**	38	35	25	25	30
Dash 8-300 (DH8C)	Max	30	40	36	**43**	**44**	46	14	16	23
	Min	13	21	26	31	24	20	13	11	15
Dash 8-300 (DH8C)	Max	39	**49**	43	**49**	**52**	**57**	26	24	31
(Adverse Weather)	Min	20	28	34	35	31	28	18	18	23
Assigned Outdoor Noise Level – Night (nearest receiver)		43	45	52	35	41	48	42	37	44

Table 13-18 Predicted engine ground run L_{A10} levels at surrounding receivers dBA
Source: Wilkinson Murray

The predicted noise level at sensitive receptors in future catchment areas cannot be calculated without knowing their location within that catchment area. Though the exposure of a future catchment area to ground-based noise can be inferred from Figure 13-9 to Figure 13-12.

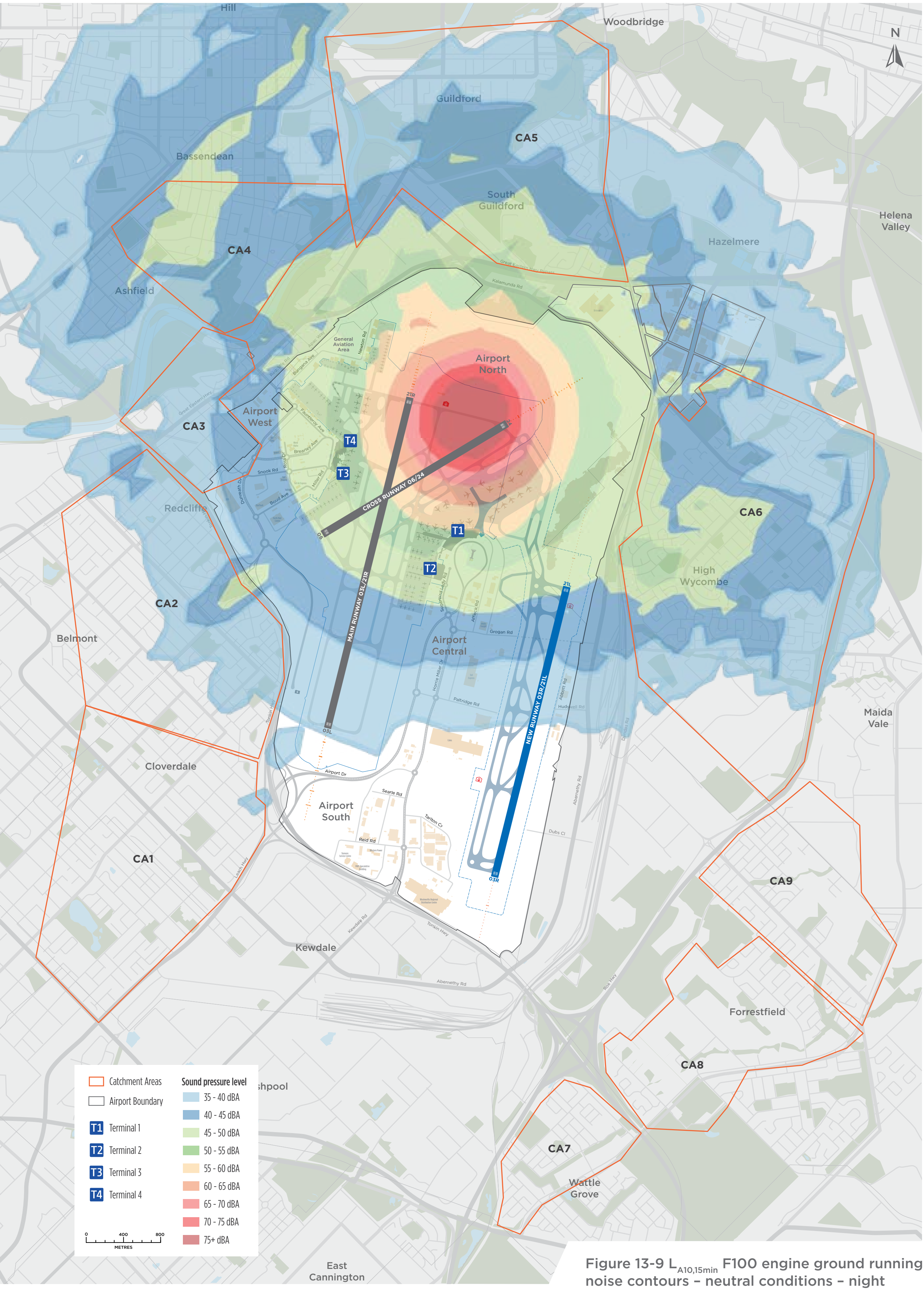


Figure 13-9 $L_{A10,15min}$ F100 engine ground running noise contours – neutral conditions – night
Source: Wilkinson Murray

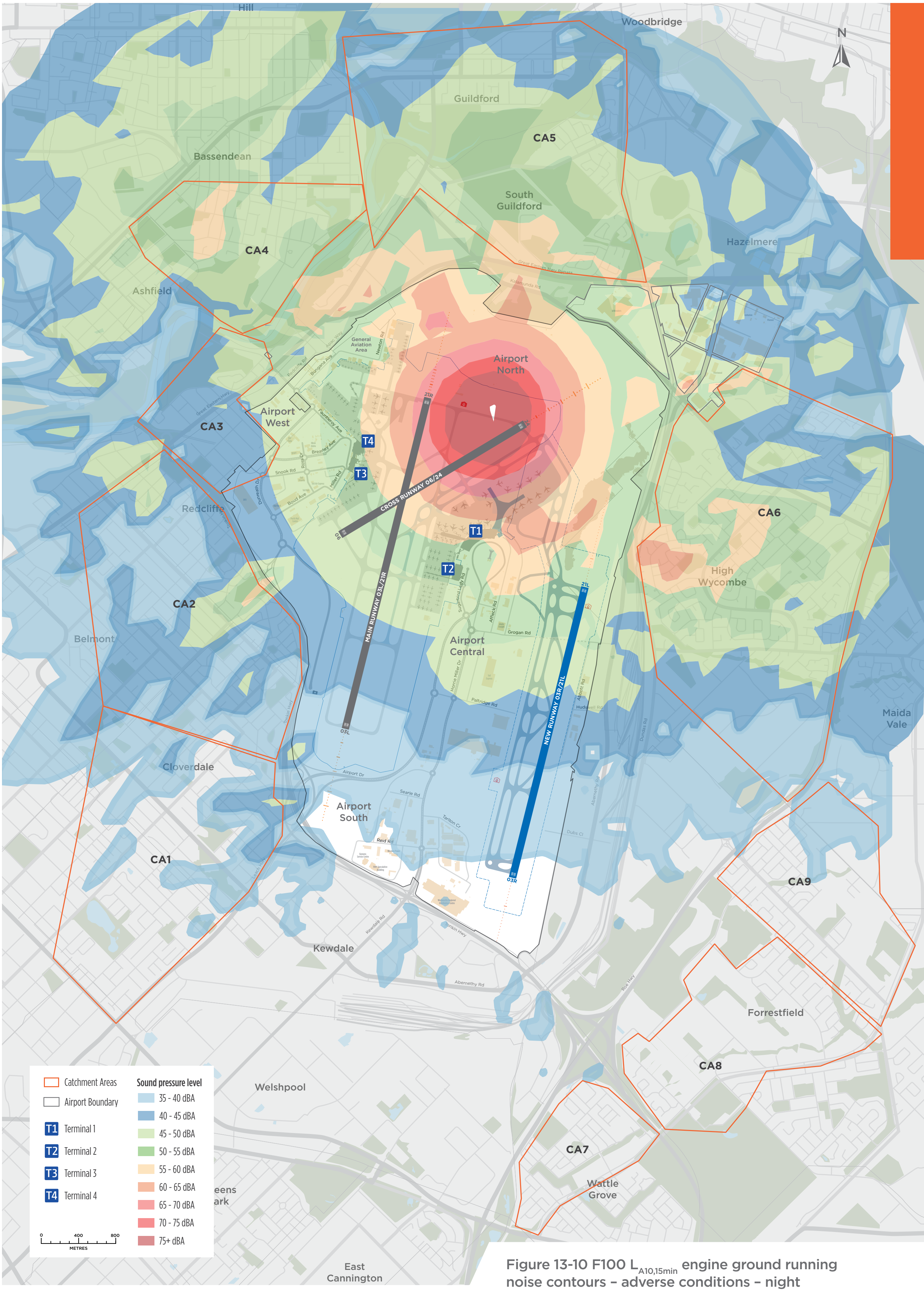


Figure 13-10 F100 $L_{A10,15min}$ engine ground running noise contours – adverse conditions – night
Source: Wilkinson Murray

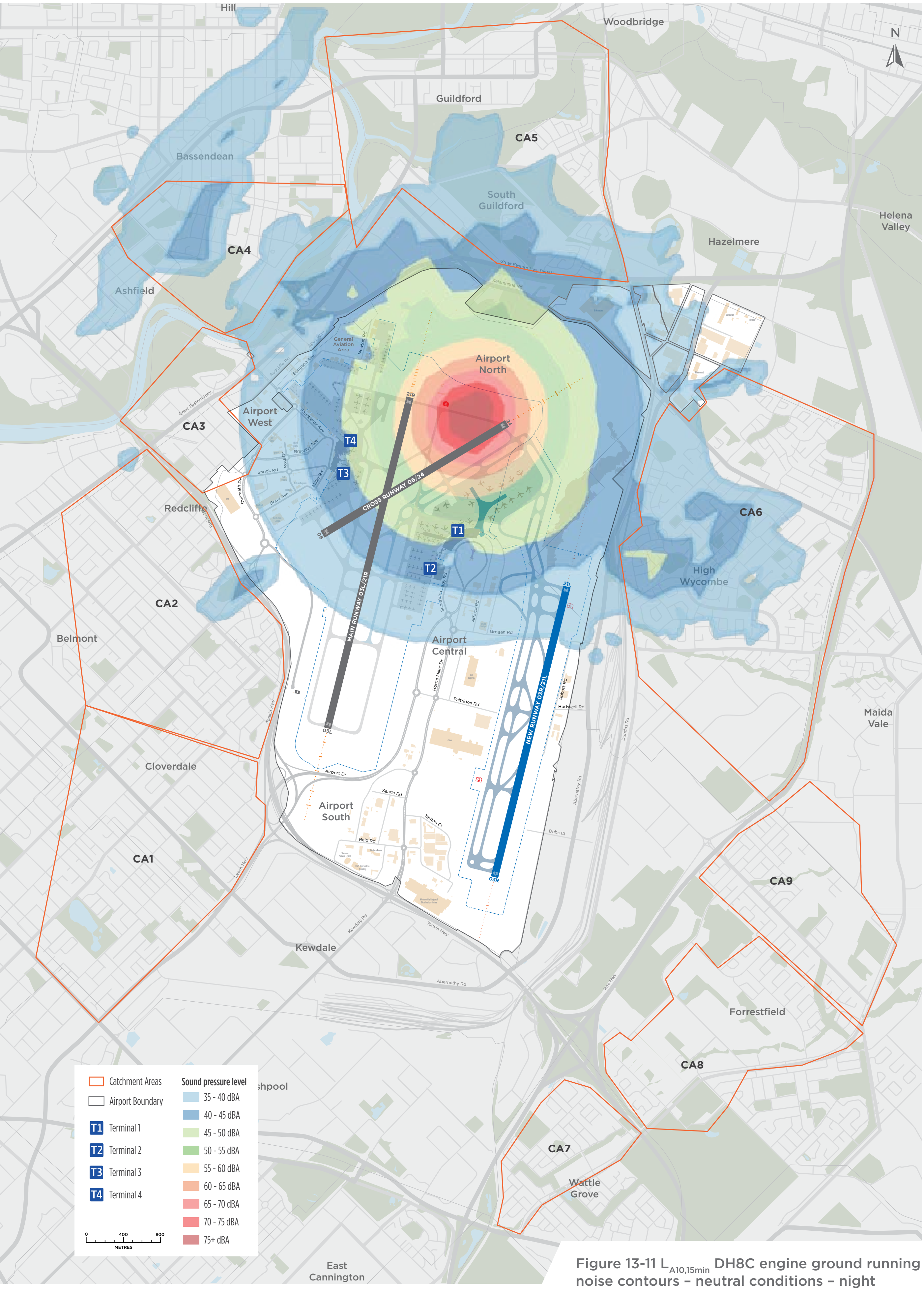


Figure 13-11 $L_{A10,15min}$ DH8C engine ground running noise contours – neutral conditions – night
Source: Wilkinson Murray

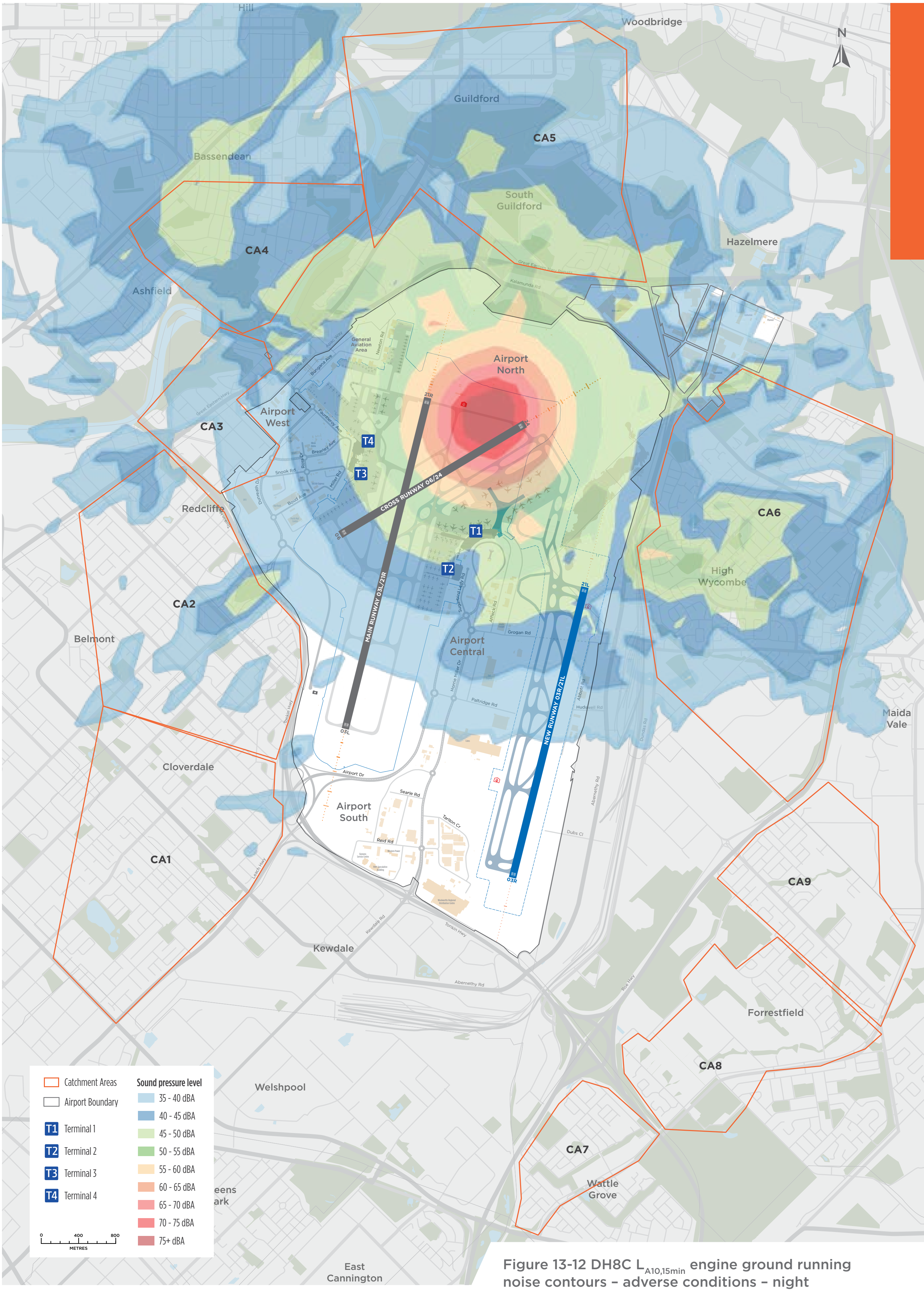


Figure 13-12 DH8C $L_{A10,15min}$ engine ground running noise contours – adverse conditions – night
Source: Wilkinson Murray

The greatest potential impact is likely to occur under temperature inversion conditions, when there is generally little wind. Noise levels will be greatest in Ashfield (CA4), South Guildford (CA5) and High Wycombe (CA6).

At other times for any individual engine running, not all of the above areas would be affected at the noise levels shown in the contour plots at the same time. This is because aircraft would be oriented in a particular direction during an engine run-up, usually facing into the prevailing wind and noise would not be radiated or propagated equally in all directions, with noise levels behind and downwind much higher than in-front and upwind.

The predicted L_{A10} levels reflect both current and future operations whereby noise levels over a 15-minute period are not expected to increase as there is only one engine ground run location. Similarly, the duration of any engine ground running sequence will not increase and it is likely only one event will occur in any one night. However, the number of occurrences of engine ground runs over a year is expected to increase in line with increased airport operations of those aircraft types.

An analysis of total aircraft numbers relative to existing indicate an increase of approximately 43 per cent by 2025 and 96 per cent by 2045. However, the difference between the with new runway and without new runway is less than one per cent in 2025. Although the two main models of aircraft that undergo engine ground runs at Perth Airport are relatively old, no assumptions have been made about the eventual phasing out of these aircraft to ensure that these predictions are conservative.

Although the assigned outdoor noise level is exceeded by more than 10 dBA in some catchment areas the impact must be considered in the context that Perth Airport hosts no heavy maintenance operations and engine ground runs are infrequent. As this exceedance would only occur occasionally a moderate adverse impact is most appropriate for the risk assessment.

13.6.1.2 Auxiliary Power Unit and Aircraft Taxiing

Discussion about potential noise impacts can be considered broadly in terms of the daytime and night time periods, under neutral and adverse weather conditions for each of the catchment areas outlined in Section 13.5.3. Changes in noise levels between the with new runway and without new runway are also discussed.

Table 13-19 presents the highest noise levels at surrounding catchment areas for APU and aircraft taxiing based on each scenario under neutral or adverse weather conditions (wind in the day and temperature inversions at night). Levels are shown as bold where they exceed the Assigned Outdoor Noise Level. These noise levels can be visualised in Figure 13-13 to Figure 13-18.

Catchment Area	Period	Assigned Level	Scenario	Max/Min	Neutral Weather			Adverse Weather		
					2016	2025	2045	2016	2025	2045
CA1 - Cloverdale	Day	53	Without New Runway	Max	46	48	-	**54**	**56**	-
				Min	13	14	-	11	12	-
			With New Runway	Max	-	49	52	-	**60**	**63**
				Min	-	16	9	-	12	5
	Night	43	Without New Runway	Max	**44**	**46**	-	**53**	**54**	-
				Min	14	15	-	22	23	-
			With New Runway	Max	-	**48**	**52**	-	**56**	**60**
				Min	-	15	17	-	24	25
CA2-Redcliffe and Belmont	Day	55	Without New Runway	Max	51	53	-	55	**57**	-
				Min	20	20	-	17	18	-
			With New Runway	Max	-	53	53	-	**61**	**64**
				Min	-	21	14	-	18	11
	Night	45	Without New Runway	Max	**51**	**52**	-	**54**	**56**	-
				Min	20	20	-	29	30	-
			With New Runway	Max	-	**57**	**53**	-	**60**	**62**
				Min	-	21	19	-	29	29
CA3 - Redcliffe	Day	62	Without New Runway	Max	47	49	-	49	51	-
				Min	26	27	-	25	26	-
			With New Runway	Max	-	47	43	-	50	46
				Min	-	21	14	-	26	17
	Night	52	Without New Runway	Max	47	48	-	49	51	-
				Min	22	20	-	33	33	-
			With New Runway	Max	-	48	42	-	51	46
				Min	-	21	19	-	34	30
CA4 - Bassendean	Day	45	Without New Runway	Max	42	44	-	43	44	-
				Min	24	20	-	22	23	-
			With New Runway	Max	-	45	44	-	**46**	45
				Min	-	21	14	-	25	19
	Night	35	Without New Runway	Max	**40**	**41**	-	**45**	**46**	-
				Min	23	20	-	30	30	-
			With New Runway	Max	-	**44**	**42**	-	**48**	**47**
				Min	-	21	19	-	31	25
CA5 - South Guildford	Day	51	Without New Runway	Max	35	36	-	43	45	-
				Min	13	13	-	10	10	-
			With New Runway	Max	-	38	38	-	47	46
				Min	-	15	8	-	12	10
	Night	41	Without New Runway	Max	32	33	-	39	40	-
				Min	13	13	-	21	21	-
			With New Runway	Max	-	37	36	-	44	**43**
				Min	-	13	11	-	21	20

Table 13-19 L_{A10} Noise levels from Taxiing and operation of Auxiliary Power Units
Source: Wilkinson Murray

Catchment Area	Period	Assigned Level	Scenario	Max/Min	Neutral Weather 2016	Neutral Weather 2025	Neutral Weather 2045	Adverse Weather 2016	Adverse Weather 2025	Adverse Weather 2045
CA6 -High Wycombe	Day	58	Without New Runway	Max	41	42	-	52	53	-
				Min	15	15	-	13	14	-
			With New Runway	Max	-	53	53	-	61	61
				Min	-	22	17	-	19	19
	Night	48	Without New Runway	Max	39	40	-	49	50	-
				Min	15	16	-	22	23	-
			With New Runway	Max	-	52	**52**	-	59	**60**
				Min	-	20	20	-	28	28
CA7 -Wattle Grove	Day	52	Without New Runway	Max	24	25	-	30	31	-
				Min	12	12	-	12	13	-
			With New Runway	Max	-	35	37	-	45	47
				Min	-	22	13	-	20	10
	Night	42	Without New Runway	Max	22	24	-	32	33	-
				Min	12	13	-	21	22	-
			With New Runway	Max	-	32	37	-	43	48
				Min	-	21	24	-	32	35
CA8 - Forrestfield	Day	47	Without New Runway	Max	23	25	-	27	30	-
				Min	10	10	-	9	10	-
			With New Runway	Max	-	34	36	-	38	40
				Min	-	17	10	-	15	9
	Night	37	Without New Runway	Max	21	23	-	31	32	-
				Min	10	10	-	16	17	-
			With New Runway	Max	-	32	36	-	40	**45**
				Min	-	15	17	-	22	24
CA9 - Forrestfield	Day	54	Without New Runway	Max	30	31	-	33	34	-
				Min	12	12	-	12	12	-
			With New Runway	Max	-	40	42	-	43	46
				Min	-	19	13	-	19	14
	Night	44	Without New Runway	Max	28	29	-	32	34	-
				Min	12	13	-	19	19	-
			With New Runway	Max	-	38	42	-	42	**47**
				Min	-	17	20	-	24	26

Table 13-19 L_{A10} Noise levels from Taxiing and operation of Auxiliary Power Units (Continued)

At daytime under neutral weather conditions, the predicted noise levels for all future years with the new runway are within the assigned level. In CA1, CA2 and CA4 the levels are within 5 dB of the assigned level. In these circumstances, the difference between the with new runway and without the new runway scenarios are typically 1 to 2 dB higher for 2025, but are 1 to 2 dB higher at CA1 and 2 to 3 dB lower at CA2 and CA4 for 2045.

At daytime under adverse conditions, the predicted noise levels increase by typically up to 10 dB and under these circumstances the assigned level is exceeded in CA1, 2, 4 and 6. In these circumstances the difference between the with new runway and without new runway is typically 1 to 4 dB higher for 2025 for the western catchment areas CA1, CA2 and CA4, but 3 to 4 dB higher for catchment areas CA1 and 2 and 1 dB lower for CA4 for 2045. The difference between the with new runway and without is typically 5 to 8 dB higher for 2025 for the catchment area CA6, but are 5 to 7 dB higher for 2045.

At night time under neutral weather conditions, the predicted noise levels with the new runway exceed the assigned level in CA 1,2,4 and 6. In CA2 for 2025, the predicted level is more than 10 dB above the assigned level, however, this reduces beyond 2030. In these circumstances, the difference between the scenario with the new runway and the scenario without the new runway is typically 2 to 5 dB higher for 2025 at CA1, 2 and 4 but up to 12 dB higher at CA6. By 2045 the levels are typically 3 dB higher at CA1 and 1 to 2 dB lower at CA2 and 4. At CA6 they are also 12 dB higher.

At night time under adverse conditions, the predicted noise levels increase by typically up to 10 dBA compared with "neutral" conditions and under these circumstances the assigned level is exceeded in Catchment Areas 1,2,4,6 and 8. In CA1, 2, 4 and 6 the predicted level is more than 10 dB above the assigned level. In these circumstances, the difference between the with new runway and without are typically 2 to 4 dB higher for 2025 at CA1, 2 and 4 and between 7 to 9 dB higher at CA6 and 8 respectively.

By 2045 the levels are typically 3 to 4 dB higher at CA1 and 2 and 1 dB lower at CA4. At CA6 and 8 the predicted levels are also 9 to 11 dB higher respectively.

These results require discussion in relation to the established significance criteria. While the results show various degrees of exceedances for daytime and night time for neutral and adverse weather conditions, the significance criteria need to be considered in terms of the overall impact rather than focussing on any particular period.

Two points need consideration to inform the significance assessment.

- there are fewer night time hours where a large number of aircraft operations occur, compared with daytime, and
- for both daytime and night time periods adverse conditions affecting individual receivers only account for relatively small percentage of these periods.

On this basis, predicted noise levels for the daytime period under "neutral" conditions are most relevant and therefore minor adverse impact is expected from the NRP. This has been upgraded to a moderate adverse impact for the risk assessment in acknowledgement of the potential for the daytime neutral noise levels to be exceeded in occasional circumstances.

The predicted noise level at sensitive receptors in future catchment areas cannot be calculated without knowing their location within that catchment area. Though the exposure of a future catchment area to ground-based noise can be inferred from Figure 13-13 to Figure 13-18.

In CA1-CA5, areas to the west of the airport, the comparison of noise levels with and without the new runway are within a few decibels for the worst-affected sensitive receivers. This difference is only just able to be detected by a sensitive human ear. To the east, the most sensitive receivers will experience a significant increase in noise, though it will be consistent with the background noise level experienced in an average suburb and well below conversation level.

It is only in CA6, High Wycombe, where the worst-affected sensitive receivers would experience noise levels that approach a normal conversation. Even then, this is only expected to become a reality by 2045 and only in adverse weather conditions. Most receivers in this catchment area will experience significantly lower than the highest predicted noise levels as the noise will rapidly attenuate with distance. The noise levels experienced refer to outdoor noise, and lower levels of noise would be experienced indoors.

Aircraft taxiing noise would be relatively low in comparison to other noise associated with operation of the airport. There are few, if any, practicable mitigation measures that would reduce this noise.

Accordingly, a holistic approach is best adopted to the assessment and control of airport noise. One of the best methods of limiting any increase in potential impact over time is good planning around the estate, including limiting residential development near the site. Perth Airport works closely with local planning authorities seeking to ensure appropriate land-use planning is implemented.

The use of ground power and pre-conditioned air for aircraft at the gates avoids the use of aircraft APUs and the associated noise. However, these sources are not the dominant contributor to overall operational noise levels and therefore this measure would have a relatively small benefit to surrounding residences.

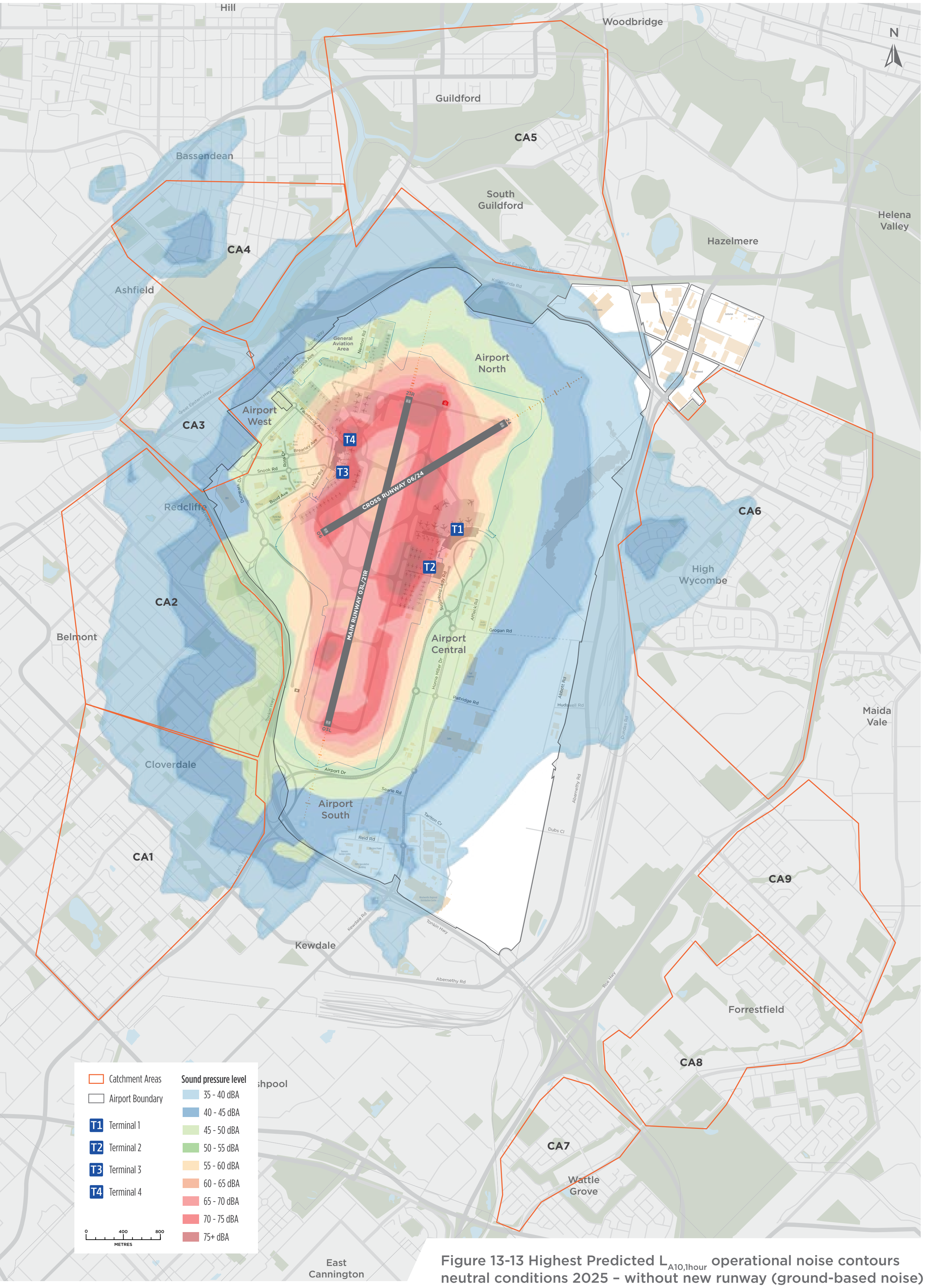


Figure 13-13 Highest Predicted $L_{A10,1hour}$ operational noise contours neutral conditions 2025 – without new runway (ground-based noise)
Source: Wilkinson Murray

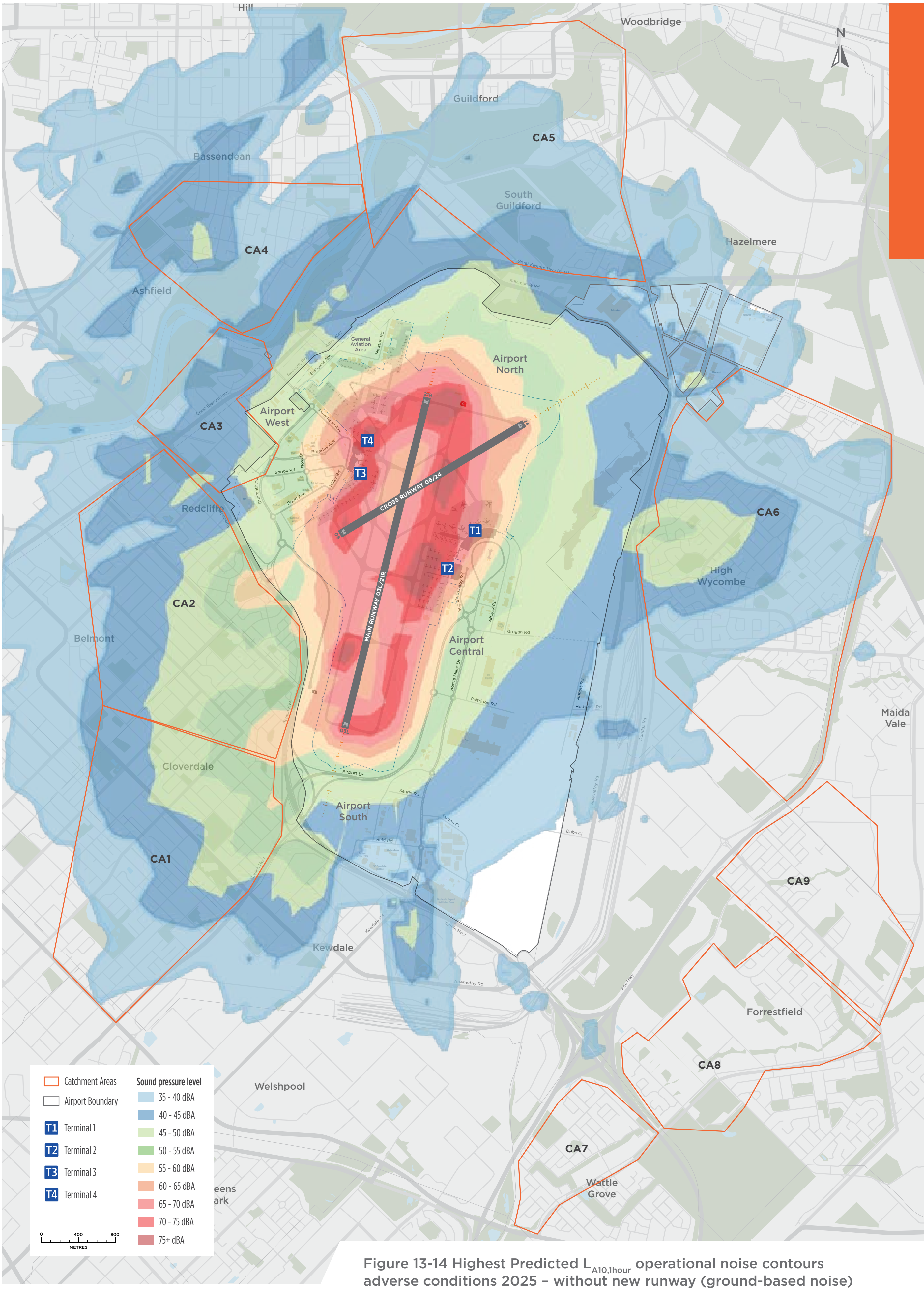


Figure 13-14 Highest Predicted $L_{A10,1hour}$ operational noise contours adverse conditions 2025 – without new runway (ground-based noise)
Source: Wilkinson Murray

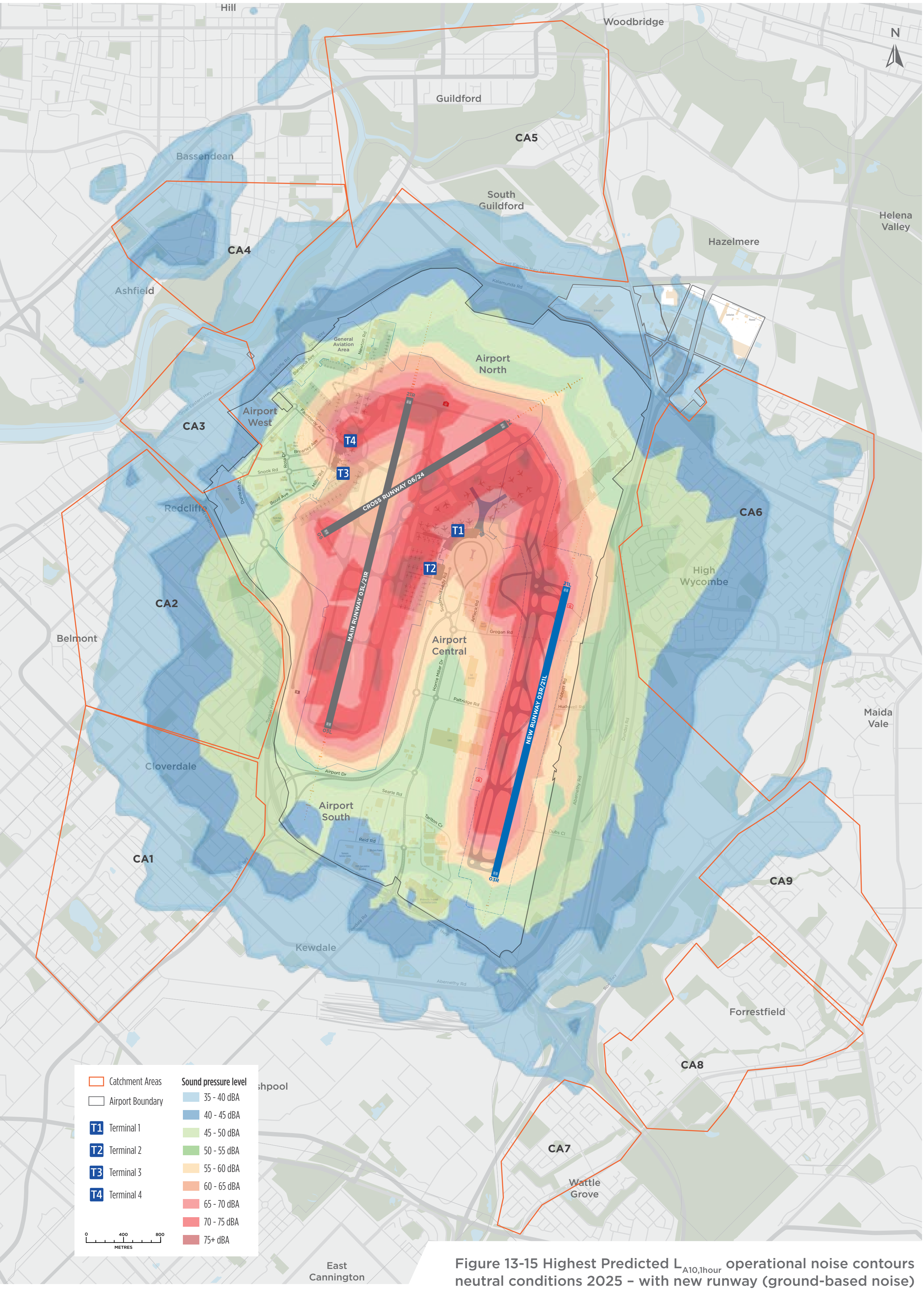


Figure 13-15 Highest Predicted $L_{A10,1hour}$ operational noise contours neutral conditions 2025 – with new runway (ground-based noise)
Source: Wilkinson Murray

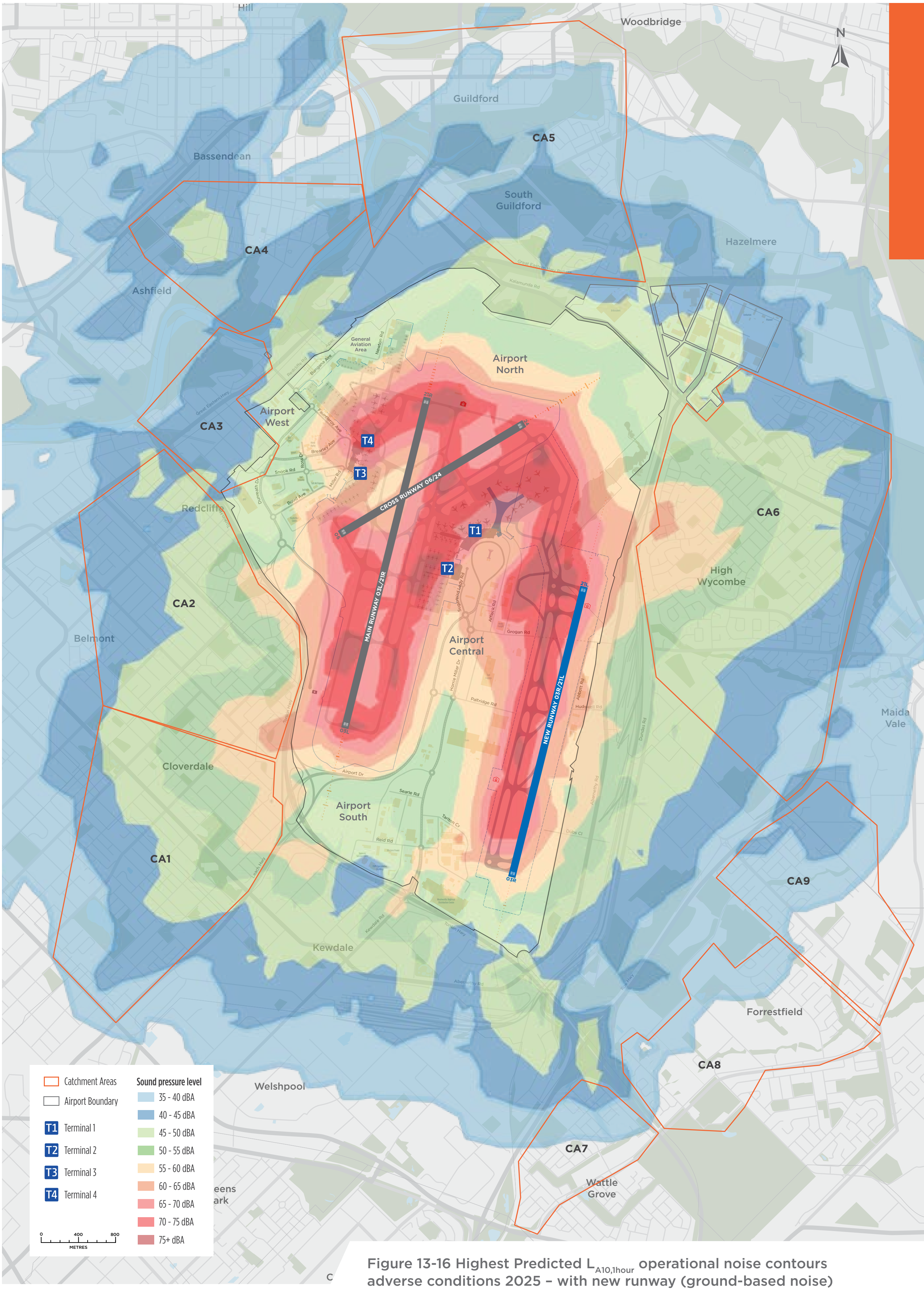


Figure 13-16 Highest Predicted $L_{A10,1hour}$ operational noise contours adverse conditions 2025 – with new runway (ground-based noise)
Source: Wilkinson Murray

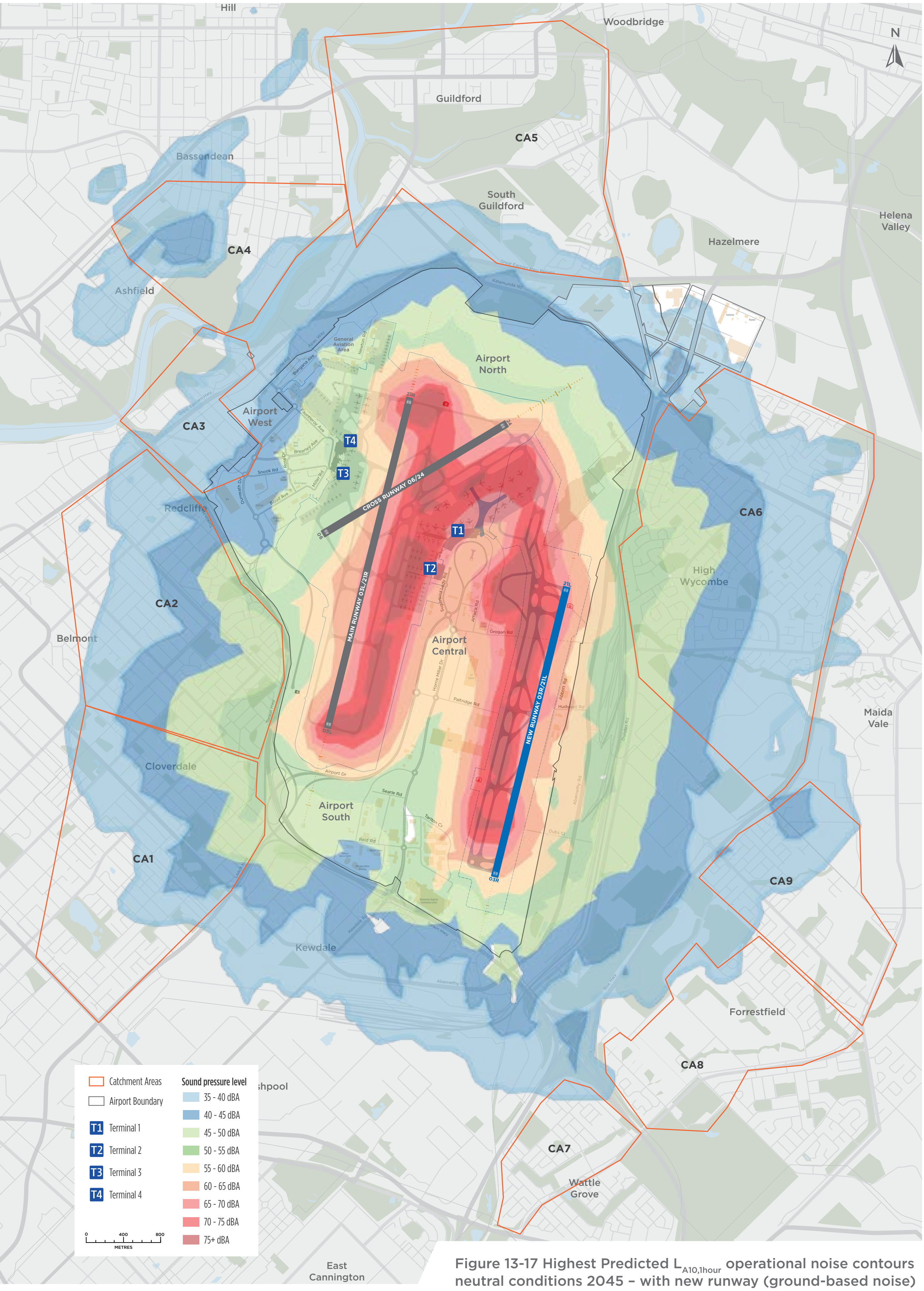


Figure 13-17 Highest Predicted $L_{A10,1hour}$ operational noise contours neutral conditions 2045 – with new runway (ground-based noise)
Source: Wilkinson Murray

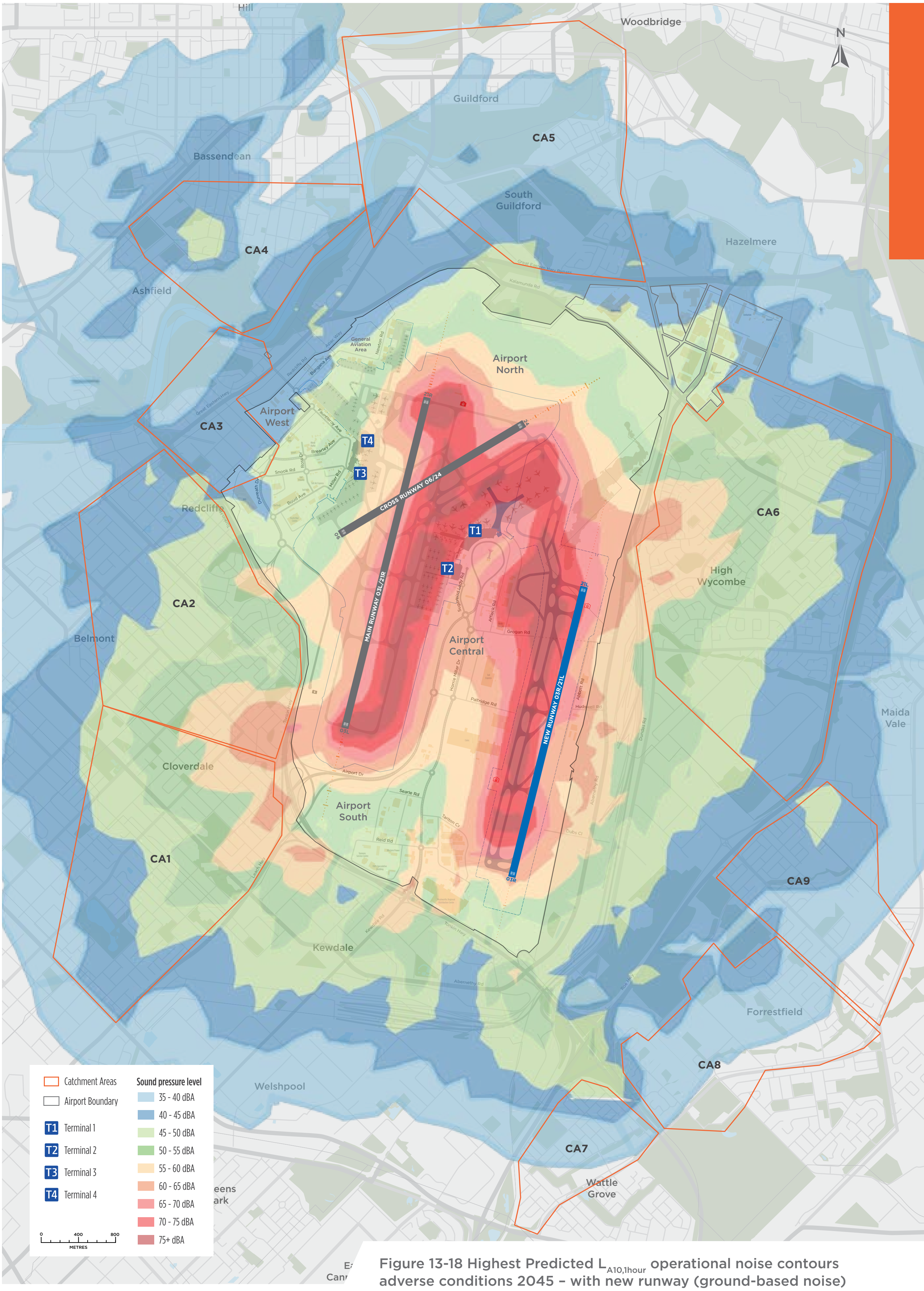


Figure 13-18 Highest Predicted $L_{A10,1hour}$ operational noise contours adverse conditions 2045 – with new runway (ground-based noise)
Source: Wilkinson Murray

13.6.2 Road Traffic Noise

The development of the NRP would result in increased construction and operational traffic near the estate. Noise generated from road traffic on an airport site is regulated by the AEPR, which set 24 hour and night time equivalent continuous noise standards.

An assessment of potential impacts that the construction and operation of the new runway will have on ground transport in surrounding areas was undertaken as outlined in Section 18. The outputs of this study formed key inputs in assessing the road traffic noise. Key surrounding roads were Roe Highway, Abernethy Rd, Horrie Miller Drive and Tonkin Highway.

To assess the additional road-traffic noise that runway construction will cause, the daily and peak-hour volumes of cars and trucks on these roads was calculated as part of the ground transport study discussed in Section 18.

To assess what additional road traffic noise will be present once the runway is in operation, the peak-hour traffic volumes for these roads were projected for 2025 and 2045. Three peak hours were used for each road: the AM peak (7.15 am to 8.15 am), the PM peak (4.30 pm to 5.30 pm) and the peak hour for traffic travelling to and from the airport (2.00 pm to 3.00 pm).

Table 13-20 shows only the changes in noise level due to airport-related traffic in 2025 and 2045 as opposed to reporting the total noise level that is attributable to road traffic. The aircraft impacts detailed in the previous section are typically single events that can be measured in isolation. The difference with a road is that it operates at various levels at various times of day, and is different every day. Furthermore, it is not possible to breakdown ambient noise measurements into their various components. Therefore, it is not possible to tell how much of a noise measurement is directly attributable to road traffic noise.

With the NRP, the expected noise level increase is less than one dBA compared to the without scenario for most roads. Accordingly, it is concluded there would not be a perceptible noise increase resulting from road traffic because of the NRP. This outcome reflects the relative proportion of airport-induced traffic as a component of the total regional traffic forecast to use these roads.

It is noted that both the Roe and Tonkin highways are classified as primary freight roads, and are subject to significant heavy traffic of approximately 25 per cent heavy vehicles. In the case of Abernethy Road, heavy vehicle percentages are of a similar magnitude.

As a result, the AM and PM peak hours will reflect increased traffic-noise levels that are not primarily a function of the airport. Therefore, the airport peak provides the best indication of the impact additional airport operations will have on road noise levels.

Assessment showed that with the NRP, noise levels on identified roads will increase by less than one dBA during the peak hour. Such an increase is acoustically insignificant. Therefore, it can be concluded that the vehicle traffic generated by the NRP will not adversely impact on any noise-sensitive receivers near roadways serving the airport.

Year	Period	Without Runway (dBA)	With Runway (dBA)
Roe Highway			
2025	AM Peak	1.6	1.7
	Airport Peak	2.4	2.8
	PM Peak	1.5	1.7
2045	AM Peak	n/a	3.2
	Airport Peak	n/a	3.6
	PM Peak	n/a	3.5
Tonkin Highway			
2025	AM Peak	0.8	1.0
	Airport Peak	1.0	1.3
	PM Peak	1.0	1.4
2045	AM Peak	n/a	1.8
	Airport Peak	n/a	2.1
	PM Peak	n/a	1.5
Abernethy Road			
2025	AM Peak	1.5	2.6
	Airport Peak	1.1	1.5
	PM Peak	2.0	3.0
2045	AM Peak	n/a	2.3
	Airport Peak	n/a	3.5
	PM Peak	n/a	2.5

Table 13-20 Predicted road traffic noise level increases with new runway compared to without new runway
Source: Wilkinson Murray

Year	Increased dBA
Roe Highway	
2025	0.4
2045	0.8
Tonkin Highway	
2025	0.3
2045	0.7
Abernethy Road	
2025	0.4
2045	0.3

Table 13-21 Predicted road traffic noise level increases compared to without new runway during the airport peak hour
Source: Wilkinson Murray

Scenario	Peak Hour - L_{Aeq} (one hour)	Day (6.00 am - 10.00 pm) – L_{Aeq} (day)
No construction traffic	59.3	56.8
With construction traffic	59.6	57.0

Table 13-22 Predicted construction traffic noise levels at nearest residence
Source: Wilkinson Murray

13.6.3 Construction Noise and Vibration

Predicted noise levels with and without construction traffic are detailed in Table 13-22. These were calculated from outputs of the ground transport study which is discussed in Section 18.

The assessment indicates that traffic noise levels at the nearest potentially affected residences will increase between 0.3 dBA for peak hour and 0.2 dBA for the day period. These increases are acoustically insignificant and would not represent a noticeable change in noise levels at this receiver.

Therefore, it can be concluded that there will be no adverse noise impact associated with construction traffic.

Table 13-23 presents predicted noise levels from construction at surrounding sensitive receiver catchment areas. Maximum L_{A10} noise levels are those which will be experienced by the closest receivers in catchment areas while the minimum levels are the receivers in a catchment area furthest from the NRP area. The impacts have been broken up into different seasons and construction areas to ensure the modelled noise levels are most representative of the highest expected noise impacts. They are not a reflection of construction methodology.

A review of the predictions shows that the there are no locations where noise levels are expected to exceed the 75 dBA criterion set out by the AEPR. In all catchment areas, with the exception of CA6, resultant noise levels are expected to be below 50 dBA. In these areas noise levels are expected to be below assigned noise levels and typical L_{A10} daytime noise levels.

In the case of sensitive receivers in CA6 (which contains the closest sensitive receivers to the NRP) site noise levels can be expected to be up to 63 dBA at the closest residences to the NRP. This magnitude compares with existing ambient L_{A10} noise levels of 47 to 48 dBA. The greatest impact will be when earthworks and paving occurs in the northern section of the worksite. This noise level is still consistent with the level of a normal conversation and will be lower indoors.

Worst-case envelopes of all construction scenarios for summer and winter as noise contours are shown in Figure 13-19 and Figure 13-20.

The predicted noise level at sensitive receptors in future catchment areas cannot be calculated without knowing their location within that catchment area. Though the exposure of a future catchment area to ground-based noise can be inferred from Figure 13-19 to Figure 13-20.

Without mitigation, noise levels from construction activities have been predicted to exceed existing ambient L_{A10} levels at the nearest residential receivers in CA6 when works occur in the northern end of the construction site. Therefore, noise-control measures should be considered to ensure that construction-noise levels are minimised at sensitive receivers.

Construction Scenario		Sensitive Receiver Catchment Area								
		CA1	CA2	CA3	CA4	CA5	CA6	CA7	CA8	CA9
Bulk Earthworks North – Summer	Max	29	33	32	26	31	59	20	25	31
	Min	15	21	22	17	14	29	15	20	25
Bulk Earthworks North – Winter	Max	36	39	36	30	31	59	28	34	37
	Min	22	24	28	17	14	29	23	26	28
Bulk Earthworks Central – Summer	Max	34	33	28	23	23	44	25	32	36
	Min	21	23	23	20	13	23	18	25	31
Bulk Earthworks Central – Winter	Max	41	43	32	23	30	43	34	39	40
	Min	26	27	23	20	13	23	26	35	23
Bulk Earthworks South – Summer	Max	39	36	28	25	21	43	37	40	40
	Min	29	23	18	20	15	23	30	33	35
Bulk Earthworks South – Winter	Max	41	41	28	25	21	43	45	45	45
	Min	31	24	18	20	15	23	39	37	37
Paving works North – Summer	Max	37	39	36	32	36	63	30	36	40
	Min	26	29	29	26	23	35	25	30	35
Paving works North – Winter	Max	43	43	40	35	36	63	37	43	45
	Min	32	34	33	26	23	35	32	37	38
Paving works South – Summer	Max	41	39	32	29	24	46	39	42	43
	Min	32	25	22	24	20	27	32	35	38
Paving works South – Winter	Max	43	44	32	29	24	46	47	47	47
	Min	34	28	22	24	20	27	40	40	40
Assigned Noise Level (Nearest Receiver)		43	45	52	35	41	48	42	37	44

Table 13-23 Predicted construction L_{A10} noise levels at surrounding receivers
Source: Wilkinson Murray

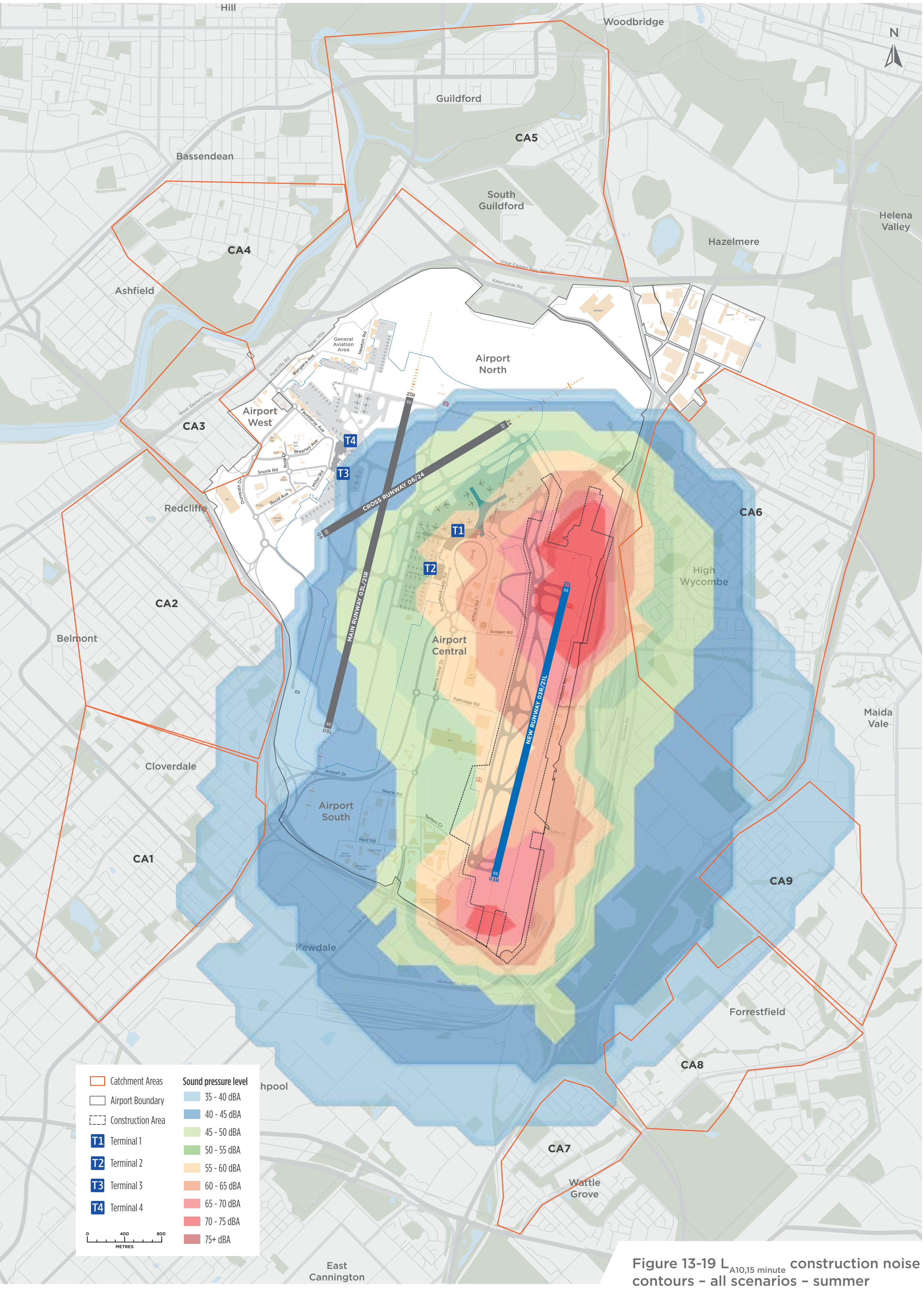


Figure 13-19 $L_{A10,15\ minute}$ construction noise contours – all scenarios – summer
Source: Wilkinson Murray

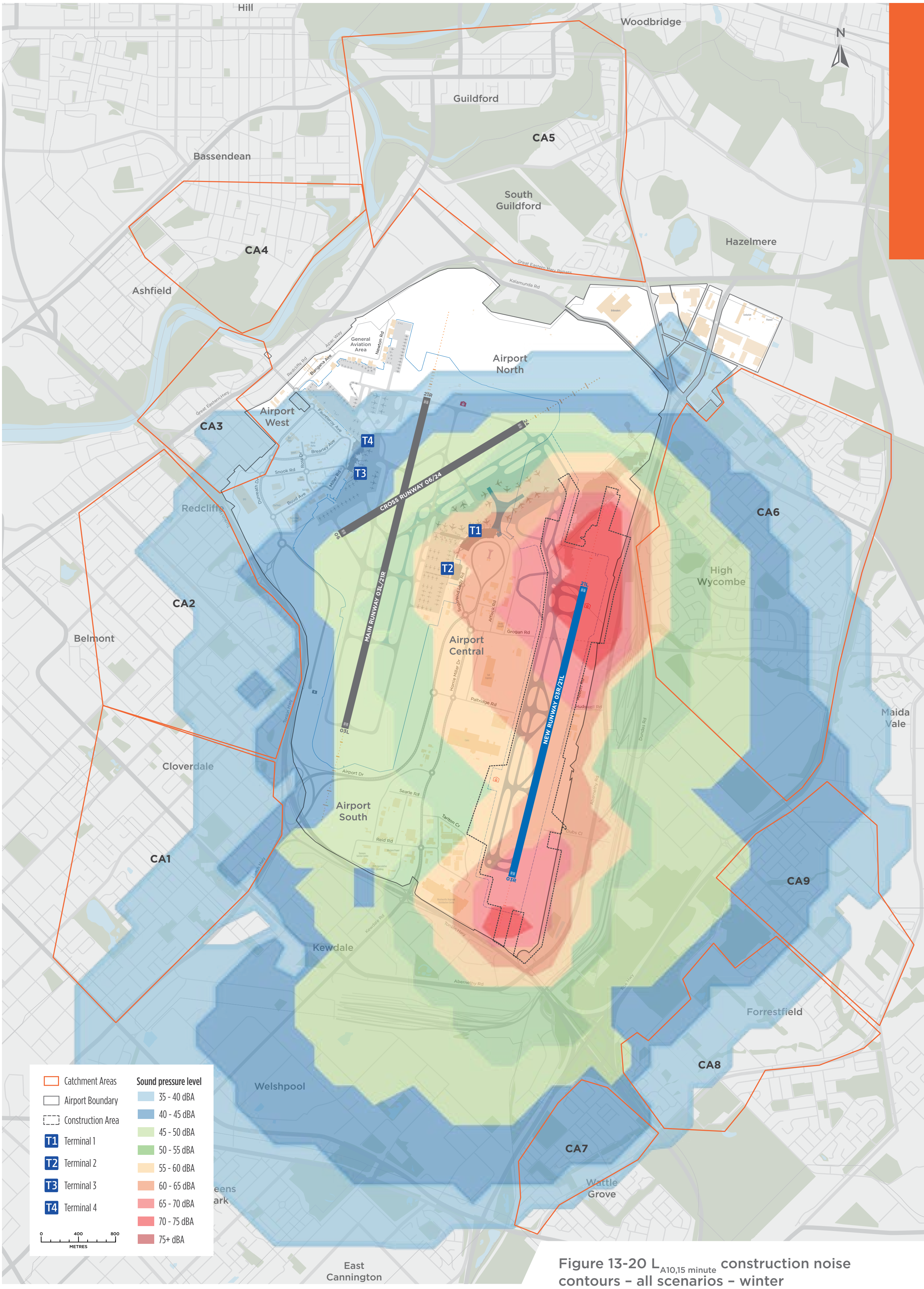


Figure 13-20 $L_{A10,15\ minute}$ construction noise contours – all scenarios – winter
Source: Wilkinson Murray

13.6.3.1 Vibration

Vibration would be generated by the proposed construction works. As a very conservative approach, the lower guideline value (from DIN 4150-3) applying to vibration-sensitive buildings (three millimetres per second) has been adopted as the threshold of damage from construction vibration.

Figure 13-21 shows vibration levels previously measured on construction sites at a range of distances. Apart from blasting, vibration levels from vibro or impact piling generate the highest vibration levels. However, it is extremely unlikely that impact piling or blasting will be required to construct the runway.

Figure 13-21 shows that the three millimetres per second value could be achieved even when using the piling method generating the highest vibration level at a distance of less than 20 metres. Given that any piling associated with building construction would occur well within the NRP area, there would be no risk of damage to buildings from vibration outside of the estate even if it were to be used.

Vibration may also be generated by the ripping of rock, but again the guideline value of a peak component particle velocity of three millimetres per second is likely to be complied with inside the estate and there is no risk of damage outside the estate. As the guideline value of a peak component particle velocity of three millimetres per second is set in the context of protection of heritage buildings in Germany, airport buildings on the estate will not experience damaging levels of vibration. Due to the geology in the runway footprint it is highly unlikely any ripping of rock will be required.

The assessment concluded that it will be possible to ensure that vibration from the NRP does not affect nearby sensitive receivers.

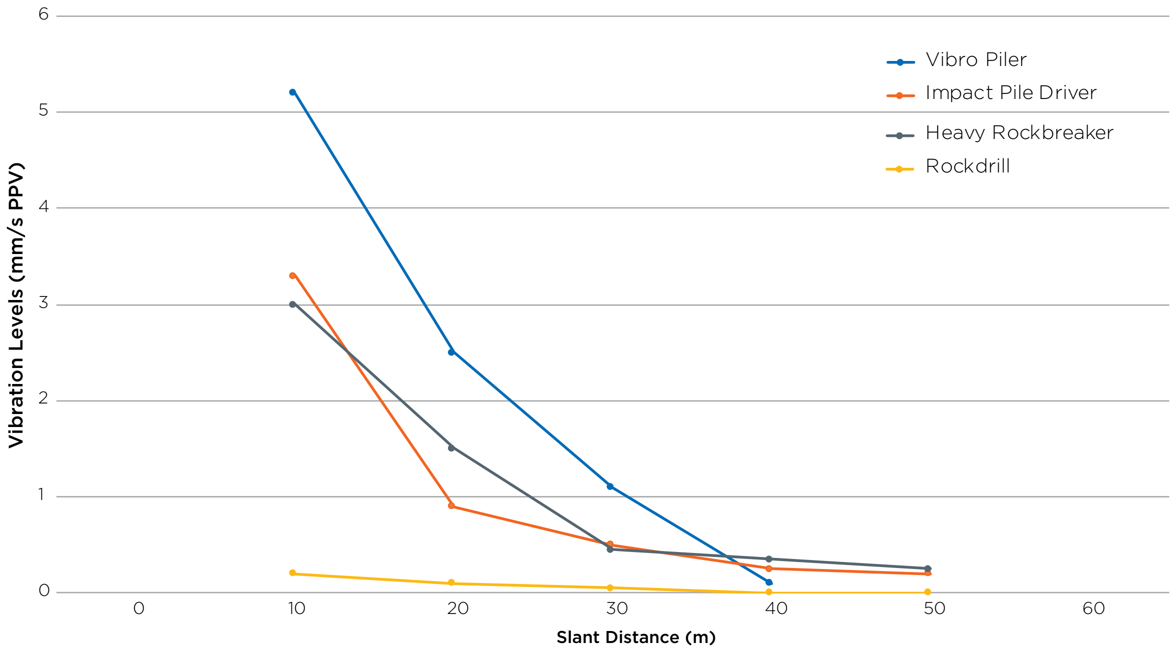


Figure 13-21 Predicted vibration levels
Source: Wilkinson Murray

13.7 Mitigation

The impacts of noise from ground-based sources on the community resulting from the construction and operation of the NRP were subject to a risk assessment as outlined in Section 8. The outcome of this assessment was that the majority of the impacting processes resulted in risks that were rated low. The one impacting process that did not result in a low risk rating was an increase in aircraft taxiing in line with growth in movements. The impact on sensitive receivers for this process was rated medium.

Both the standard and additional mitigation measures for the identified impacts are outlined below.

13.7.1 Ground-Based Operational Noise

13.7.1.1 Engine Ground Running

Perth Airport will continue to maintain, review and monitor EGR so that any impact on residents can be effectively assessed.

There are many factors that contribute to Perth Airport's low level of complaints regarding EGR, including that Perth Airport does not host any routine maintenance, the relative geographic isolation of the EGR location from the nearest sensitive receivers, and management through the EGR Management Plan.

Perth Airport will continue to carry out regular reviews of the EGR Management Plan.

13.7.1.2 APU and Aircraft Taxiing

The use of fGPU and pre-conditioned air over APU usage will be encouraged.

Design of the taxiway system considers taxiing distances and the need to minimise the impact of ground based noise.

13.7.2 Road Traffic Noise

No mitigation measures have been identified for road traffic noise from the project due to the expected negligible impact.

13.7.3 Construction Noise and Vibration

A range of possible approaches to reducing the impact of construction noise and vibration will be considered. A Construction Environmental Management Plan (CEMP), developed prior to construction, will address the following issues relating to construction noise impact management, including:

- construction hours (having regard to day of the week, work locations and distance to sensitive receivers),
- best practice noise levels for equipment (including use of noise-compliant equipment, periodic compliance audit of equipment, use of clackers instead of reversing beepers etc.),
- training of equipment operators,
- noise monitoring and reporting,
- communication with potentially affected residents, and
- complaints management and response.

In practice, there is limited action that can be taken to reduce construction noise levels but the impacts can often be reduced by management measures, such as restricting noisy activities outside of standard construction hours.

13.7.4 Additional Mitigation

In order to further reduce impacts considered to present medium to very high risks to the environment, additional mitigation measures are required to be proposed where possible to reduce the risk level of the impact. Additional mitigation measures will be considered for the increase in aircraft taxiing in line with growth in movements.

Additional mitigation will consider improved communication of information to surrounding residents on ground-based noise.

13.8 Summary

A summary of the impacts of ground-based noise and an impact risk assessment are provided in Table 13-24.

Impacting Process	Impact Detail	Project Phase	Initial Assessment				Residual Assessment			
			Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Construction of the new runway	Noise from plant involved with the bulk earthworks and paving involved in the new runway construction impacting on sensitive receivers.	Construction	Preparation and implementation of noise management plan by construction contractor in consultation with Perth Airport. Construction limited to daytime hours. Use of modern well-maintained construction plant	Negligible	Almost Certain	Low	No additional mitigation measures identified			
Construction of the new runway	Noise from additional road traffic associated with construction of new runway.	Construction	Construction limited to daytime hours. Trucks access via primary freight routes wherever possible.	Negligible	Almost Certain	Low	No additional mitigation measures identified.			
Growth in aircraft movements following new runway construction	Increase in APU usage in line with growth in aircraft movements will impact on sensitive receivers.	Operation	Provision of fGPU and pre-conditioned air at newly constructed aerobridge-serviced bays	Negligible	Possible	Low	No additional mitigation measures identified.			
Growth in aircraft movements following new runway construction	Increase in aircraft taxiing in line with growth in movements will impact on sensitive receivers	Operation	Taxiway design is undertaken in accordance with Manual of Standards (MOS) 139 - Aerodromes Part 6.3 Taxiways.	Moderate Adverse	Likely	Medium	Improved communication of information to surrounding residents on ground-based noise	Minor Adverse	Possible	Low
Growth in aircraft movements following new runway construction	Increase in frequency of EGR in line with growth in movements beyond 2030 will impact on sensitive receivers	Operation	EGR Management Plan continues to be implemented and reviewed including: • aircraft oriented into wind • restrictions on power settings and durations at different times of day • coordination with Air Traffic Control	Moderate Adverse (Negligible until 2030 then Moderate Adverse thereafter).	Possible	Low	No additional mitigation measures identified.			
Growth in passenger numbers following new runway construction	Increase in road traffic on nearby roads increasing the noise impact on sensitive receivers.	Operation	Considered as part of planning for the surrounding road network.	Negligible	Almost Certain	Low	No additional mitigation measures identified.			

Table 13-24 Summary of impacts, risks and mitigation measures - ground-based noise
Source: Wilkinson Murray

13.9 Conclusion

The impacts from ground-based noise are mostly benign and naturally mitigated by the distance between operations on the airport and the nearest sensitive receivers.

Little can be done to mitigate noise from APU noise. APU noise could be diminished by encouraging the use of fGPU. However, as this contribution is minimal it would do little to ameliorate noise impact in surrounding catchment areas.

Good planning which limits residential development in noise-affected areas is the best measure to minimise the impact of aircraft taxiing noise. Perth Airport works closely with local planning authorities seeking to ensure appropriate land-use planning is implemented. Perth Airport is committed to clear and transparent engagement with the community, therefore Perth Airport will work to provide information to the community on ground-based noise.

The EGR Management Plan, as well as limited occurrence of major maintenance at Perth Airport, already results in very few complaints that can be attributed to EGRs. The greatest impacts, which are on the nearest sensitive receivers in each of the catchment areas, are comparable to the noise level of a normal conversation.

The worst-affected receivers will experience significantly above background level of noise-associated with construction of the northern section of the NRP area. This level is comparable to a normal conversation and is well below the 75 dBA criterion set out in the AEPR. This will nevertheless be managed by a noise management plan as part of the CEMP.

The additional noise due to increased road traffic after the runway is operational will be negligible; well below what is detectable by the human ear.

14 Air Quality and Greenhouse Gas (Ground)

This section describes the impacts on air quality and greenhouse gas emissions from ground-based activities resulting from the construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What are the existing air quality, odour and greenhouse gas emission conditions around Perth Airport and its surrounds?
- What are the expected impacts to air quality, odour and greenhouse gases emissions from the NRP in the future?
- How will any potential impacts to air quality, odour and greenhouses gases emissions be mitigated?

14.2 Key Findings

Key findings from investigations into air quality and greenhouse gas emissions from ground-based sources include:

- The only ground based activity directly impacted by the NRP is the road traffic as a result of the additional aircraft capacity provided by the new runway.
- The majority of Perth Airport's greenhouse gas emissions result from electricity consumption and the NRP will not significantly contribute to electricity use across the estate.
- It is considered unlikely that operation of the NRP will create odour impacts as combustion of jet-fuel by auxiliary power units is expected to be lower in future years due to increased use of ground power units compared to current levels.

14.1 Introduction

This section describes the impacts to air quality, odour and greenhouse gas emissions from ground-based activities resulting from the construction and operation of the NRP.

For this assessment, ground-based emissions were defined as all emissions from airport-related activities released within the estate other than emissions released by aircraft.

The following significant ground-based sources are included in this assessment:

- ground service equipment (GSE),
- auxiliary power units (APU),
- fuel and organic liquids storage,
- operation of stationary engines (excluding aircraft),
- operation of a cogeneration plant (a power station also used for heating and cooling of air and water), and
- road traffic accessing the airport.

A study was undertaken to quantify emissions at Perth Airport and identify potential impacts of the NRP and appropriate mitigation measures.

The impact from air-based air quality (including when aircraft are taxiing and taking off or landing) is covered in Section 23 of Volume C, which deals with the airspace components of the NRP. Additional information on construction of the new runway and ground transport can be found in Sections 6 and 18 respectively.

14.3 Policy Context and Legislative Framework

Air-pollutant emissions, ambient air quality and greenhouse gas emissions are governed by legislation, guidelines and standards introduced at the Commonwealth and State government level. Perth Airport is subject to Commonwealth legislation. However, State legislation and guidance documents have been referenced where relevant.

Regulated air pollutants are considered as 'ambient' pollutants and 'air toxics'. Ambient pollutants are typically emitted from a variety of common emission sources in large quantities. Air toxics are pollutants present in the air in low concentrations and have hazardous characteristics. Excessive amounts of any regulated pollutant can cause health impacts.

A summary of applicable legislation and guidelines is provided in Table 14-1.

Legislation/Measure	Legislating Body	Understanding
Airports Act 1996 (Airports Act)	Commonwealth Government	The Airports Act provides a legal framework for the Commonwealth-leased airports and promotes environmental management of activities conducted at those airports. A number of offences and corresponding penalties are described for air pollution. No objective criteria to limit air emissions from airport operations are specified.
Airports (Environment Protection) Regulations 1997 (AEPR)	Commonwealth Government	The objective of the AEPR is to provide regulation and accountability for activities conducted at airports, and to promote improved environmental management. This Regulation: • does not apply to aircraft emissions, • requires prevention or minimisation of air pollution (including odour), • sets out monitoring and reporting requirements and corresponding penalties, • sets out contamination limits for emissions from specific sources (mainly stationary sources such as generators), and • sets out ambient air limits (applicable to air within the airport estate).
National Environment Protection (National Pollutant Inventory) Measure (NEPM)	Commonwealth Government	Aims to improve ambient air quality and minimise environmental impacts via emissions reporting by facilities which exceed the specified threshold. A reporting threshold is provided for 93 substances (including NEPM substances). This legislation affects Perth Airport's annual reporting obligations.
National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM)	Commonwealth Government	Establishes air quality standards, monitoring and reporting protocols for the seven listed pollutants (these pollutants were assessed in this study). Air quality standards set out by this legislation have been considered in combination with those specified by the AEPR, as AEPR standards are only relevant for locations within the estate, whereas these standards are applicable at all locations nationally. The State Government does not have its own limits. AAQ NEPM standards were developed for assessment of whole of airshed impacts, rather than a local area.
National Environment Protection (Air Toxics) Measure	Commonwealth Government	Sets out procedures to collect information regarding five hazardous air pollutants based on investigation limits (for reporting only).
Air Quality and Air Pollution Modelling Guidance Notes 2006	State Government	Provides general guidance for air-dispersion modelling including meteorological data preparation, model acceptability and reporting.
A guideline for managing the impacts of dust and associated contaminants from land development sites remediation and other related activities 2011	State Government	Objective of the guideline is to assist in the development and implementation of dust management programs. Applicability of this guideline relates to the assessment of construction activities.
Environment Protection Authority (EPA) Guidance Statement No. 47: Guidance Statement for Assessment of odour impacts from new proposals 2002 *(WITHDRAWN)*	State Government	This statement was withdrawn in 2010, but is yet to be replaced. This statement is assumed to provide the most appropriate guidance for selecting odour criteria to assess impacts of the NRP.
National Greenhouse and Energy Reporting Act 2007 (NGER Act)	Commonwealth Government	National framework for corporations to report on emissions. Annual threshold values are specified for both facilities and corporations – emissions must be reported if estimated emissions exceed any of the thresholds. The airport is defined as a 'facility' by this Act during both construction and operational phases.
National Greenhouse and Energy Reporting (Measurement) Determination 2008	Commonwealth Government	Provides methods for quantifying emissions from production and consumption of energy by a facility, and from operation of the facility.

Table 14-1 Summary of legislation and guidelines applicable to air quality and greenhouse gas emissions
Source: Perth Airport

Where there is both an AEPR limit and a National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) limit for the same pollutant and averaging period, the AAQ NEPM limit has been adopted as these limits are typically the most conservative and are applicable for assessments throughout Western Australia.

Emissions of lead have not been assessed as atmospheric concentrations of lead have rarely caused air quality impacts since the introduction of unleaded petrol. Assessment of total suspended particulates emissions has also been excluded, as Particulate Matter (PM) PM_{10} and $PM_{2.5}$ are both constituents of total suspended particulates and it is considered that, provided PM_{10} and $PM_{2.5}$ limits are satisfied, total suspended particulates limits will also be satisfied. A summary of limits and criteria is provided in Table 14-2.

Pollutant	Criterion	Averaging Period	Legislation
Carbon Monoxide (CO)	9 ppm[1] or 10,000 μg/m³	8 hours	AAQ NEPM
Nitrogen Dioxide (NO_2)	0.16 ppm or 328 μg/m³	1 hour	AEPR
	0.12 ppm[1] or 246 μg/m³	1 hour	AAQ NEPM
	0.03 ppm or 62 μg/m³	1 year	AAQ NEPM
Photochemical oxidants (as ozone, O_3)	0.10 ppm[1] or 214 μg/m³	1 hour	AAQ NEPM/AEPR
	0.08 ppm[1] or 171 μg/m³	4 hours	AAQ NEPM/AEPR
Particulate matter less than 10 μm diameter (PM_{10})	50 μg/m³	1 day	AAQ NEPM
	25 μg/m³	1 year	AAQ NEPM
Particulate matter less than 2.5 μm diameter ($PM_{2.5}$)	25 μg/m³	1 day	AAQ NEPM
	8 μg/m³	1 year	AAQ NEPM
Sulfur dioxide (SO_2)	0.25 ppm or 712 μg/m³	10 minutes	AEPR
	0.20 ppm[1] or 570 μg/m³	1 hour	AAQ NEPM/AEPR
	0.08 ppm[1] or 228 μg/m³	1 day	AAQ NEPM
	0.02 ppm or 60 μg/m³	1 year	AAQ NEPM
Lead	0.50 μg/m³	1 year	AAQ NEPM
	1.5 ppm	3 months	AEPR
Total Suspended Particulates	90 μg/m³	1 year	AEPR
Benzene	0.003 ppm or 9.7 μg/m³	1 year	Air Toxics NEPM
Benzo(a)pyrene	0.3 ng/m³or 0.0003 μg/m³	1 year	Air Toxics NEPM
Formaldehyde	0.04 ppm or 44 μg/m³	1 day	Air Toxics NEPM
Toluene	1 ppm or 4,000 μg/m³	1 day	Air Toxics NEPM
	0.1 ppm or 400 μg/m³	1 year	Air Toxics NEPM
Xylene	0.25 ppm or 1,188 μg/m³	1 day	Air Toxics NEPM
	0.2 ppm or 950 μg/m³	1 year	Air Toxics NEPM
Odour	2 OU/m³, 99.5th percentile	3 minutes	EPA Guidance Statement No. 47
	4 OU/m³, 99.9th percentile	3 minutes	EPA Guidance Statement No. 47

[1] 1 day of exceedances per year allowed by AAQ NEPM

Table 14-2 Air quality criteria relevant to the assessment of the New Runway Project
Source: AEPR, AAQ NEPM, Air Toxics NEPM

Greenhouse gas emissions reporting thresholds for facilities and corporations are summarised in Table 14-3. The facility thresholds apply to Perth Airport and its annual reporting requirements.

Entity type	Threshold Greenhouse Gas Emissions (Scope 1 & 2) (kt CO_2-e)	Energy usage (Tera Joules)
Corporate	50	200
Facility	25	100

Table 14-3 Summary of national greenhouse gas and energy reporting thresholds
Source: DCCEE 2007

14.4 Significance Criteria

The State Department of Water and Environmental Regulation (DWER) uses the parameter of 'Air Quality Index' (AQI) to describe air quality within Western Australia. AQIs describe the percentage of the AAQ NEPM Standard reached for each pollutant (e.g. if levels of $PM_{2.5}$ are equal to the AAQ NEPM for that averaging period, the AQI will be a value of 100). The AQI is determined for each pollutant and averaging period, and the AQI for the assessment is taken as the maximum of each pollutant. The key used by the DWER is presented in Table 14-4.

The classifications detailed in Table 14-4 were used in this assessment to classify the baseline air quality for each pollutant and averaging period (based on the maximum predicted concentration at the worst-case receptor). The impact of each future scenario for each pollutant was determined by comparing the AQI for all future scenarios (opening year and 20 years post-opening referred to as AQI_{future}) to the baseline AQI (referred to as $AQI_{baseline}$) according to Table 14-6. In addition to considering the AQI at each receptor, classification of impact significance considered the ground-level concentration (GLC) contours to identify the extent of impacts.

Air Quality Description	AQI Range
Extreme	200 +
Very poor	150 – 200
Poor	100 – 149
Fair	67 – 99
Good	34 – 66
Very good	0 – 33

Table 14-4 Regional air quality description by the measured Air Quality Index
Source: Department of Water and Environmental Regulation 2017a

The impact significance criteria adopted for assessment of greenhouse gas emissions in this study are presented in Table 14-2. Australia has a commitment to reduce the nation's future greenhouse gas emissions, which includes a targeted reduction of emissions to five per cent below 2000 levels by 2020, and further reductions for future years. Use of this target to assess impacts of the NRP is not considered appropriate as Perth Airport's emissions relative to national GHG emissions are insignificant – transport emissions account for 16 per cent of Australia's greenhouse gas emissions (DoE, 2016[b]), with Perth Airport's contribution to transport emissions accounting for only 0.03 per cent (refer Table 14-5). It is therefore unlikely that any changes to Perth Airport's emissions will affect Australia's performance in achieving the future targeted greenhouse gas emission reduction. Development of a more suitable method for assessing greenhouse gas impacts due to the NRP was therefore necessary.

In contrast to Australia's targeted greenhouse gas reductions, emissions from the transport sector are predicted to continue to increase due to population growth (DEE, 2016). It is therefore reasonable to expect that greenhouse gas emissions from Perth Airport will increase in a similar fashion to cater for the increased demand. The greenhouse-gas significance criteria are based on Perth Airport's annual greenhouse gas emissions relative to those from Australia's transport sector, shown in Table 14-5, termed the Greenhouse Gas Index (GHGI) in this study.

Greenhouse gas emission significance criteria for the construction phase of projects are not commonly used. Assessment of construction greenhouse gas emissions is complicated as various parties can contribute to these emissions (e.g. different contractors). The method used to assess operational greenhouse gas impacts for this study was also adopted to assess impacts from construction emissions. Based on the expectation that construction will be completed over an approximate four-year period, annual construction emissions were determined and assessed. Annual greenhouse gas emissions from Australia's transport sector for the year 2019 were conservatively adopted for the assessment.

Emission Source	Emissions (t CO_{2-e})			
	2016	2019	2025	2045
Australia's transport sector	90,300,000	94,600,000	100,000,000	105,400,000
Perth Airport (Scope 1 and Scope 2)	27,500	Refer to Section 14.6.3 for estimates		
Baseline emissions as percentage of transport sector (percent) ($GHGI_{baseline}$)	0.03			

Table 14-5 Summary of greenhouse gas emission projections used for significance assessment
Source: Aurecon 2017a

Significance criteria used in the assessment of potential impacts of emissions to air associated with the NRP are described in Table 14-6.

Magnitude Description	Specialist Criteria Air Quality	Specialist Criteria Greenhouse Gas
Major adverse	AQI_{future} > 100, where AQI_{future} is at least one classification higher than that for $AQI_{baseline}$ (e.g. AQI_{future} is poor but $AQI_{baseline}$ is fair). Many sensitive receptors (i.e. residential, child-care centre) are affected for long-term averaging periods (one year), and repeatedly for short term averaging periods (less than one year).	**Operation:** Contribution of Perth Airport's Scope 1 and Scope 2 emissions to national transport emissions is significantly higher relative to baseline – $1.5(GHGI_{baseline}) < GHGI_{future}$ **Construction:** $GHGI_{construction} > GHGI_{baseline,}$ and $GHGI_{construction} \geq 0.20$
High adverse	AQI_{future} > 100, where AQI_{future} is at least one classification higher than that for $AQI_{baseline}$ (i.e. AQI_{future} is poor but $AQI_{baseline}$ is fair). A few sensitive receptors are affected for long-term averaging periods, and repeatedly for short-term averaging periods.	**Operation:** Contribution of Perth Airport's Scope 1 and Scope 2 emissions to national transport emissions is noticeably higher relative to baseline - $GHGI_{future} < 1.5(GHGI_{baseline})$ **Construction:** $GHGI_{construction} > GHGI_{baseline,}$ and $0.10 \leq GHGI_{construction} \leq 0.20$
Moderate adverse	AQI_{future} > 100, where AQI_{future} is at least one classification higher than that for $AQI_{baseline}$ (e.g. AQI_{future} is poor but $AQI_{baseline}$ is fair). A few non-sensitive receptors (e.g. industrial areas, roads, car parks) are affected for long term averaging periods, and/or repeatedly for short term averaging periods.	**Operation:** Perth Airport's Scope 1 and Scope 2 emissions have a higher contribution to national transport emissions relative to baseline – $GHGI_{future} < 1.4(GHGI_{baseline})$ **Construction:** $GHGI_{construction} > GHGI_{baseline,}$ and $0.05 < GHGI_{construction} \leq 0.01$
Minor adverse	AQI_{future} > 100, where AQI_{future} is at least one classification higher than that for $AQI_{baseline}$ (i.e. AQI_{future} is poor but $AQI_{baseline}$ is fair). A few receptors are affected for short-term averaging periods only. Exceedances occur only within the site boundary.	**Operation:** Perth Airport's Scope 1 and Scope 2 emissions have a slightly higher contribution to national transport emissions relative to baseline –$GHGI_{future} < 1.25(GHGI_{baseline})$ **Construction:** $GHGI_{construction} > GHGI_{baseline,}$ and $GHGI_{construction} \leq 0.05$
Negligible	$AQI_{future} > AQI_{baseline}$, but $AQI_{future} < 100$.	**Operation:** Contribution of Perth Airport's Scope 1 and Scope 2 emissions to national transport emissions is similar relative to baseline – $GHGI_{future} < 1.1(GHGI_{baseline})$ **Construction:** $GHGI_{construction} \leq GHGI_{baseline}$
Beneficial	$AQI_{future} < AQI_{baseline}$	**Operation only:** Perth Airport's Scope 1 and Scope 2 emissions have a smaller contribution to national transport emissions relative to baseline – $GHGI_{future} < GHGI_{baseline}$.

Table 14-6 Significance criteria - air quality greenhouse gas
Source: Aurecon 2017a

Likelihood of impacts were classified in accordance with the process discussed in Section 8. The highest-rated impact for a single pollutant, for each scenario, was used as the impact significance for that scenario and then combined with the relevant likelihood of the impact to determine the resulting risk level.

A significance criteria for odour has not been included. While issues with odour were assessed and are detailed within this section, most of the impacts were not considered to result from the NRP. Risks of odour impacts were determined to be low both before and after applying additional mitigation measures.

14.5 Air Quality

While Perth enjoys relatively good air quality compared to many cities around the world, it can still impact susceptible people and ground-level concentrations can still exceed current air quality standards. Both short-term and long-term exposure to air pollutants can cause health problems. Therefore, it is important to consider impacts to air quality from the NRP project.

14.5.1 Methodology

Four scenarios were assessed:

- Baseline - reflective of current operations (based on 2016 data),
- Opening with NRP - reflective of operations in 2025 with the NRP,
- Opening without NRP- reflective of operations in 2025 without the NRP, and
- 20 years - reflective of operations 20 years after opening the NRP (2045) with the NRP.

The baseline assessment establishes air quality and greenhouse gas emission impacts caused by current ground-based operations at the airport, enabling assessment of future impacts caused by the NRP.

Scenarios with and without the NRP for the opening year have the same projected number of annual and daily aircraft movements.

The air quality assessment for the NRP consists of two separate studies: an assessment of dust impacts during construction; and an assessment of operational impacts (relating to ground-based emissions). Each study is discussed in detail below, including modelling methods.

14.5.1.1 Operational Emissions

Air emissions for an emission source are typically calculated by multiplying an activity rate with an emission factor and, where appropriate, a control factor. An emission factor provides a relationship between the amount of emissions that are released, and the emission-producing activity. The activity rate describes the amount of activity conducted and the total emissions produced (e.g. an activity conducted for one-hour will produce more emissions than an activity conducted for 15 minutes). A control factor describes the reduction in an activity's emissions due to emission controls (e.g. water sprays during construction activities) which may be used. A control factor of one means emissions are completely controlled, a factor of zero means that no emission control is employed.

A summary of emission sources and corresponding data inputs included in the operational air quality assessment is provided below in Table 14-7.

Hourly emissions were estimated based on operations representative of those conducted on a typical day of the assessment year and consider significant ground-based emission sources which are controlled by Perth Airport and any of its tenants (including airlines and their use of GSE but excluding the operation of aircraft).

This assessment is considered conservative, as likely future industry improvements to APUs and GSE have not been considered. These include development and use of electric GSE and increasing combustion engine emission requirements (e.g. implementation of Euro 6, a European Emission Standard for light passenger and commercial vehicles). Likely changes to future ambient levels of pollutants have also not been considered. For the example, increased restrictions on use of wood-fire heaters and improvements to combustion technology are expected to reduce ambient levels.

14.5.1.2 Construction Emissions

The construction air-quality assessment considered impacts from dust-generating activities only. Although vehicles and machinery with diesel-combustion engines will be deployed to carry out construction activities, emissions from construction-related fuel combustion are typically insignificant for nearby sensitive receptors. Assessment of dust impacts on occupational health and safety was also excluded, as it is assumed site controls adopted as part of the NRP's construction environmental management plan (CEMP) will sufficiently mitigate this impact.

The proposed construction program for the NRP and information available in the NPI's Emission Estimation Technique Manual for Mining version 3.1 (2012a) were studied to determine expected construction-activity levels for assessment of the NRP's proposed construction design.

Emission Source	Data Input	Source of Emission Factors
Ground service equipment (GSE) Auxiliary powered units (APUs)	2016 aircraft movements (as landing take-off cycle) sourced from Airservices and Perth Airport. Projected aircraft movements sourced from Perth Airport.	Emission estimation technique manual for airports (National Pollution Inventory, 2008). Benchmarking against other Australian airports. Aviation Environmental Design Tool.
Fuels and organic liquid storage	Perth Airport National Pollution Inventory Report 2015-2016	Emissions estimation technique manual for fuel and organic liquid storage (National Pollution Inventory, 2012).
Cogeneration plant	Perth Airport National Pollution Inventory Report 2015-2016	Emissions estimation technique manual for fossil fuel electric power generation (National Pollution Inventory, 2012).
Road traffic	Perth Airport (2017) and Aurecon (2017)	World Road Association.

Table 14-7 Summary of emission sources and data inputs for air quality assessment
Source: Aurecon

Construction activities identified as those likely to generate the most significant amount of dust emissions during construction are detailed in Table 14-8.

Source ID	Source/Activity	Release Height (metre)	Control Measure	Emission Reduction (per cent)	PM_{10} Emission Rate (grams per second)
1	Excavators/shovels/ front-end loaders on overburden	1	No control	0	0.06
2	Bulldozers on material	1	No control	0	2.26
3	Large trucks using unpaved roads	1	Level 1 watering assumed (two litres per square metre per hectare)	50	5.33
4	Scrapers removing topsoil	1	Soil artificially moist (i.e. water sprays)	50	0.02
5	Wind erosion from exposed areas	1	Water sprays	50	3.58
6	Grading of roads	1	No control	0	0.58
Total					**11.8**

Notes: The pollutant sources were modelled as a single area source.
The area of the pollutant-source is 129 hectares (i.e. area of vegetation to be cleared)

Table 14-8 Summary of New Runway Project construction emission sources
Source: Aurecon 2017a

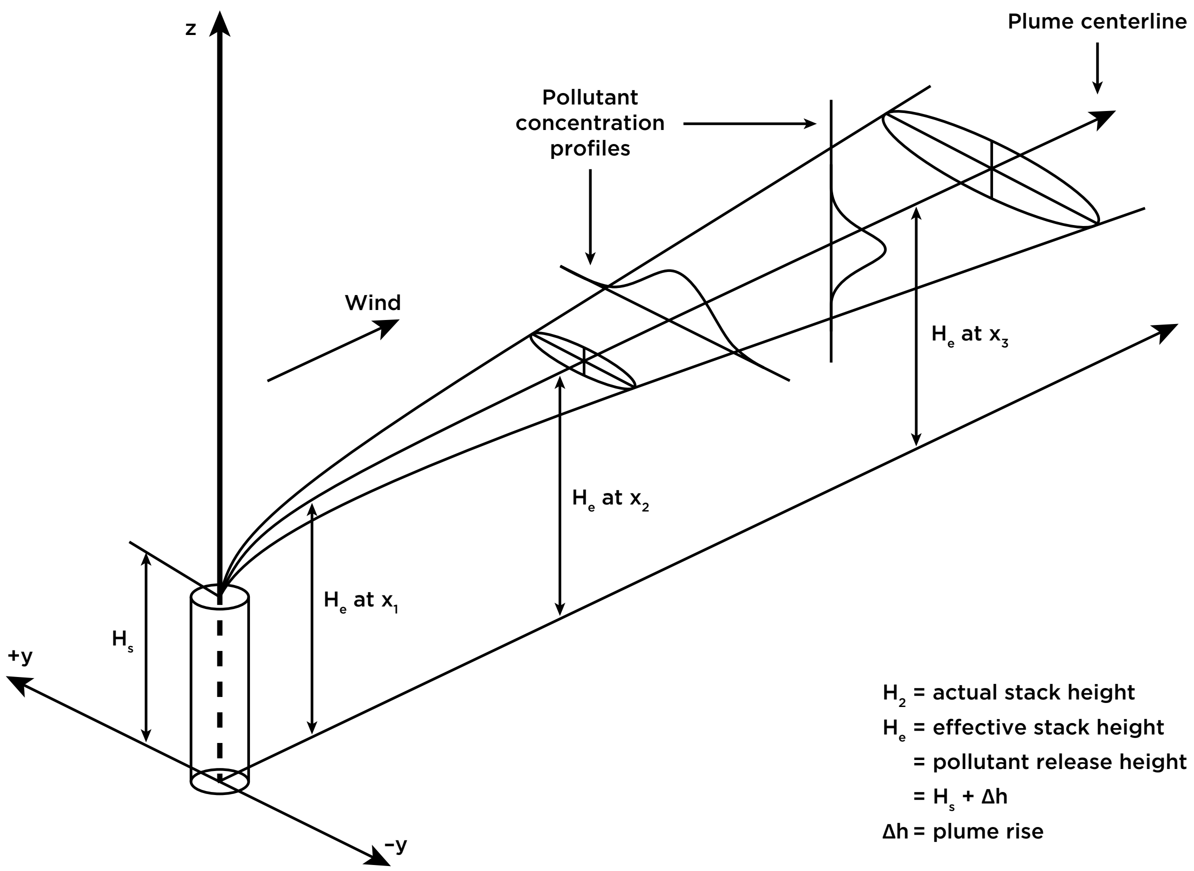


Figure 14-1 Image illustrating pollutant dispersion assumed in the Gaussian plume approach
Source: Aurecon 2017a

Likely air quality impacts of dust-generating construction activities were assessed via assessment of PM_{10}. Assessment of PM_{10} impacts is considered representative of impacts of Total Suspended Particulates. Due to the nature of activities conducted during construction, particulates tend to be relatively coarse. This means $PM_{2.5}$ impacts are considered less of a concern and so they have also been excluded from this assessment.

14.5.1.3 Modelling

The air dispersion model, AERMOD, was used for assessment of both operational and construction impacts. Although the State Department of Water and Environmental Regulation (DWER) does not typically prescribe required models, AERMOD is acknowledged as a frequently used and valid model according to the Western Australian modelling guidance. AERMOD is a US Environmental Protection Agency regulatory model which uses a Gaussian plume dispersion approach (Emission plumes follow the direction of the mean wind, with dispersion following a normal distribution in horizontal and vertical directions as shown in Figure 14-1). Modelling dispersion of pollutants using a Gaussian approach is considered a relatively conservative approach as, in reality, plume dispersion is affected over time by changes in wind speeds and direction over distance – more accurately represented by Lagrangian or Eulerian models. Notwithstanding this, the Gaussian model provides reliable estimates of ground-level concentrations.

Emission sources are modelled in AERMOD and combined with meteorology data specific to the NRP area to predict ground-level concentrations at receptor points. Using AERMOD, the following emission source types were used in the air quality assessment:

- point sources (e.g. cogeneration unit stack):
  - spatial location,
  - height above ground level that emissions are released at,
  - emission rate (grams per second),
  - internal diameter of release point, and
  - gas exit temperature and velocity.
- area sources (e.g. wind erosion of soil):
  - spatial location,
  - height above ground level that emissions are released at,
  - emission rate (grams per second metre squared), and
  - dimensions of area.
- volume sources (e.g. auxiliary power unit discharge):
  - spatial location,
  - emission rate (grams per second),
  - length of the volume's side (must be quadrilateral), and
  - height of volume.
- line sources (e.g, road traffic):
  - spatial location,
  - height above ground level that emissions are released at,
  - emission rate (grams per second), and
  - width of line.

14.5.1.4 Sensitive Receptors

A common methodology adopted for air quality assessments is to estimate pollutant concentrations at discrete locations (termed sensitive receptors) which are considered representative of public exposure in the area being investigated. The concentrations estimated at these receptor locations are then compared against relevant air quality criteria. Receptors typically represent locations which the public can access regularly. Sensitive locations such as schools, hospitals and residential properties are also typically identified.

The estate covers a large area and is surrounded by a high density of sensitive receptors. A series of off-estate receptor locations were identified including residential properties, community properties (including schools, child-care centres, aged-care facilities, recreational areas and places of worship), and work places located within industrial zones. Several on-estate receptors were also identified, corresponding to car parks, a child care centre and a work place.

For the ground-based operational assessment, air quality was assessed at a total of 57 receptors. Receptor locations are described in Table 14-9 and shown in Figure 14-2. They are categorised as community (considered sensitive), residential (considered sensitive); industry (considered less sensitive); off-site (places of worship, schools, child care, aged care facilities, considered sensitive); and on-site (locations within the estate which are accessible but persons are not expected to spend more than one hour are considered nonsensitive locations within the estate where persons are expected to spend more than one hour are considered sensitive).

ID	Description	Type	ID	Description	Type
R1	Ngala Early Learning Centre	On-site (S)	R30	Whiteside Street	Residential (S)
R2	Terminal 1 Short Term Car Park	On-site (NS)	R31	Love Street	Residential (S)
R3	Terminal 2 Short Term Car Park	On-site (NS)	R32	Guilfoyle Green	Residential (S)
R4	Terminal 3 and Terminal 4 Short Term Car Park	On-site (NS)	R33	Forster Park	Community (S)
R5	Mulberry Tree Child Care	Off-site (S)	R34	Mack Place	Residential (S)
R6	Belmay East Pre-School Centre	Off-site (S)	R35	Pioneer Park	Community (S)
R7	Redcliffe Park	Community (S)	R36	Maida Vale Road	Residential (S)
R8	Ollie Worrell Reserve	Community (S)	R37	Sultana Road West	Residential (S)
R9	Kids HQ Child Care	Off-site (S)	R38	Nardine Close	Residential (S)
R10	Great Eastern Highway Site 1	Residential (S)	R39	Belgravia Street	Residential (S)
R11	National Lifestyle Villages Hillview	Off-site (S)	R40	Abernethy Road Site 1	Industry (NS)
R12	Aurora Entrance	Residential (S)	R41	Hudswell Road	Industry (NS)
R13	Waterhall Road	Residential (S)	R42	Abernethy Road Site 2	Industry (NS)
R14	Queens Road Arboretum	Community (S)	R43	Abernethy Road Site 3	Industry (NS)
R15	Fleming Reserve	Community (S)	R44	Glassford Road	Industry (NS)
R16	Koel Court	Residential (S)	R45	Onsite industry	On-site (NS)
R17	Palmer Court	Residential (S)	R46	Casella Place	Industry (NS)
R18	Central Avenue	Residential (S)	R47	Abernethy Road Site 4	Industry (NS)
R19	Coolgardie Avenue	Residential (S)	R48	Mustang Court	Residential (S)
R20	Middleton Park	Community (S)	R49	Worrell Avenue	Residential (S)
R21	Coolbarro Lane	Residential (S)	R50	Great Eastern Highway Site 2	Industry (NS)
R22	Hoskin Street	Residential (S)	R51	Reid Street	Residential (S)
R23	Pindi Court	Residential (S)	R52	Hyland Street	Residential (S)
R24	Hatch Court	Residential (S)	R53	Peter Road	Residential (S)
R25	Upwood Circuit	Residential (S)	R54	Citrus Grove	Residential (S)
R26	St Maria Goretti's Catholic School	Off-site (S)	R55	Gregory Street	Residential (S)
R27	Redcliffe Primary School	Off-site (S)	R56	Newburn Road	Residential (S)
R28	Bulong Avenue	Residential (S)	R57	General Aviation (GA)	On-site (NS)
R29	Anglican Church of Australia	Off-site (S)			

Note: (S) = sensitive and (NS) = non-sensitive

Table 14-9 Receptors assessed in air quality and greenhouse gas study
Source: Perth Airport

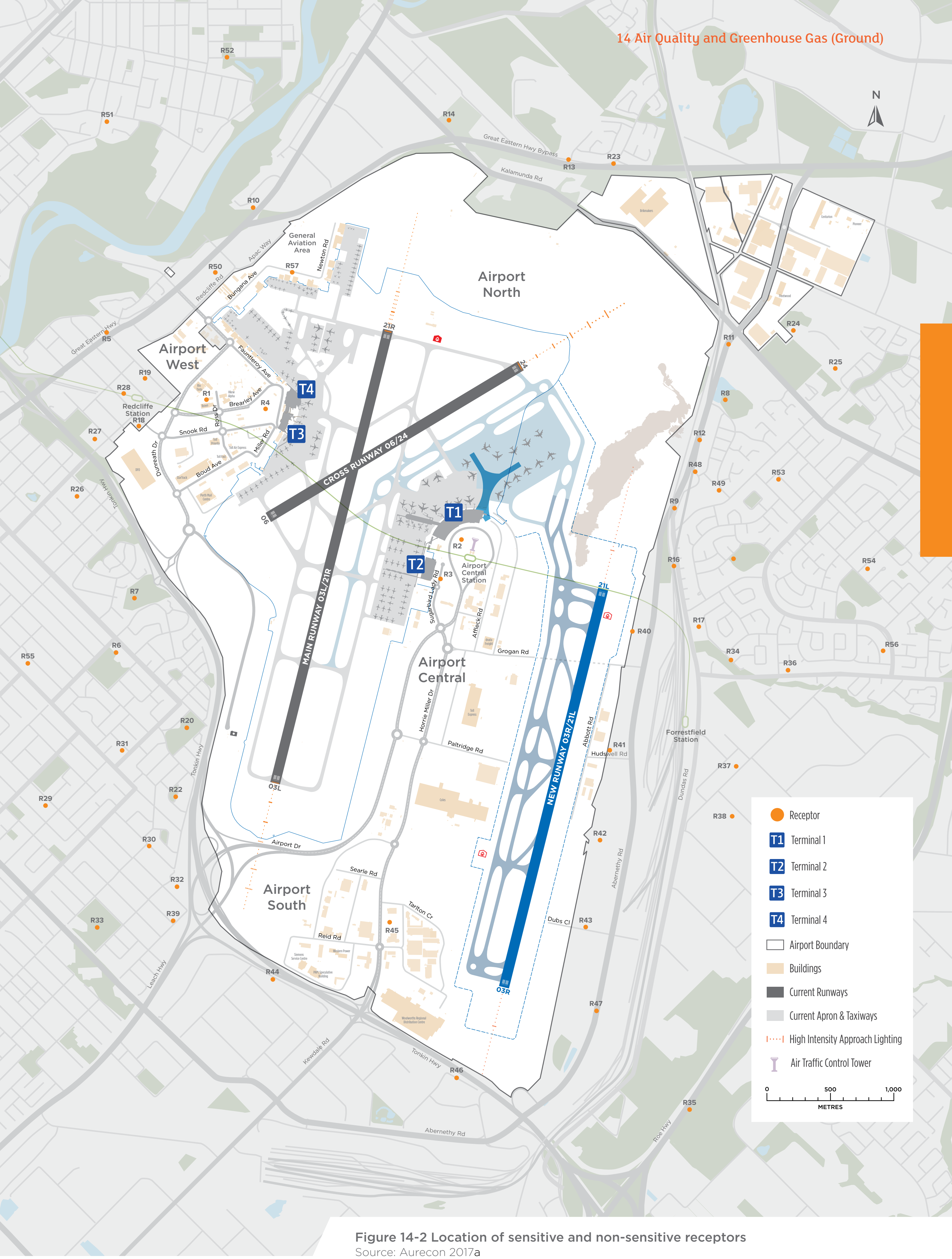


Figure 14-2 Location of sensitive and non-sensitive receptors
Source: Aurecon 2017a

14.5.1.5 Meteorology Input

Meteorology is fundamental to the dispersion of pollutants. It is therefore important to carefully consider the meteorological data (particularly wind and atmospheric stability conditions) used when modelling pollutant dispersion.

The dispersion of pollutants is primarily influenced by the following meteorological factors:

- wind speed and direction,
- vertical wind and turbulence intensity profile (which are affected by terrain),
- temperature gradient, which is determined from atmospheric stability and based on wind speed, cloud cover and solar radiation, and
- mixing height (depth of the atmospheric boundary layer).

Dispersion modelling using AERMOD requires suitable meteorological information. Additionally, the State Department of Environment specifies requirements for meteorological data as input for modelling. These requirements include using at least one year of meteorology data for the area which has high data recovery rate, collected in the immediate vicinity of the modelled emissions sources, and has verifiable data accuracy. Temperature, wind speed and wind direction was sourced from the Bureau of Meteorology for 2016.

14.5.1.6 Adopted Air Quality Background Concentrations

Assessment of air quality impacts from the NRP requires combining ground-level concentration contributions from the existing environment (background level) and the NRP (incremental) to determine the cumulative impacts. Background levels for all pollutants and averaging periods adopted for this assessment were selected from data monitored at Caversham and South Lake monitoring stations in 2015 as detailed in Section 14.5.2.3.

In the absence of specific requirements for selecting appropriate air quality background levels for assessments located in Western Australia, a review of requirements for other Australian States and Territories was completed.

Review of Requirements for Selecting Appropriate Background Levels

No specific guidance for selection of an appropriate background level is provided in the Western Australian 2006 Department of Environment document 'Air quality and air pollution modelling guidance notes'. Accordingly, guidance provided for other states and territories in Australia was reviewed.

New South Wales EPA legislation requires air quality impacts to adopt maximum values for background levels where hourly-varying contemporaneous data is not available. Maximum values are overly conservative and not representative of typical ambient concentrations and are often attributed to extreme events. Exceedances of short-term (averaging period of less than one year) limits for particulates (PM_{10} and $PM_{2.5}$) and ozone are particularly sensitive to occurrences of bushfires and scheduled burning for hazard reduction burning.

In Victoria, the State's Environment Protection Policy for Ambient Air Quality dictates that where hourly varying background levels are not available for an air-quality assessment using dispersion modelling, the seventieth percentile concentration (concentration which is exceeded by 30 per cent of concentrations for that averaging period) should be adopted as the background level.

In Queensland, air-quality assessment requirements are specified under each City Council's planning scheme. For assessments located in Brisbane, the seventieth percentile concentration should be adopted for assessment of all one-hour averaging periods, and can be used in place of contemporaneous data for eight-hour and 24-hour averaging periods.

Tasmanian draft guidelines specify that when nearby monitoring data is available the seventieth percentile concentration can be adopted as the background. Otherwise, the maximum concentration can be adopted for a basic screening model, or when more detailed data is available, hourly-varying contemporaneous background concentrations can be adopted.

No specific guidance regarding the appropriate background level to adopt is provided for assessment of developments in South Australia, Australian Capital Territory or the Northern Territory.

This review indicates a seventieth percentile concentration would be most suitable to include considering hourly-varying data was not available at the time of assessment.

Selected Background Levels

Ambient air-pollutant levels are available in the Western Australian annual AAQ NEPM compliance reports. In these reports, the DWER report seventy-fifth percentile concentrations rather than seventieth percentile. Therefore, based on the above review across other jurisdictions, the seventy-fifth percentile background concentrations for 2015 (latest reported date) were conservatively adopted in this assessment. These levels are summarised in Table 14-10. All adopted background levels satisfy the air quality limits, with the exception of the $PM_{2.5}$ annual averaging period.

Pollutant and averaging time	Background Level (µg/m³)	Criteria (µg/m³)
CO, eight hour	375	10,000
NO_2, one hour	41	246
NO_2, annual average	12	62
PM_{10}, 24 hour	20	50
PM_{10}, annual average	17	25
$PM_{2.5}$, 24 hour	10	25
$PM_{2.5}$, annual average	8.5	8
SO_2, ten minute[1].	33	712
SO_2, one hour	23	570
SO_2, 24 hour	9	228
SO_2, annual average	6	60
O_3, one hour [2]	79	214
O_3, annual average[3]	64	Not applicable

[1] The SO_2 background concentration for the ten-minute averaging period was estimated from the one-hour averaging period concentration using the Victoria EPA described conversion function (2013).
[2] Ozone is included for the purpose of conversion of NO_x to NO_2 only.
[3] No annual average was reported for O_3, instead the concentration was approximated as the 50th percentile of onehour average concentrations. There is no limit for O_3 as an annual average. The concentration is included only for the purpose of converting NO_x to NO_2.

Table 14-10 Background levels adopted for the air quality assessment of baseline conditions
Source: Aurecon 2017a

14.5.1.7 Assumptions and Modelling Inputs

Key assumptions adopted to complete air emission calculations for each emission source are detailed below.

General Assumptions

Emissions from APUs and GSE depend on the number of landing and take-off cycles. The amount of reported landing and take-off cycles are equivalent to half of the number of reported aircraft movements (an arrival or a departure). Calculation of annual emissions and emissions for operations on a typical day required the number of landing and take-off cycles for both of these situations, for each assessment scenario, as well as an hourly distribution of landing and take-off cycles for a typical day. The hourly distribution of landing and take-off cycles summarised in Table 14-11 for the baseline year was considered representative of future years and used for their assessment.

Assessment scenario	Annual landing take-off cycles	Typical daily landing take-off cycles
Baseline (2016)	66,241	223
Opening (2025), with the NRP	86,350	275
Opening (2025), without the NRP	86,350	275
20 years post-opening (2045), with the NRP	129,850	404

Table 14-11 Annual and daily landing and take-off cycles
Source: Perth Airport

Terminal	Per cent of movements at terminal for each assessment year		
	2016	2025	2045
Terminal 1	36	19	67
Terminal 2	17	18	16
Terminal 3	15	22	0
Terminal 4	20	21	0
General Aviation	12	20	17

Table 14-12 Distribution of aircraft movements by terminal for assessment of air emissions
Source: Perth Airport

The distribution of landing take-off cycles at each terminal, including the General Aviation area, are summarised in Table 14-12.

It has been assumed that, following the relocation of Qantas to Airport Central, Terminal 3 (T3) and Terminal 4 (T4) are not expected to be used for regular public transport operations.

Operation of Ground Service Equipment

The approach stipulated by the NPI Emission Estimation Technique Manual for Airports for GSE emissions estimates was adopted for this assessment and adjusted for the assessment year using the Aviation Environmental Design Tool and World Road Association-PIARC influencing factors. The approach assumes that the amount and type of GSE required for each aircraft is a function of aircraft size and type.

Area sources for each terminal were created to represent the area where GSE is expected to travel. Emissions were distributed among the terminal area sources using the hourly-based (see Figure 14-3) and terminal-based (see Table 14-12) distributions of landing take-off cycles.

GSE emission factors for the baseline year were conservatively adopted for assessment of future years as no significant changes in aircraft fleet are expected for the next ten to 20 years.

Operation of Auxillary Power Units

The NPI Emission estimation technique manual for airports provides a list of APUs typically used for each aircraft type, and emission factors per landing take-off. Movement data was analysed to determine the aircraft types which frequent Perth Airport most often for the baseline year. These aircraft were the Fokker F100 and Boeing 737-800, accounting for at least 40 per cent of all movements. Emission rates for the Boeing 737-800 APU (APU 131-9) are more conservative than those for the Fokker F100. Emission rates for the APU 131-9 were therefore considered representative of all APUs used by aircraft at Perth Airport and adopted for this assessment.

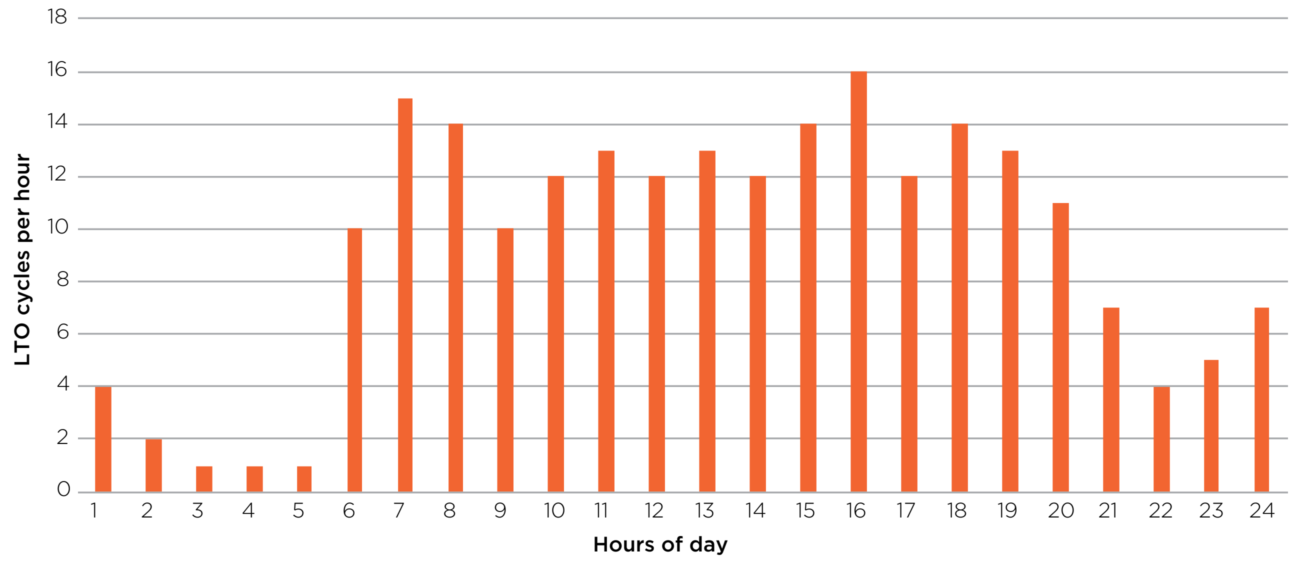


Figure 14-3 Hourly landing take-off cycles adopted for dispersion modelling of typical daily operations
Source: Perth Airport

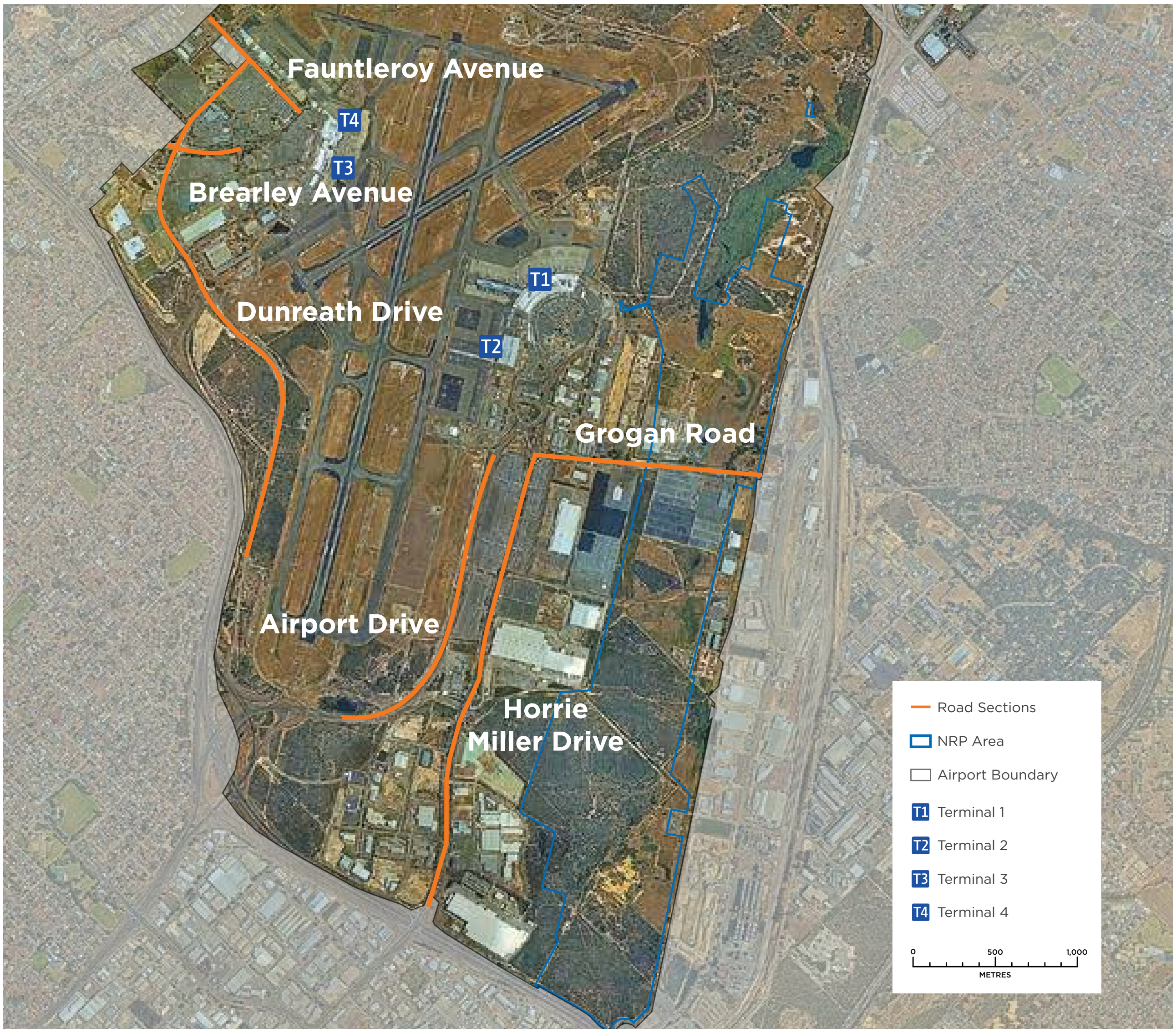


Figure 14-4 Aerial image of Perth Airport showing the estate and road sections included in air dispersion modelling
Source: Perth Airport, Google Earth

Only Terminal 1 (T1) and Terminal 2 (T2) have GPUs available. All landing take-off cycles using Terminal 1 and Terminal 2 were assumed to use a GPU,and all landing take-off cycles using the general aviation area, Terminal 3 and Terminal 4 assumed to use an APU. An APU operation time of 60 minutes per landing take-off was assumed. It is also assumed that use of a GPU provides the aircraft with electricity for ground-based operation and produces negligible air emissions.

APU emission factors for the baseline year were conservatively adopted for assessment of future years as no significant changes in aircraft fleet are expected for the next ten to 20 years.

Fuels and Organic Liquid Storage

Only data reported in the Perth Airport 2015-2016 NPI report and on the NPI website was considered for assessment of the baseline year. Sufficient data relating to fuel storage of tenants was not available to allow emissions modelling. However, the NPI website shows that BP has a site within the estate that released 11,000 kilograms of total volatile organic-compound emissions (VOC) in the 2015/2016 financial year. A quantity of 64 kilograms of total VOC emissions from Shell, located within the estate, were also reported but considered negligible compared to other emission sources and so omitted from this study. Although BP emissions were excluded from modelling, they were included in the annual emission summary.

Within the NPI report, VOC emissions for Perth Airport fuel storage were only reported for an underground horizontal fixed-roof tank. It is assumed that the compounds are released at ground-level from an area such as a manhole. Based on the NPI report, it is assumed that this fuel tank serves stationary engines (including lighting towers). The source was located on this basis.

In the absence of more accurate data, negligible increase in emissions from fuels and organic liquid storage was assumed for future years. This assumption is considered appropriate because baseline fuels and organic liquid storage emissions for both Perth Airport and BP demonstrated significant reductions compared to the previous year.

Stationary Engines

Only data reported in the Perth Airport 2015/2016 NPI report and annual emissions were considered for assessment. However, due to the nature of stationary engines used by Perth Airport (such as backup power and mobile lighting towers), these emission sources were excluded from dispersion modelling as they do not represent typical operational conditions.

In the absence of more accurate data, negligible increase in emissions from stationary engines was assumed for future years compared to baseline emissions. This assumption is considered appropriate as the majority of baseline emissions from stationary engines for Perth Airport were due to operation of backup power generators and it is not unreasonable to assume future power outages will occur at a similar frequency.

Cogeneration Facility

Emissions from the cogeneration facility for the baseline year were estimated in accordance with the annual fuel usage detailed in the Perth Airport 2015/2016 NPI report. Emissions for a typical day were calculated assuming negligible change in hourly combustion rates.

Projected annual fuel usage for future assessment years was provided by Perth Airport.

Road Traffic

Projected road-traffic counts for assessment of air quality impacts in the opening year (2025) and 20 years post-opening (2045) will include growth due to operation of the new runway, and natural growth. To ensure this assessment quantifies impacts due to operation of the NRP only, emissions from road traffic on internal roads and main entry roads have been assessed. All vehicles were assumed to travel at a speed of 50 kilometres per hour. This is a conservative assumption given the posted speed for Horrie Miller Drive and Airport Drive is 70 kilometres per hour. The following roads were included in the assessment and are shown in Figure 14-4:

- Grogan Road,
- Horrie Miller Drive,
- Brearley Avenue,
- Fauntleroy Avenue,
- Airport Drive, and
- Dunreath Drive.

Representative road-traffic counts for 2016 were used in this assessment. Traffic projections were obtained from the traffic assessment for the NRP project as outlined in Section 18. Emissions from road traffic using Paltridge Avenue were excluded from assessment as its contribution was negligible compared to other roads.

Brearley Avenue was only included for assessment of baseline conditions, as the road was closed in January 2017 to allow construction of the Forrestfield-Airport Link.

Sulfur dioxide (SO_2) emissions from road traffic were not included in this assessment as the contribution is negligible compared to other sources and is not typically assessed for road projects.

An hourly traffic profile and percentage of commercial vehicles for each road for the baseline year was obtained from the NRP traffic assessment. Negligible changes to the traffic profile and percentage of commercial vehicles were assumed for future years.

Projected changes in road traffic emissions are well documented. Emission projections demonstrate a likely reduction in vehicle emissions due to more stringent emission standards. Changes in emissions (until the year 2036) specific to NSW are documented by the NSW EPA and were adopted for this assessment. It was assumed these changes were representative of those projected nationally. And conservatively assumed that no further emission reductions occur beyond 2036.

Tenant Emissions

Perth Airport tenants and their activities have the potential to produce significant emissions, including:

- fuel usage, and therefore fuel storage and emissions (i.e. Joint Oil Supply Facility and Joint User Hydrant Installations) are expected to increase with operation of the future NRP,
- emissions from Brikmakers and Fulton Hogan are not considered to be influenced directly by airport operations and have therefore not been included in the assessment of air quality and greenhouse gases. However, there is potential that these properties affect background odour levels, and
- emissions from Perth Mint are unrelated to airport operations and odour impacts have not been identified. These emissions are excluded from assessment.

Conversion of SO_x to SO_2

Concentration standards relevant to air emissions for this assessment exist for sulfur dioxide (SO_2). However, emission factors are provided for oxides of sulfur (SO_x). A conversion factor must be applied to predicted levels of SO_x to determine ground-level concentrations of SO_2. A conversion factor of one (i.e. all SO_x emissions are in the form of SO_2) has been conservatively adopted for this assessment.

Conversion of PM_{10} to $PM_{2.5}$

Emission factors for particulate matter with diameter less than 2.5 µm ($PM_{2.5}$) are typically not available and must be determined from PM_{10} (particulate matter with diameter less than ten µm) emission factors. This assessment has conservatively adopted the approach that 97 per cent of PM_{10} is $PM_{2.5}$, as per the conversion factor specified by the NPI Emission Estimation Technique Manual for Airports for combustion of diesel. This assumption is considered appropriate as GSE and road traffic both consume diesel and are key emission sources of particulate matter.

The AAQ NEPM limits for $PM_{2.5}$ are expected to be made more stringent by 2025, with the 24-hour averaging period limit reduced from the current 25 µg/m³ to 20 µg/m³ and the current annual averaging period limit reduced from 8 µg/m³ to 7 µg/m³. This study has adopted these lower limits for assessment of 2025 and 2045 scenarios.

Conversion of NO_x to NO_2

Concentration standards relevant to air emissions for this assessment exist for nitrogen dioxide (NO_2). However, emission factors are provided for oxides of nitrogen (NO_x). The amount of NO_2 present in exhaust from combustion of fuels varies greatly between vehicle and engine types. Additionally, following release of NO_x to the atmosphere, complex photochemical reactions of atmospheric ozone and NO_x occur which produces additional quantities of NO_2. The quantity of NO_2 produced from reactions with ozone (O_3) varies depending on the quantity of ozone available in the atmosphere which is reliant on several factors including location, time of day and date.

A number of approaches are available for estimating transformation of NO_x to NO_2 that occurs post exhaust discharge. The ozone limited method has been adopted for this assessment, as detailed in the NSW Department of Environment and Conservation document 'Approved methods for the modelling and assessment of air pollutants in New South Wales' (2016). The following equation has been used to calculate the ground-level concentrations GLCs of NO_2 from NO_x emissions:

$$[NO_2]_{total} = \{0.1 \times [NO_x]_{pred}\} + MIN\left\{0.9 \times [NO_x]_{pred}\ OR\ \left(\frac{46}{48}\right) \times [O_3]_{bkgnd}\right\} + [NO_2]_{bkgnd}$$

where:

- $[NO_2]_{total}$ = the total predicted concentration of NO_2 in µg/m³,
- $[NO_x]_{pred}$ = the predicted GLC of NO_x in µg/m³ from the dispersion model,
- MIN = the minimum of the two quantities included in the brackets,
- $[O_3]_{bkgnd}$ = the ambient/background concentration of O_3 in µg/m³ for the same averaging period,
- 46/48 = the molecular weight of NO_2 divided by the molecular weight of O_3, and
- $[NO_2]_{bkgnd}$ = the ambient/background concentration of NO_2 in µg/m³ for the same averaging period.

In accordance with the NSW Approved Methods (2016), the selected assessment type was Level 1 whereby the maximum predicted NO_x concentration was used. The background concentrations of O_3 and NO_2 adopted for the conversion are detailed in Section 14.5.1.6.

Conversion of Total Volatile Organic Compounds to Air Toxics

Air quality impacts of VOCs are typically determined by the assessment of individual pollutants. Emissions of total volatile organic compounds (TVOCs) have been calculated, consisting of a number of pollutant species.

Species investigated in this assessment are those regulated by the Air Toxics NEPM (refer to Table 14-2) and are benzene, toluene, formaldehyde, xylenes and benzo(a)pyrene.

The majority of TVOC emissions are produced from the combustion of fuel, particularly diesel, in mobile engines. The diesel vehicle exhaust organics speciation described in the NSW EPA Technical Report No. 7 was adopted.

The effect of biogenic TVOCs has not been considered in this assessment. However, it is noted that biogenic compound emissions are significant in Perth and its surroundings.

14.5.2 Existing Conditions

Terrain, ambient air quality and sensitive-receptor locations influence air quality at sensitive receptor locations at Perth Airport and surrounding areas.

14.5.2.1 Terrain

Perth Airport is located approximately 19 kilometres inland from the coast and approximately one kilometre south of the Swan River. The proximity of the coast to the estate may influence the local climate.

Located just over six kilometres to the east is the Darling Scarp. Terrain in all other directions is relatively flat. Presence of the Scarp has potential to limit dispersion of air pollutants in the flat region surrounding the estate.

14.5.2.2 Sensitive Receptors

In Western Australia impacts to air quality sensitive receptors are defined as per the DWER's 'A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities' published in January 2011.

Sensitive receptors are defined as the following premises (which may exist now or in the future):

- residential dwellings,
- schools,
- hospitals,
- nursing homes,
- child-care facilities,
- offices,
- public recreation areas, and
- protected wetlands.

Sensitive receptors located closest to a significant emission source are most likely to be exposed to adverse air quality. Aerial imagery and land use zoning maps were used to identify relevant sensitive receptors.

Land use zoning for Perth Airport and its surrounds is shown in Figure 14-5. Much of the land surrounding the estate is classified as urban and contains sensitive receptors. The following observations were made from inspection of land use zoning and aerial imagery:

- sensitive receptors are located in high density within urban zones, predominantly residential properties,
- sensitive receptors exist in medium to low density within rural zones, and
- many public properties are located near the airport, including schools, halls and nursing homes.

Some receptors may have a heightened sensitivity to air quality, particularly those that support the elderly and young.

Several industrial zones are located near the airport. Properties within these industrial zones contain emission sources which affect local air quality. A map which shows emissions reported to the National Pollutant Inventory (NPI) in areas surrounding Perth Airport is provided in Figure 14-6. This map shows a high density of NPI reported emissions within the southern industrial zone. Emissions from these sources are mainly VOCs and likely to impact sensitive receptors located to the south west of the estate.

Additionally, an abundance of vegetation and forestry is located to the east of the estate at Kalamunda National Park and surroundings. This vegetation generates biogenic VOCs, the amount of which is expected to exceed industrial sources. Biogenic VOC species are not NPI-listed pollutants.

14.5.2.3 Ambient Air Quality

To enable assessment of potential impacts of the NRP against the relevant air-quality assessment criteria, it is necessary to establish background concentrations of pollutants so that the cumulative impact (emissions from the airport plus ambient concentrations) can be assessed.

The DWER operates an air-pollutant monitoring network throughout Western Australia consisting of 13 stations. Eight of these sites are within the Perth metropolitan area, with the three closest locations to Perth Airport shown in Figure 14-7. Caversham (CA) monitoring station is located closest to estate, thus air quality monitoring data for all pollutants (other than SO_2) collected from the CA monitoring station between 2011 and 2015 (most recent data) were used to establish existing air quality at Perth Airport and compared against the relevant air-quality criteria. SO_2 is not monitored at CA, and so SO_2 levels collected at the South Lake (SL) monitoring station were used because SL is the closest monitoring station which records SO_2.

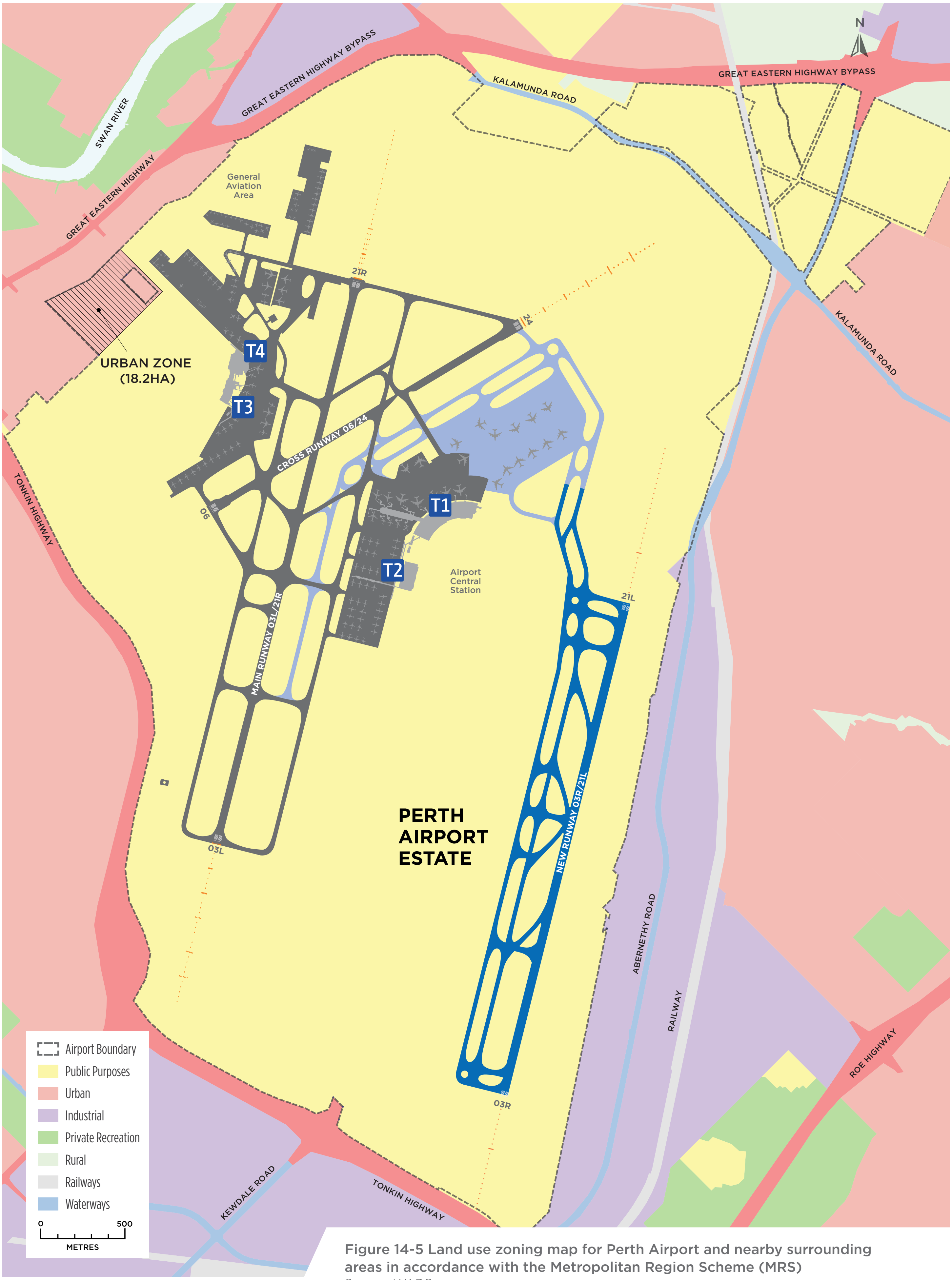


Figure 14-5 Land use zoning map for Perth Airport and nearby surrounding areas in accordance with the Metropolitan Region Scheme (MRS)
Source: WAPC

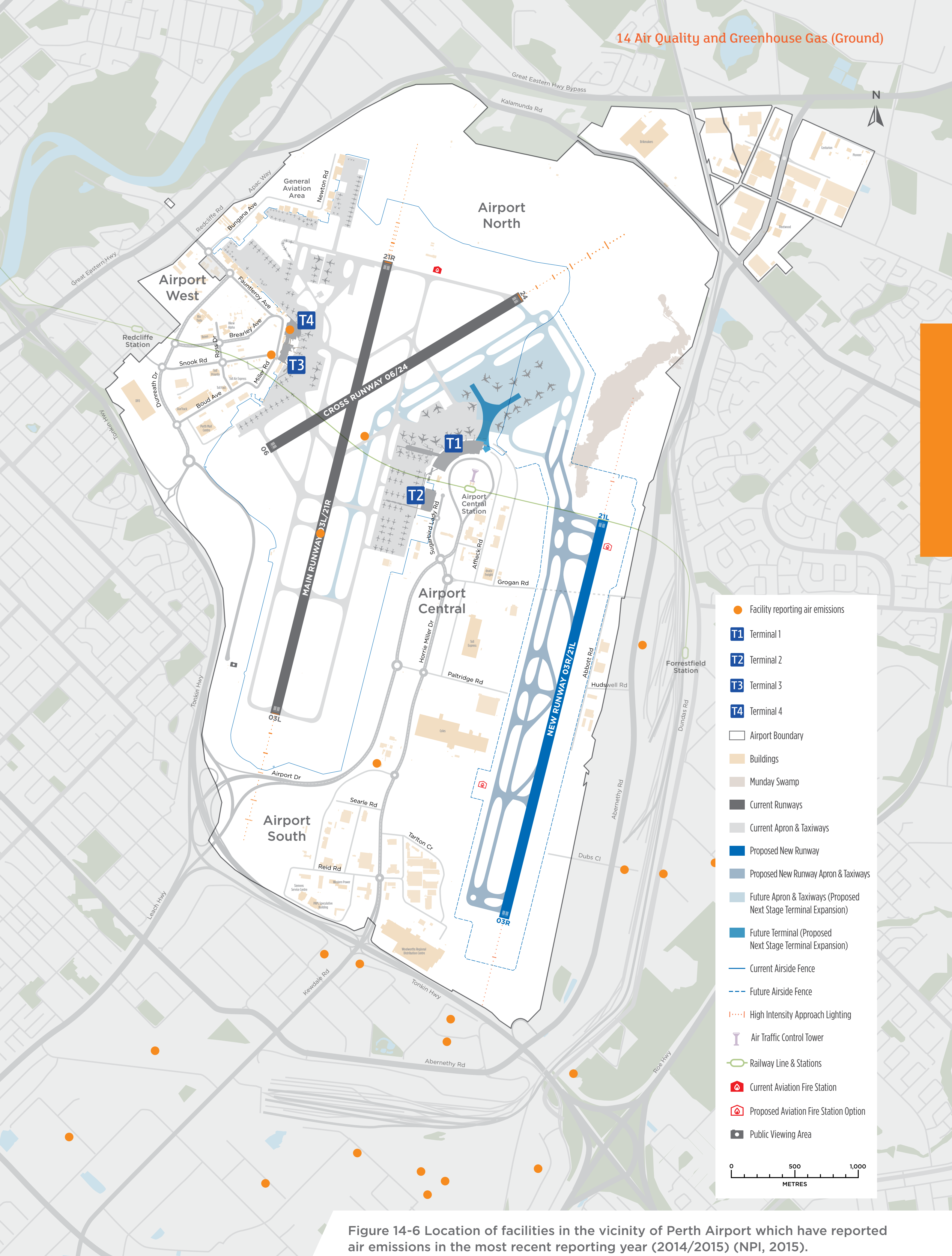


Figure 14-6 Location of facilities in the vicinity of Perth Airport which have reported air emissions in the most recent reporting year (2014/2015) (NPI, 2015).
Source: Aurecon 2017a

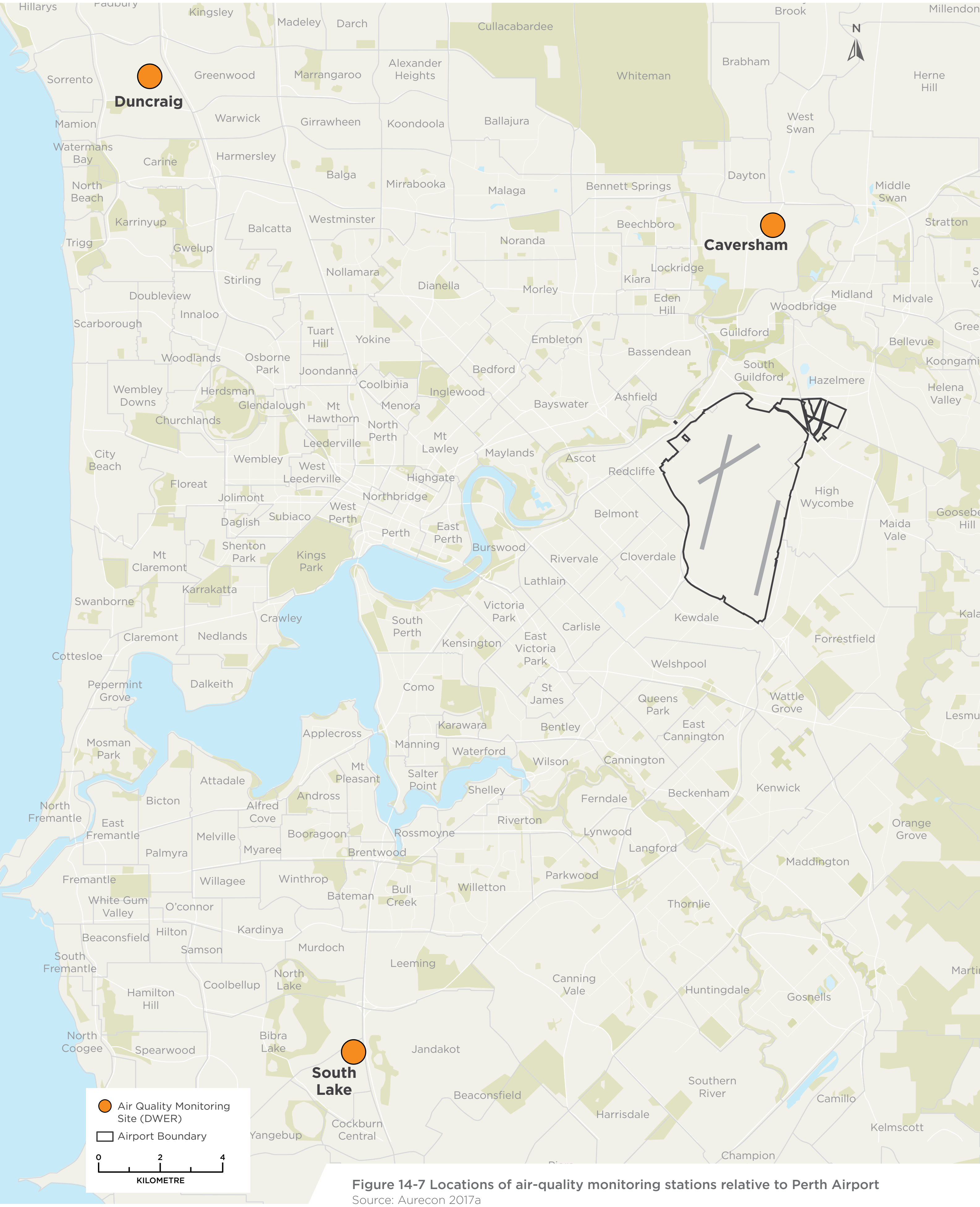


Figure 14-7 Locations of air-quality monitoring stations relative to Perth Airport
Source: Aurecon 2017a

A summary of the comparison between collated air-quality data and relevant criteria is provided below in Table 14-13.

Pollutant and averaging time	2011	2012	2013	2014	2015	Criteria	Notes
CO, 8 hour max. (ppm)	1.5	0.9	0.9	0.7	1.2	9	No exceedances
NO_2, 1 hour max. (ppm)	0.035	0.037	0.043	0.033	0.041	0.12	No exceedances
NO_2, annual ave. (ppm)	Met[1]	Met[1]	Met[1]	Met[1]	0.006	0.03	No exceedances
PM_{10}, 24 hour max.(µg/m³)	**76.1,(1)**	**68.7,(4)**	**62.4,(1)**	**52.6,(1)**	46.8	50	Exceedances due to: 2011 smoke haze 2012 - multiple events of smoke haze and one crustal event 2013 - smoke haze 2014 - bushfire
PM_{10}, annual ave. (µg/m³)	16.2	16.8	15.4	17.4	16.7	25	No exceedances
$PM_{2.5}$, 24 hour max. (µg/m³)	**41.5,(1)**	**45.9(3)**	22.6	**39.3,(1)**	**30,(5)**	25	Exceedances due to: 2012 - multiple events of smoke haze 2014 - bushfire 2015 - bush fires and prescribed burning (excluded from assessment)
$PM_{2.5}$, annual ave. (µg/m³)	7	7.8	7.9	**8.1**	**8.5**	8	No sites in Perth met criteria in 2015
SO_2, 1 hour max. (ppm)	0.044	0.039	0.044	0.051	0.037	0.2	SO_2 isn't monitored at Caversham. South Lake data was used as this station is most representative and closest. No exceedances.
SO_2, 24 hour max. (ppm)	0.006	0.006	0.014	0.01	0.007	0.08	
SO_2, annual ave. (ppm)	0.001	0.001	0.001	0.001	0.002	0.02	
O_3, 1 hour max. (ppm)	0.077	0.098	**0.101,(1)**	0.091	**0.103,(1)**	0.1	Exceedances due to: 2013 – inland event/wind conditions/ assessable 2015 – no exceptional circumstances
O_3, 4 hour max. (ppm)	0.063	**0.086,(2)**	0.075	0.073	**0.084,(1)**	0.08	Exceedances due to: 2012 – smoke induced 2015 – no exceptional circumstances

[1] No concentration value was available. The report only detailed that the limit had been met.
Note: Exceedances are shown in bold and number of exceedances shown in brackets.

Table 14-13 Ground-based air-quality monitoring area for the New Runway Project as recorded at the Caversham monitoring station
Source: Aurecon 2017a

Air quality around the Caversham monitoring station (and, therefore, the NRP area) is typically good with the exception of some isolated events and high pollution periods. Atmospheric levels of NO_2, CO and SO_2 remained well below the criteria, and have satisfied relevant criteria for at least the last five years.

Atmospheric levels of PM_{10} and $PM_{2.5}$ typically satisfy criteria except for days where a smoke haze over the Perth metropolitan area was observed due to bushfires and prescribed burning events. Most exceedances recorded over the last five years occurred during summer months, with no exceedances recorded during winter months. No exceedances of the annual averaging period criterion for PM_{10} have been recorded in the last five years. Over the last two years the $PM_{2.5}$ annual averaging period criterion has been exceeded at the Caversham monitoring station.

Ozone is the product of chemical reactions between reactive organic gases and oxides of nitrogen (NO_x) in the presence of sunlight, whereby the reactive organic gases are predominantly biogenic VOCs. Ozone concentrations close to the ground vary based on several factors including time of day, year and availability of nitrogen oxides; and tend to be highest during summer months when more sunlight is available. Ozone levels typically satisfy criteria, with only several exceedances recorded over the last five years. All exceedances occurred during summer.

In the last five years, maximum values for PM_{10} and $PM_{2.5}$ 24-hour average concentrations have decreased. This is likely due to implementation of more stringent emissions legislation and improved technology. Despite this, negligible change in annual average concentrations is observed. Maximum values of ozone one-hour average and four-hour average concentrations have shown a slight increase over the last five years. Negligible difference in maximum concentrations was observed for pollutants SO_2, CO and NO_2.

14.5.2.4 Existing Air Emissions

Assessment of existing (baseline) air emissions is necessary to establish current air impacts on receptors and the airshed. An airshed is a geographical area, in this case the area surrounding the Caversham monitoring location including the NRP area, that shares a common flow of air, with all parts of the area being subject to similar conditions. Air emission calculations used activity data for current operations during the baseline year. Relative contributions from emission sources are summarised in Table 14-14 and Figure 14-8.

It is apparent that emissions from airport-related road traffic dominate emissions of NO_x and TVOCs. The contribution from GSE dominates emissions of CO, while the contribution from APUs dominate emissions of SO_2, PM_{10} and $PM_{2.5}$. Emissions from operation of GSE, APUs and aircraft in idle mode are most significant for airport operations.

Maximum predicted incremental air pollutant concentrations and cumulative impacts at receptor locations, using the 2016 summary of air emissions described above, are summarised in Table 14-15. Cumulative impacts for SO_2 and CO are well below the criteria at all receptors for all averaging periods. Cumulative impacts for PM_{10} and NO_2 also satisfy the limits for all averaging periods. Air quality limits are exceeded for the $PM_{2.5}$ annual averaging period only. This is because the background concentration already exceeds the limit. All incremental impacts satisfy the limit.

The baseline air-quality index (AQI), a universal index used for reporting daily air quality, is also provided in Table 14-15, allowing assessment of future scenarios.

Source type	CO		NO_x		SO_2		PM_{10}		$PM_{2.5}$		TVOCs	
	Tonnes per year	per cent	Tonnes per year	per cent	Tonnes per year	per cent	Tonnes per year	per cent	Tonnes per year	per cent	Tonnes per year	per cent
GSE	95	49	12	13	1	19	1	14	1	14	5	11.1
APUs	18	9.0	24	26	4	80	3	47	3	48	1	3.4
Perth Airport fuel storage	0	0.0	0	0	0	0	0	0	0	0	<1	<0. 1
Stationary engines	<1	0.1	1	0.6	<1	<0.1	<1	0.6	0	0.6	<1	0.1
Cogeneration unit	2	0.8	11	12	0	0.9	1	8.2	0	8.4	<1	0.3
BP fuel storage	0	0	0	0	0	0	0	0	0	0	11	26.1
Road traffic	81	42	46	49	0	0.0	2	30	2	29	25	58.9
Total	**195**	**100**	**94**	**100**	**5**	**100**	**6**	**100**	**6**	**100**	**51**	**100**

Table 14-14 Air emissions as tonnes per year for baseline operations
Source: Aurecon 2017a

Pollutant	Averaging period	Maximum incremental receptor impact (µg/m³)	Maximum cumulative receptor impact (µg/m³)	Limit (µg/m³)	AQI	Air quality Class	Receptor
CO	8-hour	744	1,119	10,000	11	Very good	R50
SO_2	10-minute	245	278	712	39	Good	R4
	1-hour	172	195	570	34	Good	R4
	1-day	15	24	228	11	Very good	R57
	1-year	2	8	60	13	Very good	R57
PM_{10}	1-day	12	32	50	65	Good	R57
	1-year	1.4	18	25	72	Fair	R57
$PM_{2.5}$	1-day	12	22	25	88	Fair	R57
	1-year	1.3	**10**	8	**123**	**Poor**	R57
NO_2	1-hour	200	241	246	98	Fair	R4
	1-year	12	24	62	39	Good	R57
Formaldehyde	1-day	1.8	n/a[1]	44.0	4	Very good	R50
Benzene	1-year	0.02	n/a	9.7	0.24	Very good	R1
Benzo(a)pyrene	1-year	8.32_{E-05}	n/a	0.0003	28	Very good	R1
Toluene	1-day	0.09	n/a	4,000	<0.01	Very good	R50
	1-year	0.01	n/a	400	<0.01	Very good	R1
Xylene	1-day	0.07	n/a	1188	<0.01	Very good	R50
	1-year	0.01	n/a	950	<0.01	Very good	R1

[1] Cumulative impacts were not assessed for air toxic pollutants. Note: Refer to Table 14-9 for receptor details.

Table 14-15 Maximum predicted cumulative impacts at receptors
Source: Aurecon 2017a

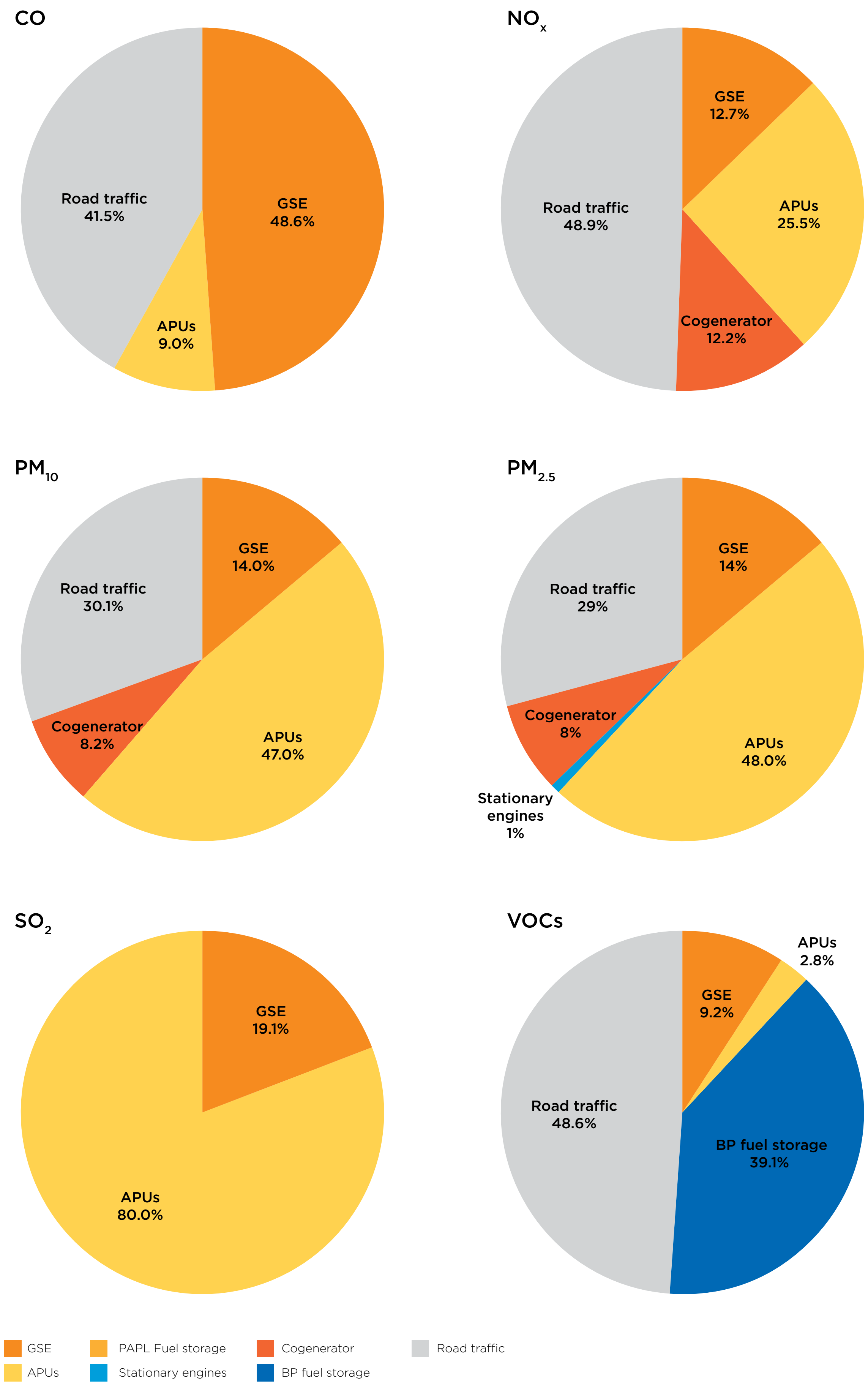


Figure 14-8 Estimated emissions for airport related activities within the estate by activity type
Source: Aurecon 2017a

14.5.3 Impact Assessment - Operational

The results of the emission calculations and air-dispersion modelling for projected operational scenarios on 2025 (day of opening) and 2045 (20 years after day of opening) is described below.

14.5.3.1 Opening Year – 2025

Air-dispersion modelling of typical operations in 2025 was completed using the assumptions outlined previously.

As there are no differences in the number of aircraft movements between 2025 scenarios with and without the NRP, there are no differences in air-quality impacts between scenarios in the opening year. Similar to the assessment of baseline impacts, receptors located closest to the General Aviation area and Terminal 3 and Terminal 4 are typically most adversely affected. Impacts due to operations in 2025 are summarised in Table 14-16.

It is apparent that negligible impacts are experienced for all pollutants other than $PM_{2.5}$ and NO_2. Although negligible impacts were predicted for the annual averaging period for $PM_{2.5}$ and NO_2, adverse impacts were predicted for a 24-hour averaging period ($PM_{2.5}$) and a one-hour averaging period (NO_2). Exceedances were predicted for the NO_2 one-hour and $PM_{2.5}$ 24-hour averaging periods in 2025, compared to no exceedances for baseline conditions.

Exceedances of the one-hour NO_2 limit (246 µg/m³) were predicted at two on-site receptors, R4 (T3 and T4 car park) and R57 (General Aviation area). Concentrations at the worst-affected receptor were shown to exceed the NO_2 one-hour limit for six hours of the year. Exceedances of the $PM_{2.5}$ 24-hour limit were also predicted at these on-site receptors (R4 and R57) as well as one off-site receptor (R50) which is an industrial property on Great Eastern Highway located to the north-west of the estate. Concentrations at the worst-affected receptor were shown to exceed the $PM_{2.5}$ 24-hour limit for ten days of the year. These exceedances are summarised in Table 14-17. From assessment of ground-level concentration contours, a small off-site industrial area is affected by exceedances. Impacts for NO_2 and $PM_{2.5}$ were therefore classified as moderate.

Pollutant	Averaging period	Maximum incremental receptor impact (µg/m³)	Limit (µg/m³)	AQI	Receptor	Baseline AQI	Impact significance
CO	8-hour	1,328	10,000	13	R50	11	Negligible
SO_2	10-minute	373	712	52	R57	39	Negligible
	1-hour	261	570	46	R57	34	Negligible
	1-day	35	228	16	R57	11	Negligible
	1-year	9	60	15	R57	13	Negligible
PM_{10}	1-day	42	50	83	R57	65	Negligible
	1-year	18	25	72	R57	72	Negligible
$PM_{2.5}$	1-day	31	20	**155**	R57	88	Moderate adverse
	1-year	10	7	**140**	R57	**123**	Negligible
NO_2	1-hour	277	246	**113**	R57	98	Moderate adverse
	1-year	34	62	54	R57	39	Negligible
Formaldehyde	1-day	1.79	44.0	4	R57	4	Negligible
Benzene	1-year	0.02	9.700	0.24	R57	0.24	Negligible
Benzo(a)pyrene	1-year	8.32_{E-05}	0.0003	28	R57	28	Negligible
Toluene	1-day	0.09	4,000	<0.01	R57	<0.01	Negligible
	1-year	0.01	400	<0.01	R57	<0.01	Negligible
Xylene	1-day	0.07	1188	<0.01	R57	<0.01	Negligible
	1-year	0.01	950	<0.01	R57	<0.01	Negligible

Note: Exceedances of air quality limits (equivalent to an AQI of at least 100) are shown in bold.

Table 14-16 Predicted air quality impacts at sensitive receptors in 2025 compared to baseline conditions
Source: Aurecon

Pollutant	Averaging period	Number of affected receptors	Maximum number of exceedances at worst-affected receptor
NO_2	1-hour	2	6
$PM_{2.5}$	1-day	3	10

Table 14-17 Predicted exceedances at receptor locations for 2025
Source: Aurecon 2017a

The predicted air-quality impacts at receptors correlate with ground-level concentration contours, with the areas of highest concentrations and impacted receptors located near Terminal 3, Terminal 4 and the General Aviation area. Only a small fraction of the affected area is located outside of the estate. These results demonstrate that APU and GSE emissions strongly influence compliance with criteria.

Table 14-8 demonstrates that, in 2025 with or without the new runway, operations of APUs is the biggest contributor to annual emissions of NO_2, $PM_{2.5}$ and PM_{10} with road traffic being the second-largest.

With impacts being the same for scenarios with and without the NRP in 2025 this highlights that adverse air quality impacts are due to ground-based operations resulting from the normal airport operations and is proportional to the number of aircraft movements.

Those impacts that have been modelled to exceed criteria in 2025 will be considered as part of Perth Airport's overall environmental management.

14.5.3.2 20 Years Post-Opening – 2045

Air-dispersion modelling of typical operations predicted in 2045 was completed. The scenario shows the impact of air emissions from the new runway 20 years from day of opening.

For the 2045 scenario, adverse impacts were predicted for a one-hour averaging period (NO_2), 24-hour averaging period (PM_{10} and $PM_{2.5}$) and annual averaging period ($PM_{2.5}$). Exceedances of the limit for $PM_{2.5}$ 24-hour and annual averaging period, and NO_2 one-hour averaging period were predicted. Figure 14-9 and Table 14-19 show the results for 2045.

The most-affected receptor (considering impacts for all pollutants and for with and without NRP scenarios) is the on-site receptor R57. At this receptor, APU and GSE emissions from the General Aviation area are most influential. No exceedances of air-quality limits were predicted at any other receptor (both on-site and off-site). This is an improvement compared to predicted impacts for 2025, where exceedances were expected at several locations. This improvement is likely due to the relocation of Qantas from Terminal 3 and Terminal 4 to Airport Central, which will happen in this period; however, is independent of the NRP. The total number of exceedances predicted for the 2045 scenario is provided in Table 14-19.

Source type	CO		NO_x		SO_x		PM_{10}		$PM_{2.5}$		TVOCs	
	t/year	per cent	t/year	per cent	t/year	per cent	t/year	per cent	t/year	per cent	t/year	per cent
GSE	123	62.2	16	16.2	1	15.1	1	13.0	1	13.2	6	18.4
APUs	31	15.4	42	43.4	6	84.3	5	58.7	5	59.5	3	7.6
Perth Airport fuel storage	0	0	0	0	0	0	0	0	0	0	<1	<0.1
Stationary engines	<1	0.1	1	0.6	<1	<0.1	<1	0.4	<1	0.5	<1	<0.1
Cogeneration unit	2	1.0	14	14.2	0	0.6	1	7.1	1	7.4	<1	0.5
BP fuel storage	0	0	0	0	0	0	0	0.0	0	0	11	32.9
Road traffic	42	21.4	25	25.5	0	0	2	20.7	2	19.5	14	40.5
Total	**199**	**100**	**96**	**100**	**7**	**100**	**9**	**100**	**8**	**100**	**33**	**100**

Table 14-18 Air emissions as tonnes per year for New Runway Project opening-year operations
Source: Aurecon 2017a

Source type	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$	TVOCs
GSE	**186**	**23**	**2**	**2**	**2**	**9**
APUs	**13**	**17**	**3**	2	**2**	1
Perth Airport fuel storage	0	0	0	0	0	<1
Stationary engines	<1	1	<1	<1	<1	<1
Cogeneration unit	2	14	0	1	1	<1
BP fuel storage	0	0	0	0	0	11
Road traffic	58	34	0	3	3	20
Total	**258**	**89**	**4**	**8**	**7**	**42**

Table 14-19 Airport air emissions as tonnes per year for operations 20 years post-opening, with the New Runway Project
Source: Aurecon 2017a

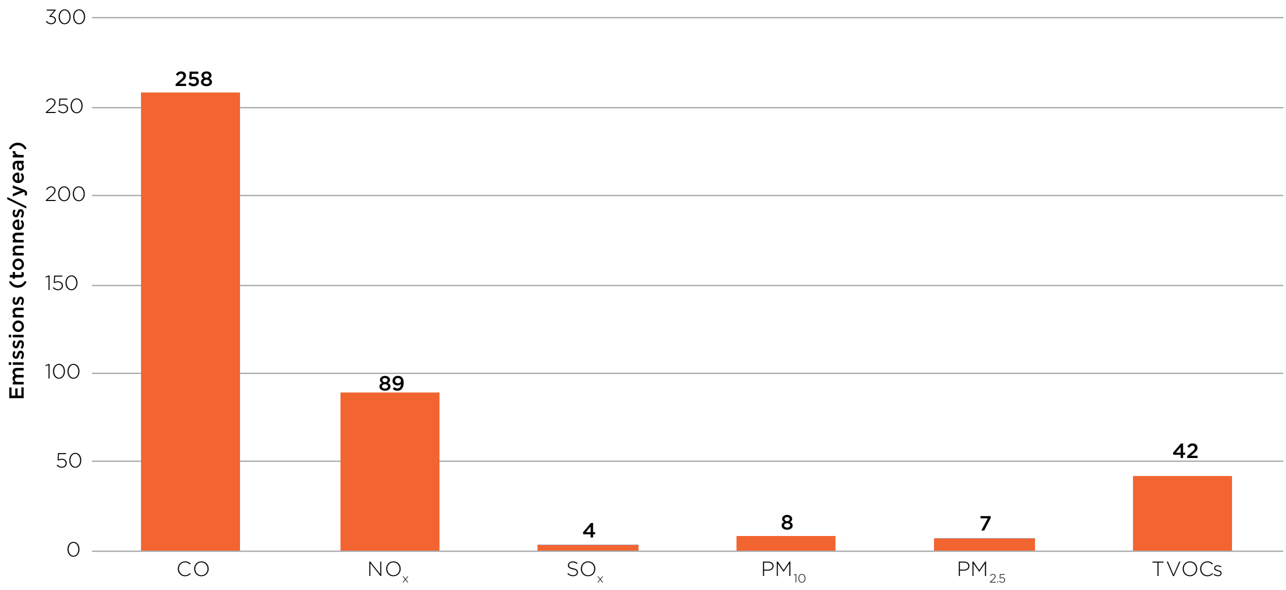


Figure 14-9 Estimated emissions (2045) for airport related ground-based operations by pollutant
Source: Aurecon 2017a

		With NRP	
Pollutant	Averaging Period	Number of Affected Receptors	Maximum number of exceedances at worst-affected receptor
NO_2	1-hour	1	6
$PM_{2.5}$	1-day	1	14

Table 14-20 Predicted exceedances at receptor locations for 2045 with the new runway
Source: Aurecon 2017a

For the 2045 scenario, exceedances of the limit for $PM_{2.5}$ 24-hour and annual averaging period, and NO_2 1-hour averaging period were predicted at R57. Receptor R57 is the General Aviation car park. Air-quality impacts are limited to this area for the 2045 scenario. The most influential emissions are those from APU's and GSE. Regardless of the construction of the NRP, the predicted exceedances are still expected to occur due to the nature of APU and GSE usage in the General Aviation area, whereas operations at the terminals are expected to transition to fixed ground power, generating less emissions. This area is not located near large passenger terminals and only a small amount of Perth Airport's total aircraft movements occur at the General Aviation area. In considering the duration of the averaging periods for the exceedences, and that people are unlikely to linger at the receptor location,it is unlikely the general public will experience adverse health effects from the air quality impacts.

The likelihood and resulting risk of air-quality impacts for each scenario is determined in accordance with the methodology described in Section 8. Air-quality exceedances were shown to occur in locations where people do not typically linger, and these predicted concentrations are only expected during worstcase dispersion conditions. The resulting risk level of air quality impacts is considered medium.

The modelling results for R57 are shown in Table 14-21.

A comparison of the change from day of opening in 2025 to 20 years after opening results in a medium risk rating, as shown in Table 14-22. The highest-rated impact for each scenario is shown in bold.

Pollutant	Averaging Period	Limit (µg/m³)	Baseline AQI	Change between baseline and 2045		
				AQI	Receptor	Impact Significance
CO	8-hour	10,000	11	10	R57	Beneficial
SO_2	10-min.	712	39	67	R57	Negligible
	1-hour	570	34	59	R57	Negligible
	1-day	228	11	15	R57	Negligible
	1-year	60	13	15	R57	Negligible
PM_{10}	1-day	50	65	82	R57	Minor adverse
	1-year	25	72	77	R57	Negligible
$PM_{2.5}$	1-day	20	88	**153**	R57	Moderate Adverse
	1-year	7	**123**	**158**	R57	Minor Adverse
NO_2	1-hour	246	98	**132**	R57	Moderate Adverse
	1-year	62	39	55	R57	Negligible
Formaldehyde	1-day	44.0	4	4	R57	Negligible
Benzene	1-year	9.700	0.24	0.24	R57	Negligible
Benzo(a)pyrene	1-year	0.0003	28	28	R57	Negligible
Toluene	1-day	4,000	<0.01	<0.01	R57	Negligible
	1-year	400	<0.01	<0.01	R57	Negligible
Xylene	1-day	1188	<0.01	0.01	R57	Negligible
	1-year	950	<0.01	<0.01	R57	Negligible

Table 14-21 Predicted air quality impacts at sensitive receptors in 2045 compared to baseline conditions
Note: Exceedances of air quality limits are shown in bold. Source: Aurecon 2017a

Pollutant	Averaging Period	Limit (µg/m³)	Baseline AQI	2025 (with & without NRP)		2045 with NRP	
				AQI	Impact	AQI	Impact
CO	8-hour	10,000	11	13	Negligible	10	Beneficial
SO_2	10-min.	712	39	52	Negligible	67	Negligible
	1-hour	570	34	46	Negligible	59	Negligible
	1-day	228	11	16	Negligible	15	Negligible
	1-year	60	13	15	Negligible	15	Negligible
PM_{10}	1-day	50	65	83	Minor adverse	82	Minor adverse
	1-year	25	72	72	Negligible	77	Negligible
$PM_{2.5}$	1-day	20	88	155	**Moderate adverse**	153	**Moderate adverse**
	1-year	7	123	140	Negligible	158	**Moderate adverse**
NO_2	1-hour	246	98	113	**Moderate adverse**	132	**Moderate adverse**
	1-year	62	39	54	Negligible	55	Negligible
Formaldehyde	1-day	44.0	4	4	Negligible	4	Negligible
Benzene	1-year	9.700	0.24	0.24	Negligible	0.24	Negligible
Benzo(a)pyrene	1-year	0.0003	28	28	Negligible	28	Negligible
Toluene	1-day	4,000	<0.01	<0.01	Negligible	<0.01	Negligible
	1-year	400	<0.01	<0.01	Negligible	<0.01	Negligible
Xylene	1-day	1188	<0.01	<0.01	Negligible	0.01	Negligible
	1-year	950	<0.01	<0.01	Negligible	<0.01	Negligible
Significance of air quality impacts (the worst rating was selected, making the risk conservative given that most are negligible)				Moderate adverse		Moderate adverse	
Overall likelihood of impacts for scenario				Likely		Likely	
Risk rating				Medium		Medium	

Table 14-22 Impact significance classifications for each pollutant for 2025 and 2045 scenarios
Source: Aurecon 2017a

The effect of vertical structures (such as buildings and solid fences/ gates) separating airside and landside zones on nearby air quality has not been considered in this study. Research has shown that similar structures can improve air quality at receptors located near roads; termed the barrier effect as shown in Figure 14-10 (Baldauf et al., 2008). Thus, it is likely a similar effect will be observed at landside receptors located near apron areas.

This assessment is considered conservative as likely future industry improvements to APUs and GSE have not been considered. These include development and use of electric GSE and increasing combustion engine emission requirements. These factors could potentially remove the predicted exceedances of limits for $PM_{2.5}$ 24-hour averaging period and NO_2 one-hour averaging period.

Preventing exceedance of the annual averaging period limit for $PM_{2.5}$ must be an airshed-wide effort, given current background levels exceed the limit. Increased restrictions on use of wood-fire heaters and improvements to combustion technology is expected to reduce airshed ambient levels of $PM_{2.5}$.

14.5.3.3 Health Effects Related to Adverse Air Quality

Predicted cumulative concentrations of all pollutants other than NO_2, $PM_{2.5}$ and PM_{10} are well below the criteria. Predicted cumulative concentrations of NO_2, $PM_{2.5}$ and PM_{10} are close to, if not exceeding, the limits.

A threshold concentration is yet to be established below which exposure to these pollutants does not cause health effects. However, reducing the concentration of pollutants present in ambient air will reduce the severity of potential health effects.

For the 2025 scenarios, exceedances of the NO_2 one-hour averaging period were predicted at receptors R4 (T3 and T4 Short Term Car Park) and R57 (General Aviation Car Park) and exceedances of the $PM_{2.5}$ 24-hour averaging period were predicted at receptors R4, R50 (Great Eastern Highway industrial Property) and R57. Exceedances at R57 are predicted for the 2045 scenario. Due to the nature of activities conducted at these locations, and the extended duration of averaging periods for these exceedances, it is unlikely that the general public will experience health effects from air quality impacts. However, management strategies, that attempt to reduce or limit the use of emission generating equipment should be in place to ensure that persons working at the identified locations are not materially affected. It is likely alternative technologies replacing current emission generating equipment will be in use by 2045, however, this assumption cannot be solely relied upon as a mitigator.

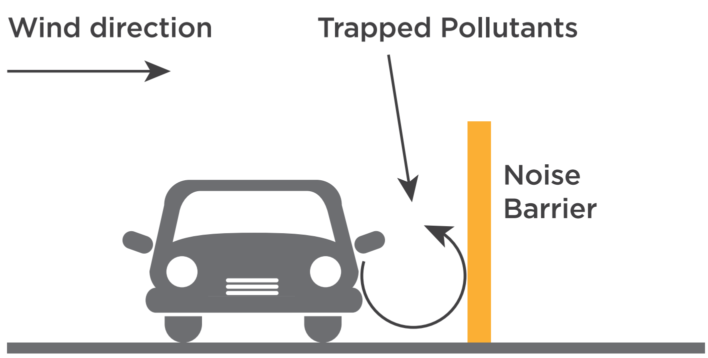


Figure 14-10 Illustration of the barrier effect on air quality, commonly considered for roadside air quality
Source: Aurecon 2017a

14.5.4 Impact Assessment - Construction

Dispersion modelling was completed using the modelling program AERMOD and emission rates detailed in Table 14-8.

Maximum predicted concentrations of PM_{10} demonstrate exceedances of the 24-hour averaging period air-quality limit for both incremental and cumulative concentrations at a number of on-site and off-site receptors, despite application of basic controls (i.e. water spraying). No exceedances of the limit for the PM_{10} annual averaging period were predicted.

Maximum predicted concentrations represent ground-level concentrations resulting from dispersion under worst-case, or extreme, meteorological conditions. The 99.9th percentile (or ninth highest) predicted concentrations are sometimes used in air-quality assessments as they represent dispersion under meteorological conditions which, while not extreme are still not favourable. The 99.9th percentile ground-level concentrations demonstrate no exceedances at incremental concentrations at receptor locations, and exceedances for cumulative concentrations for only four receptor locations (including two on-site receptors, R2 and R3). The two affected off-site receptors are R9 (child care centre) and R41 (industrial site), both located immediately to the east of the estate. PM_{10} concentrations at these receptors are predicted to be 62 $\mu g/m^3$ and 59 $\mu g/m^3$, respectively. While these exceedances are considered high adverse (using the 99.9th percentile ground level concentrations for the reasons stated above) in terms of impact significance, standard controls for dust generated by construction activities are expected to reduce the residual risk of the impacts to low.

A summary of predicted air-quality impacts due to construction activities is presented in Table 14-23.

Parameter	PM_{10} 24-hour averaging period, maximum ground-level concentrations	PM_{10} 24-hour averaging period, 99.9th percentile ground-level concentrations
Cumulative concentration at most affected receptor	122	62
AQI at most affected receptor	244	124
Impact significance	Major adverse	High adverse
Number of receptors at which incremental PM_{10} levels exceed limit	17	0
Number of receptors at which cumulative PM_{10} levels exceed limit	37	4

Table 14-23 Predicted air-quality impacts resulting from construction activities
Source: Aurecon 2017a

14.5.5 Mitigation

Opportunities to reduce ground-based operational air quality impacts relate to optimising the use of GPUs, use of electrified GSE and explore feasibility of alternative fuels. Consideration of these and other opportunities is part of ongoing operational management implemented by Perth Airport.

For risks identified as being medium to high, additional mitigation measures have been identified to reduce the risk level where possible.

14.5.5.1 Construction

The CEMP will include standard measures for the management of dust during construction, including watering where required.

Given exceedances are predicted for both maximum and 99.9th percentile ground-level concentrations for the PM_{10} 24-hour averaging period, additional mitigation measures are recommended.

These recommendations are listed below in Table 14-24, and can be applied to other dust-generating activities not evaluated in this assessment to help mitigate dust impacts. Prior to construction, an air quality management plan will be developed to manage these impacts.

Construction Activity	Mitigation Measure	Emissions Control Effectiveness (per cent)
Scrapers on topsoil	Soil is naturally or artificially moist	50
Dozers on material	None	Not applicable
Vehicles on haul roads	Watering – 2 litres per square metre per hour	50
	Watering – >2 litres per square metre per hour	75
	Sealed or salt-encrusted roads	100
Wind erosion of stockpiles and exposed areas	Water sprays	50
	Wind breaks	30
	Total enclosure	99
	Primary earthworks (profiling/reshaping, installation of drainage structures)	30
	Rock armour and/or topsoil applied	30
	Primary rehabilitation	30
	Vegetation established but not demonstrated to be self-sustaining	40
	Secondary rehabilitation	60
	Revegetation	90
	Fully rehabilitated vegetation	100

Table 14-24 Potential mitigation measures to reduce construction dust impacts
Source: Aurecon 2017a

14.6 Odour

Odour can be an issue when sensitive receptors are located close to odour sources. It has the potential to reduce the amenity of sensitive receptors located both on and off the estate.

14.6.1 Methodology

A qualitative assessment of odour impacts for the estate has been conducted. Baseline odour conditions were understood by reviewing Perth Airport's complaints register and understanding current operations. Expected changes in odour impacts due to NRP operations in future years were assessed by comparing current and future activity levels. Although fuel combustion is expected to be the primary source of odour within the estate, other activities such as spray painting by tenants can create odour impacts.

14.6.1.1 Assumptions

Quantitative methods such as odour modelling and/or dynamic olfactometry were not adopted for the assessment of ground-based odour. There are no significant odour issues beyond the estate resulting from the airport's consumption and storage of fuel.

Potential odour impacts due to ground-based operations were qualitatively assessed based on activity locations and projected changes in activity levels.

14.6.2 Existing Condition

The estate contains a number of industrial properties, some of which have the potential to produce odour. When considering existing odour conditions it is important to also consider the effect of these on surrounding properties.

The Perth Airport environmental complaints register for the last five years was reviewed to understand existing odour issues. Since October 2012, Perth Airport recorded 14 complaints relating to odour. Only one of these odour-related complaints was associated with fuel fumes, and was lodged in 2013. The majority of the odour-related complaints were related to odour produced from commercial developments on the estate, including the activities of spray painting. Operations at these facilities are not expected to be affected by the NRP.

It is considered that current aviation operations conducted at Perth Airport do not result in odour issues.

14.6.3 Impact Assessment - Operational

Operation of the NRP will result in a greater number of annual aircraft movements compared to operation without the NRP. Use of jet fuel, and the corresponding emissions of TVOCs, is the odour source most likely to result in odour impacts and corresponds to APU usage. Operation of the new runway will also bring aircraft closer to the estate's eastern boundary, potentially exposing off-site sensitive receptors to ground-based odour sources to which they were previously not exposed.

The 2045 scenario with the NRP has the most potential for creating odour impacts at sensitive-receptor locations because this scenario has the most aircraft movements.

Despite the much larger number of aircraft movements expected to occur in 2045 compared to baseline conditions, the amount of TVOCs emitted from APUs is expected to be similar due to greater use of GPUs.

Increased future combustion of diesel by airport GSE and the associated emissions of TVOCs is unlikely to create odour impacts at sensitive receptors. As shown in Table 14-25, predicted concentrations due to airport ground-based operations are well below criteria.

Receptor Details			2045 with NRP Airport and roads (µg/m³)			
ID	Description	Type	Benzene	Benzo(a)pyrene	Toluene	Xylene
	Air Toxics Investigation Level		9.7	0.0003	400	950
	Maximum Concentration		0.023	8.3_{E-05}	0.010	0.008
R1	Ngala Early Learning Centre	Sensitive	0.023	8.3_{E-05}	0.0104	0.0080
R2	T1 Short Term Car Park	On-site	0.011	4.2_{E-05}	0.0052	0.0040
R3	T2 Short Term Car Park	On-site	0.015	5.3_{E-05}	0.0066	0.0051
R4	T3 and T4 Short Term Car Park	On-site	0.017	6.2_{E-05}	0.0077	0.0059
R5	Mulberry Tree Child Care	Sensitive	0.004	1.3_{E-05}	0.0017	0.0013
R6	Belmay East Pre-School Centre	Sensitive	0.003	9.9_{E-06}	0.0012	0.0010
R7	Redcliffe Park	Community	0.003	1.0_{E-05}	0.0013	0.0010
R8	Ollie Worrell Reserve	Community	0.002	6.7_{E-06}	0.0008	0.0006
R9	Kids HQ Child care	Sensitive	0.002	8.6_{E-06}	0.0011	0.0008
R10	Great Eastern Highway 1	Residential	0.006	2.1_{E-05}	0.0026	0.0020
R11	National Lifestyle Villages Hillview	Sensitive	0.002	6.1_{E-06}	0.0008	0.0006
R12	Aurora Entrance	Residential	0.002	7.7_{E-06}	0.0010	0.0007
R13	Waterhall Road	Residential	0.002	8.0_{E-06}	0.0010	0.0008
R14	Queens Road Arboretum	Community	0.003	1.1_{E-05}	0.0014	0.0011
R15	Fleming Reserve	Community	0.002	5.6_{E-06}	0.0007	0.0005
R16	Koel Court	Residential	0.003	9.2_{E-06}	0.0011	0.0009
R17	Palmer Court	Residential	0.002	6.8_{E-06}	0.0008	0.0006
R18	Central Avenue	Residential	0.011	3.9_{E-05}	0.0049	0.0038
R19	Coolgardie Avenue	Residential	0.009	3.1_{E-05}	0.0039	0.0030
R20	Middleton Park	Community	0.003	1.2_{E-05}	0.0014	0.0011
R21	Coolbarro Lane	Residential	0.003	1.3_{E-05}	0.0016	0.0012
R22	Hoskin Street	Residential	0.004	1.4_{E-05}	0.0017	0.0013
R23	Pindi Court	Residential	0.002	7.0_{E-06}	0.0009	0.0007
R24	Hatch court	Residential	0.001	4.9_{E-06}	0.0006	0.0005
R25	Upwood Circuit	Residential	0.001	4.1_{E-06}	0.0005	0.0004
R26	St Maria Goretti's Catholic School	Sensitive	0.003	1.1_{E-05}	0.0014	0.0011
R27	Redcliffe Primary School	Sensitive	0.005	1.7_{E-05}	0.0022	0.0017
R28	Bulong Avenue	Residential	0.006	2.3_{E-05}	0.0028	0.0022
R29	Anglican Church of Australia	Sensitive	0.002	7.6_{E-06}	0.0010	0.0007
R30	Whiteside Street	Residential	0.003	1.2_{E-05}	0.0015	0.0012
R31	Love Street	Residential	0.003	9.2_{E-06}	0.0011	0.0009
R32	Guilfoyle Green	Residential	0.004	1.4_{E-05}	0.0018	0.0014
R33	Forster Park	Community	0.002	8.4_{E-06}	0.0010	0.0008
R34	Mack Place	Residential	0.001	4.6_{E-06}	0.0006	0.0004
R35	Pioneer Park	Community	0.000	1.4_{E-06}	0.0002	0.0001
R36	Maida Vale Road	Residential	0.001	3.6_{E-06}	0.0004	0.0003
R37	Sultana Road West	Residential	0.001	3.6_{E-06}	0.0004	0.0003

Table 14-25 Predicted incremental and cumulative concentrations of volatile organic compounds at receptors for a one-year averaging period, assessed against Air Toxics National Environment Protection Measure limits for 2045 ground-based operations with the New Runway Project
Source: Aurecon 2017a

Receptor Details			2045 with NRP Airport and roads (µg/m³)			
ID	Description	Type	Benzene	Benzo(a)pyrene	Toluene	Xylene
	Air Toxics Investigation Level		9.7	0.0003	400	950
	Maximum Concentration		0.023	8.3E-05	0.010	0.008
R38	Nardine Close	Residential	0.001	3.2E-06	0.0004	0.0003
R39	Belgravia Street	Residential	0.003	1.0E-05	0.0013	0.0010
R40	Abernethy Road 1	Industry	0.005	1.9E-05	0.0024	0.0018
R41	Hudswell Road	Industry	0.003	1.1E-05	0.0013	0.0010
R42	Abernethy Road 2	Industry	0.002	7.5E-06	0.0009	0.0007
R43	Abernethy Road 3	Industry	0.001	4.8E-06	0.0006	0.0005
R44	Glassford Road	Industry	0.003	1.2E-05	0.0015	0.0012
R45	Onsite industry	On-site	0.017	6.3E-05	0.0079	0.0060
R46	Casella Place	Industry	0.001	3.5E-06	0.0004	0.0003
R47	Abernethy Road 4	Industry	0.001	3.4E-06	0.0004	0.0003
R48	Mustang Court	Residential	0.002	8.0E-06	0.0010	0.0008
R49	Worrell Avenue	Residential	0.002	6.8E-06	0.0009	0.0007
R50	Great Eastern Highway 2	Industry	0.008	2.8E-05	0.0035	0.0027
R51	Reid Street	Residential	0.002	7.3E-06	0.0009	0.0007
R52	Hyland Street	Residential	0.003	9.5E-06	0.0012	0.0009
R53	Peter Road	Residential	0.001	4.5E-06	0.0006	0.0004
R54	Citrus Grove	Residential	0.001	2.5E-06	0.0003	0.0002
R55	Gregory Street	Residential	0.002	7.1E-06	0.0009	0.0007
R56	Newburn Road	Residential	0.000	1.8E-06	0.0002	0.0002
R57	GA	On-site	0.016	5.8E-05	0.0072	0.0055

Table 14-25 Predicted incremental and cumulative concentrations of volatile organic compounds at receptors for a one-year averaging period, assessed against Air Toxics National Environment Protection Measure limits for 2045 ground-based operations with the New Runway Project (Continued)

Emissions from GSE are also well below road-traffic emissions within the estate. Emissions of TVOCs from traffic on nearby roads external to the estate are also expected to be greater than the emissions from GSE. Considering no odour issues have been identified from these other, more significant activities, odour impacts are unlikely.

14.6.4 Mitigation

The following measures can be taken to reduce the likelihood of odour impacting on sensitive receptors:

- enforce limits to APU usage, and
- use alternative fuels.

Measures aimed at managing odour will be addressed in the construction environmental management plan for the NRP. The contractor will be required to outline management measures and maintain a complaint register, incorporating those related to odour.

14.6.5 Summary

The risk of odour impacts resulting from construction and operation of the NRP have been assessed as being low, even without additional mitigation measures.

14.7 Greenhouse Gases

Greenhouse gases contribute to climate change by trapping heat in the earth's atmosphere. Carbon dioxide is the main greenhouse gas and is released primarily by the burning of fossil fuels and removed from the atmosphere by plants.

14.7.1 Methodology

An international standard for accounting and reporting of greenhouse gas emissions has been established by the greenhouse gas protocol (WBCSD and WRI, 2004). The protocol sets out three scopes of emissions (Scope 1, Scope 2 and Scope 3). These scopes are necessary to enable accurate emission calculations, prevent two or more companies from accounting for the same emissions, and allow businesses to meet their greenhouse-gas reduction goals.

- Scope 1 emissions are direct greenhouse-gas emissions. These emissions are produced from sources that are owned or controlled by the company (e.g. combustion of fuel by airport-owned airside vehicles).
- Scope 2 emissions are electricity-related indirect greenhouse gas emissions. These emissions are created from offsite generation of electricity which is purchased and consumed by the reporting company. The Scope 2 emissions are physically produced offsite, at the electricity generation facility.
- Scope 3 emissions are other indirect greenhouse gas emissions. These emissions are produced by sources which are not owned or controlled by the reporting company but are a result of the company's activities (e.g. combustion of fuel by aircraft).

Under the *National Greenhouse and Energy Reporting (NGER) Act 2007*, larger greenhouse gas-producing companies within Australia are required to calculate their Scope 1 and Scope 2 emissions for each financial year. If the calculated emissions exceed any of the thresholds, their emissions must be reported in more detail to the clean energy regulator. Scope 3 emissions are optional for reporting emissions. However, for the purposes of this impact assessment, Perth Airport's Scope 3 emissions include sources such as the transfer of waste offsite, operation of aircraft APUs, GSE by airlines, and electricity purchased offsite and consumed by tenants. Operation of the NRP is expected to affect such sources which makes accounting for and reporting of Scope 3 emissions necessary for the impact assessment.

14.7.1.1 Operational Assessment Criteria

Greenhouse gas emissions calculations involve multiplication of activity data with an activity-specific emission factor. Emission factors and calculation methods for general emission sources are specified under the National Greenhouse and Energy Reporting (Measurements) Determination 2008. The National Greenhouse Accounts Factors (2015) also specifies emission factors but for a broader range of applications.

Greenhouse gas emissions were quantified using the Airport Carbon and Emissions Reporting Tool (ACERT). ACERT allows calculation of Scope 1, 2 and 3 greenhouse gas emissions from airports based on a number of user inputs relating to annual fuel, electricity, heat and waste usage. ACERT was developed by Transport Canada, Airports Council International, Zurich Airport, Toronto Pearson Airport, and Tetra Tech, with the intention to be used internationally.

It was considered necessary for this assessment to first conduct a study to ensure emissions are appropriate for Australian airports and, more importantly, Perth Airport.

14.7.1.2 Calibration

The Perth Airport 2015/2016 NGER report was used for calibration purposes. The report documents Scope 1 (direct) and Scope 2 (indirect) greenhouse gas emissions produced by Perth Airport during the financial year ending June 2016 which consisted of the following:

- gaseous fuel combustion: for operation of the cogeneration plant, and for cooking, heating and cooling,
- liquid fuel combustion in moving vehicles, both diesel and unleaded petrol (ULP),
- liquid fuel combustion in stationary engines (diesel), and
- electricity generated off the estate.

Documented quantities of purchased electricity and combusted fuel for the baseline year were used as input values for relevant entries in ACERT and greenhouse gas emissions calculated. As detailed in Table 14-26, greenhouse gas emissions for total carbon dioxide equivalent (t $CO_{2\text{-e}}$) emissions calculated using ACERT were consistent with those calculated for NGER reporting purposes. Combustion of gaseous fuel was the only emission source for which the difference between calculation methods was larger than five per cent. This difference was corrected by making the ACERT CO_2 emission factor equivalent to that used for NGER reporting. Corrected emissions are shown in Table 14-26.

NGER reported emission source	Greenhouse gas emissions (t $CO_{2\text{-e}}$)		Per cent difference	Corrected ACERT emissions (t $CO_{2\text{-e}}$)	Per cent difference
	NGER report	ACERT			
Gaseous fuel combustion	8,430	9,183	+13	8,420	-0.1
Liquid fuel combustion in vehicles	465	466	+0.2	466	+0.2
Liquid fuel combustion on stationary engines	27.0	27.8	+3.0	27.8	+3.0
Purchased electricity	18,600	18,600	0.0	18,600	0.0

Table 14-26 Comparison between National Greenhouse and Energy Reporting reported and Airport Carbon and Emissions Reporting Tool calculated emissions
Source: Aurecon 2017a

When calculating greenhouse gas emissions in units of t CO_{2-e}, the correct global-warming potential factor must be used. The global warming potential is a relative measure of the amount of heat that a greenhouse gas traps in the atmosphere. The global warming potential factors within ACERT were adjusted to match those prescribed for reporting emissions for the 2015/2016 financial year and onwards, as per the Clean Energy Regulator.

ACERT-calculated emissions of methane (CH_4) and nitrous oxide (N_2O) match less closely with the NGER-reported emissions. This is mainly due to a discrepancy in the global warming potential factor selected. The factor of CO_2 is one. For other greenhouse gases, their global warming potential is a factor which is applied to CO_2 calculated emissions and enables estimates of emissions for various species including CH_4 and N_2O which are most relevant for Perth Airport's emissions. Global-warming potential factors used by NGER determination, as per the NGER Regulation, and ACERT are provided in Table 14-27.

Greenhouse Gas	NGER Regulation	ACERT
CH_4	25	21
N_2O	298	310

Table 14-27 Global warming potential values used in greenhouse gas emission calculations
Source: Aurecon 2017a

14.7.1.3 Construction Assessment Criteria

Primary greenhouse gas emission sources for each Scope (1, 2 and 3) resulting from construction of the NRP were identified and are summarised in Table 14-28.

Scope	Emission Source	Explanation
1	Fuel combustion from construction equipment, construction vehicles and generators	Refers to the direct emissions occurring from sources which are controlled by the construction activities
1	Vegetation loss due to site clearing	Vegetation is considered a carbon sink and the carbon sequestered in vegetation returns to the atmosphere on its removal as direct emissions
2	Purchased electricity for construction equipment and construction associated temporary buildings	Refers to the indirect emissions from generating electricity by sources which are not owned by the builders, but such electricity is used for construction activities
3	Embedded emissions from asphalt, concrete, aggregates, steel and material transport	Refers to the indirect emissions from the production and transport of raw materials used for construction activities

Table 14-28 Construction greenhouse-gas emission sources identified
Source: Aurecon 2017a

As Scope 1 greenhouse gas emissions are expected to dominate emissions from construction activities, Scope 2 and Scope 3 emissions were not considered further. Emissions from fuel combustion for construction vehicles and equipment, and vegetation clearance were assessed.

An accurate estimate of the amount of fuel to be combusted by construction equipment was not available; instead a literature review was completed to understand likely fuel requirements.

The primary source for these estimates was the Environmental Impact Statement (EIS) for the Brisbane Airport New Parallel Runway. This assessment assumes construction of the new runway at Perth will use similar equipment to that used for Brisbane Airport's new runway, and usage is directly proportional to the scale of operations which can be approximated using the area of vegetation to be cleared.

The fuel quantities specified in the Brisbane Airport EIS were based on clearance of 361 hectares of vegetation. Quantities scaled to reflect required vegetation clearing for Perth Airport (129 hectares of good or better vegetation) are presented in Table 14-29, and were used to estimate greenhouse gas emissions. Emission rates specified by Part 4, Schedule 1 of the NGER Measurement Determination were used to estimate greenhouse-gas emissions from fuel combustion.

Source of Fuel Combustion	Quantity of Diesel Combusted for Brisbane Airport (kL)	Estimated Quantity of Diesel Combusted for Perth Airport (kL)	Energy Content of Fuel (GJ/kL)	Emission Factor (kg CO_{2-e}/GJ)
Construction vehicles	48,000	17,100	38.6	69.9
Construction equipment	21,600	7,710	38.6	69.5

Table 14-29 Estimated quantity of diesel combusted for completion of construction of the New Runway Project
Source: Aurecon 2017a

To determine greenhouse gas emissions from vegetation clearance it was necessary to understand the type of vegetation to be cleared – vegetation which has a higher biomass is able to absorb more greenhouse gases and will therefore emit more greenhouse gas when cleared. According to the Supporting Document for Greenhouse Gas Assessment Workbook for Road Projects, Perth Airport is located in an area where its Maximum Potential Biomass Class is 50-100 dry matter per hectare (Class 2) and the vegetation is defined as Mallee, Acacia Woodland and Shrubland (Transport Authorities Greenhouse Group, 2013). According to the same document, the mean carbon stock for Class 2 vegetation is 74 t CO_{2-e} per hectare. This factor was combined with the vegetation clearance area to estimate emissions.

14.7.1.4 Assumptions and Modelling Inputs

Accurate accounting of greenhouse gas emissions requires detailed input data. This data was not always available, meaning it was necessary to make assumptions regarding activity levels and emission-source details based on other sources of information, including in-depth literature reviews. Despite these limitations, the assessment is considered appropriate and consistent with industry best practice.

Projection of Scope 1 and Scope 2 Emissions

a) Perth Airport Electricity Consumption
Perth Airport's forecast electricity demand as well as the division of electricity consumption (Perth Airport usage versus tenant usage) for each terminal was used for baseline conditions. It was assumed that a similar division would be observed in 2025. However, by end 2025 it is expected that Qantas will have relocated to Airport Central and no commercial air services will occur at T3 or T4. Accordingly, for the 2045 assessment it is assumed that T3 and T4 are used entirely by tenants. T1 usage was adjusted to account for the relocation of Qantas from T3 and T4 and, as such, changes to usage will be a consequence of future terminal developments, not the new runway. This data is detailed in Table 14-30.

Assessment Period	Terminal 1 (per cent)	Terminal 2 (per cent)	Terminal 3 (per cent)	Terminal 4 (per cent)
2025	36	12	22	100
2045	45	12	100	100

Note: Terminal 1 includes the new domestic terminal that will house the Qantas Group following consolidation.

Table 14-30 Tenant electricity consumption for each terminal as a percentage of the terminal's total consumption
Source: Perth Airport

b) Fuel Combustion for Perth Airport Airside Vehicles
For assessment of fuel consumption of Perth Airport vehicles in future years, it was assumed that the change in fuel consumption for that year compared to baseline conditions is proportional to the increase in landing and take-off cycles. This assumption is considered conservative and is appropriate in the absence of more accurate data. This assumption also considered that greenhouse gas emissions from Perth Airport vehicle fuel consumption are negligible compared to other sources, especially Perth Airport and tenant electricity consumption, and also does not consider uptake of electric vehicles or use of biofuels.

Forecast gas consumption for buildings and the cogeneration plant was provided by Perth Airport to assess greenhouse gas emissions in future years. This consumption is not considered to be affected by operation of the NRP.

c) Fuel Combustion for Stationary Engines
In the absence of more accurate data, negligible increase in emissions from stationary engines was assumed for future years compared to baseline emissions. This assumption is considered appropriate as greenhouse gas emissions from stationary engines for Perth Airport are negligible compared to other greenhouse gas emissions sources and it is reasonable to assume future power outages will occur at a similar frequency. However, these changes will occur as part of normal airport operations and are not affected by the new runway.

Solid Waste

Processing of Perth Airport's solid waste is a Scope 3 emission as all processing is conducted off-estate. The airport's annual total solid waste for the baseline year was obtained from the 2015-2016 Waste Report (Cleanaway, 2016) and 2016 Waste Generation and Source Audit (APC, 2016). The quantity of waste processed as industrial waste was assumed equivalent to the waste from service yards and workshops. The remaining waste was assumed municipal waste. Quantities are summarised in Table 14-31.

For assessment of future years, it was assumed that the change in waste is proportional to the number of landing and take-off cycles for that year. This assumption is considered conservative, and is appropriate in the absence of more accurate data considering greenhouse gas emissions from waste disposal are negligible compared to other sources, especially Perth Airport and tenant electricity consumption.

Waste type	Waste Weight (tonnes)		
	2016	2025 with and without NRP	2045 with NRP
Industrial	3,100	4,040	6,077
Municipal	300	391	588
Total	**3,400**	**4,430**	**6,670**

Table 14-31 Waste data used for greenhouse gas emissions calculations
Source: Aurecon 2017a

APUs

Calculation of greenhouse gas emissions for APU usage requires aircraft activity data in terms of annual movements, breakdown of movements by aircraft type, and usage time.

Calculation of APU emissions using ACERT can be completed using either generic aircraft data, detailed aircraft data, or total fuel consumed. Sufficient data was only available for the generic method.

It was necessary to separate annual aircraft movements into the following aircraft types for the generic aircraft data option:

- large long-haul,
- medium medium-haul,
- small small-to-medium haul,
- regional short-haul,
- business,
- turboprop,
- piston,
- large helicopter, and
- small helicopter.

Only the most common aircraft/route types were adopted for classification and are described below:

- large aircraft movements are equivalent to international movements (17 per cent),
- regional movements are equivalent to general aviation movements (12 per cent),
- small, small/medium-haul movements are equivalent to movements with a maximum take-off weight of less than 50,000 kilograms (26 per cent), and
- medium, medium-haul movements are equivalent to all remaining movements (45 per cent).

The baseline distribution by aircraft type was adopted for assessment of future years on the basis that no significant changes in aircraft fleet are expected in the next ten to 20 years. This distribution is shown in Table 14-32.

An APU usage time of 60 minutes per landing and take-off for aircraft using T3, T4 and the General Aviation area (as adopted for the air quality assessment) was also adopted for the greenhouse gas assessment and is considered conservative.

Tenant Electricity

The amount of electricity consumed by tenants of the airport (94,900 MWh) was calculated as the total electricity provided by South West Interconnected System (SWIS) (119,000 MWh), minus the difference of Perth Airport's monthly electricity usage and that provided by the cogeneration facility (24,400 MWh).

Perth Airport prepared forecast electricity demand data (including tenant contributions) for future years.

In 2025, the number of aircraft movements will be the same for scenarios with and without the NRP. The only significant difference is airfield electricity consumption with the NRP will be approximately double that of the scenario without the NRP.

Fuel combusted by tenants

Insufficient data was available to allow calculation of greenhouse-gas emissions from combustion of fuel by tenants (e.g. for operation of GSE and fleet vehicles, or generation of heating or cooling). As this is a Scope 3 emission source, and is considered negligible compared to other Scope 3 sources (particularly electricity consumption by tenants and Perth Airport), it has been excluded from assessment.

Generic Aircraft Type	Per Cent of Total Movements	Annual Movements		
		2016	2025 with and without NRP	2045 with NRP
Large	17	22,500	29,400	44,100
Medium	45	59,600	77,700	117,000
Small	26	34,500	44,900	67,500
Regional	12	15,900	20,700	31,100
Total	**100**	**132,500**	**173,000**	**260,000**

Table 14-32 Aircraft-movement data used for greenhouse gas emissions calculations
Source: Aurecon 2017a

14.7.2 Existing Condition

This section describes the current condition of greenhouse gas emissions in Western Australia and Australia and details the primary emission sources by industry. Emissions for existing ground-based operations at Perth Airport are also presented.

14.7.2.1 Existing Greenhouse Gas Emission Inventories

Western Australia's greenhouse-gas emissions inventory was last documented for the year 2014. A distribution of greenhouse-gas emissions by sector is provided in Figure 14-11. It is evident that the stationary energy (power generation) sector produces the most amount of greenhouse gas emissions in Western Australia, meanwhile the transport sector is the second largest contributor.

Within the transport sector, emissions are predominantly attributed to road transport, as shown in Figure 14-12.

This data suggests that greenhouse gas emissions from aircraft are minor relative to Western Australia's complete emission inventory, with emissions due to airport operations contributing an even smaller proportion. Major ground-based greenhouse gas-emission sources for the airport are likely to be stationary energy and road transportation (including GSE and other airside vehicles).

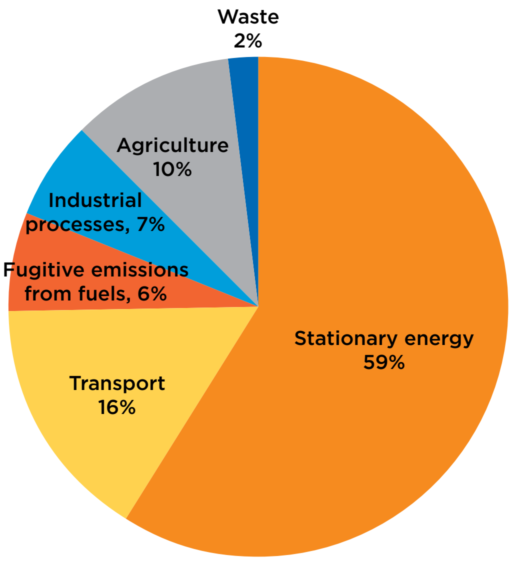


Figure 14-11 Breakdown of greenhouse-gas emissions by sector for Western Australia based on 2014 data
Source: DEE, 2016[b]

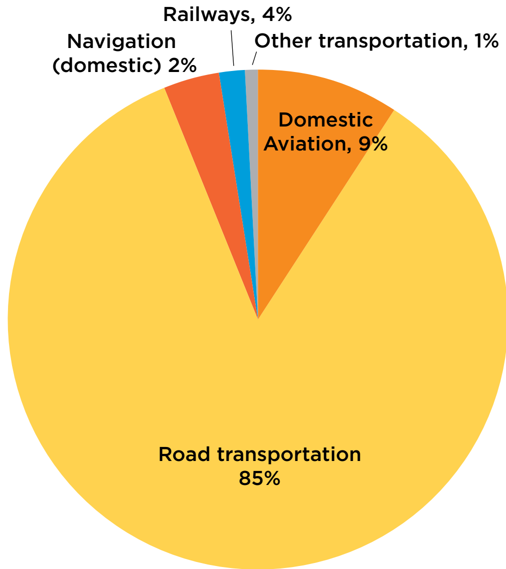


Figure 14-12 Breakdown of Australia's transport greenhouse gas emissions based on 2014 data
Source: DEE, 2016[a]

14.7.2.2 Existing Airport Emissions of Greenhouse Gases

To assess the impact of airport operations on greenhouse gas emissions upon completion of the NRP, it was first necessary to establish current greenhouse gas emissions. Scope 1, 2 and 3 emissions were calculated as summarised in Table 14-33.

Table 14-3 showed that the NGER reporting thresholds for a 'facility' is 25,000 tonnes of CO_{2-e} produced in the reporting year and 100,000 tera joules of energy produced or consumed.

Perth Airport exceeded the NGER reporting thresholds in 2016 with baseline operations.

Electricity purchased by Perth Airport is the most significant source of Scope 1 and Scope 2 emissions for baseline operations. Scope 3 emissions are optional for reporting purposes and not controlled by Perth Airport. As shown in Table 14-34, Figure 14-13 and Figure 14-14, Scope 3 emissions are the most significant contributor to the airport's total greenhouse gas emission inventory. Emissions produced by tenants, including electricity purchased by tenants on the estate, and operation of APUs are the most significant greenhouse gas emission sources.

Scope	Emission Source Controlled By	t CO_{2-e}	Per cent of Total t CO_{2-e}
1	Airport	8,920	7.0
2	Airport	18,600	14.6
3	Non-Airport	100,000	78.4
t CO_2-e (Total)		**127,520**	**100**

Table 14-33 Baseline greenhouse gas emissions for Perth Airport
Source: Aurecon 2017a

Scope	Owner of Emission Source	Source	Fuel Type	Annual Quantity	Units	Annual emissions (t CO_2-e)	CO_{2-e} %
1	Airport	Combustion for airside vehicles	ULP	51.7	kL	466	0.4
			Diesel	127	kL		
1	Airport	Combustion for building heating or cooling, electricity generation	Natural gas	164,000	GJ	8,420	6.5
1	Airport	Combustion for stationary engines	Diesel	9,970	kL	27.8	0.02
Scope 1 Sub-total						**8,920**	**7.0**
2	Airport	Electricity purchased off-site	N/A	24,500	MWh	18,600	14.5
Scope 2 Sub-total						**18,600**	**14.6**
Airport owned (Scope 1 and 2) Sub-total						**27,500**	**21.6**
3	Tenant	Combustion for aircraft APU	N/A[2]	31,100	landing take-off	18,500	14.5
3	Tenant	Combustion for aircraft engine run-ups	N/A	1,720	Run-ups	816	0.6
3	Tenant	Electricity purchased off-site	N/A	94,900	MWh	72,100	56.5
3	Off-site	Waste processing	N/A	3,400	tonnes	8,670	6.8
Scope 3 Sub-total						**100,000**	**78.4**
Total CO_2-e emissions (tonnes)						**128,000**	**100**

Table 14-34 Greenhouse gas emissions for baseline operations
Source: Aurecon 2017a

Total Scope 1 + 2 = 27,532
Scope 2 emission use Location-based Emissions Factor

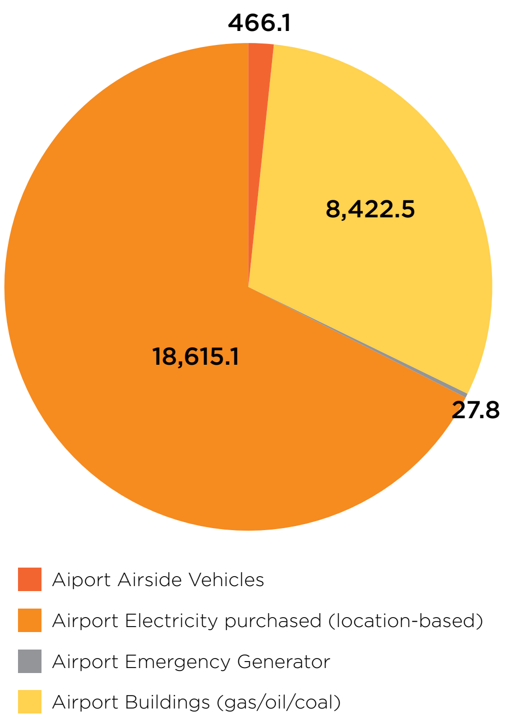


Figure 14-13 Estimated Scope 1 and 2 greenhouse-gas emissions (tonnes) distributed by each source
Source: Aurecon 2017a

Total Scope 1 + 2 + 3 = 127,610
Scope 2 emission use Location-based Emissions Factor

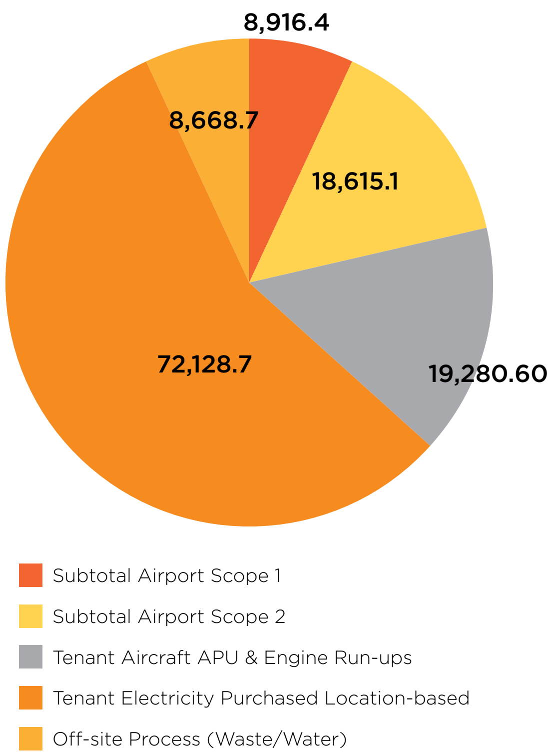


Figure 14-14 Estimated Scope 1, 2 and 3 greenhouse-gas emissions (tonnes) distributed by each source
Source: Aurecon 2017a

14.7.3 Impact Assessment - Operational

This section describes the results of the greenhouse gas emission calculations for each operational scenario.

14.7.3.1 Opening Year – 2025

Greenhouse gas emission estimates for scenarios with and without the NRP during the opening year (2025) are presented below in Table 14-35. Quantities of Scope 1 and Scope 3 emissions are consistent between scenarios. Scope 2 emissions are slightly higher with the NRP compared to the scenario without due to increased airfield electricity consumption, which is mainly due to runway lighting.

Scope	Owner of Emission Source	Source	Fuel Type	Units	With NRP			Without NRP		
					Annual Quantity	Emissions (t CO_{2-e})	CO_{2-e} %	Annual Quantity	Emissions (t CO_{2-e})	CO_{2-e} %
1	Airport	Combustion for airside vehicles	ULP	kL	67.4	608	0.3	67.4	608	0.3
			Diesel	kL	166			166		
1	Airport	Combustion for building heating/ cooling, electricity generation	Natural gas	GJ	196,000	10,100	5.4	196,000	10,100	5.5
1	Airport	Combustion for stationary engines	Diesel	kL	9,970	27.8	0.01	9,970	27.8	0.02
Scope 1 Sub-total						10,700	5.8	Sub-total	10,700	5.8
2	Airport	Electricity purchased off-site	N/A	MWh	35,500	26,900	14.5	33,700	25,600	13.9
Scope 2 Sub-total						26,900	14.5	Sub-total	25,600	13.9
Airport owned (Scope 1 and 2) Sub-total						**37,600**	**20.3**	**Sub-total**	**36,300**	**19.7**
3	Tenant	Combustion for aircraft APU	N/A[2]	landing take-off	31,100	32,600	17.6	31,100	32,600	17.7
3	Tenant	Combustion for aircraft engine run-ups	N/A	Run-ups	1,720	1,060	0.6	1,720	1,060	0.6
3	Tenant	Electricity purchased off-site	N/A	MWh	94,900	104,000	55.8	94,900	104,000	56.2
3	Off-site	Waste processing	N/A	tonnes	3,400	10,800	5.8	3,400	10,800	5.9
Scope 3 Sub-total						148,00	79.7	Sub-total	140,000	80.3
Total CO_2-e emissions (tonnes)						**186,000**	**100.0**	**Total**	**184,000**	**100**

Table 14-35 Greenhouse-gas emissions for scenarios with and without the new runway in the opening year
Source: Aurecon 2017a

14.7.3.2 20 Years Post-Opening – 2045

Estimates of annual greenhouse gas emissions for the scenario with the NRP 20 years post-opening are presented in Table 14-36.

The largest difference in emissions observed is Scope 3 emissions, resulting from APU usage and waste processing all driven by the difference in aircraft movements.

Scope	Owner of Emission Source	Source	Fuel Type	Units	With NRP		
					Annual Quantity	Emissions (t CO_{2-e})	CO_{2-e} %
1	Airport	Combustion for airside vehicles	ULP	kL	101,000	914	0.4
			Diesel	kL	249,000		
1	Airport	Combustion for building heating/cooling, electricity generation	Natural gas	GJ	197,000	10,100	4.3
1	Airport	Combustion for stationary engines	Diesel	kL	9,970	27.8	0.01
Scope 1 Sub-total						11,000	4.7
2	Airport	Electricity purchased off-site	N/A	MWh	34,700	26,300	11.2
Scope 2 Sub-total						26,300	11.2
Airport owned (Scope 1 and 2) Sub-total						**37,400**	**15.8**
3	Tenant	Combustion for aircraft APU	N/A[2]	landing take-off	22,000	12,900	5.5
3	Tenant	Combustion for aircraft engine run-ups	N/A	Run-ups	1,290	1,600	0.7
3	Tenant	Electricity purchased off-site	N/A	MWh	221,000	168,000	71.1
3	Off-site	Waste processing	N/A	tonnes	6,660	16,300	6.9
Scope 3 Sub-total						199,000	84.2
Total CO_2-e emissions (tonnes)						**236,000**	**100**

Table 14-36 Greenhouse-gas emissions for scenarios with and without the new runway in 2045
Source: Aurecon 2017a

14.7.3.3 Summary of Operational Greenhouse Gas Impacts

A summary of greenhouse-gas emissions for each modelled operational scenario is provided in Table 14-37. Annual emissions are compared against baseline emissions and projected national transport emissions to understand the significance of the quantity of emissions.

Scenario	Greenhouse Gas Emissions, t CO_{2-e}			Airport Emissions (Scope 1&2)	$GHGI_{future}$ [1] Relative to $GHGI_{baseline}$			
	Scope 1	Scope 2	Scope 3					
2016	**8,920**	**18,600**	**100,000**	**27,500**		**Significance**	**Likelihood**	**Risk**
2025 without NRP	10,700	25,300	148,000	36,000	1.19	Minor adverse	Possible	Low
2025 with NRP	10,700	26,900	148,000	37,600	1.23	Minor adverse	Possible	Low
2045 with NRP	11,100	26,300	199,000	37,400	1.16	Minor adverse	Possible	Low

[130] GHGI = Sum of Perth Airport Scope 1 and Scope 2 emissions as a ratio of emissions from Australia's transport sector for that year. Therefore, adverse impacts are experienced if Perth Airport's contribution increases.

Table 14-37 Operational greenhouse gas emissions for all scenarios assessed
Source: Aurecon 2017a

Greenhouse gas emissions resulting from airport operations (the sum of Scope 1 and Scope 2 emissions) increase in 2025 for both scenarios (with and without the NRP), which is mostly due to increased electricity consumption. Electricity consumption in 2025 is higher than the baseline year for both scenarios due to increased ground power unit (GPU) and baggage make-up area usage, as well as increased demand for operation of Perth Airport buildings. Therefore, the main increases in greenhouse gas emissions are a result of airport operations and consolidation.

Compared to 2025 levels, airport greenhouse gas emissions in 2045 are reduced but still remain above baseline levels. The reduction in emissions in 2045 relative to 2025 levels is due to expected operational changes involving the Qantas relocation to Airport Central.

In all future scenarios, greenhouse gas emissions are higher than baseline conditions. However, impacts for scenarios in 2025 with the NRP are not significantly different to those without the NRP. Maximum impacts for scenarios with and without the NRP are classified as minor adverse.

Airport greenhouse-gas emission estimates are conservative and do not consider the effect of future uptake of electric vehicles or biofuels, or implementation of additional renewable energy sources or similar abatement measures. It is likely that the Perth Airport will implement some measures, but these were excluded from assessment as Perth Airport has not definitively decided on the measures to adopt and the extent to which they will be implemented. Because the majority of the estate's greenhouse-gas emissions result from electricity consumption, and greenhouse-gas emissions are similar for scenarios with and without the runway, it is expected that implementation of abatement measures will have a similar impact on each scenario.

Impacts from Perth Airport-controlled greenhouse gas emissions (Scope 1 and Scope 2) for ground-based operations are classified as minor adverse for most future scenarios assessed. However, annual emissions remain minor (below 0.04 per cent) relative to Australia's total transport emissions for all scenarios. Scope 3 emissions demonstrate that emissions from airport operations are much lower than those produced by tenants. Scope 3 emissions are not controlled by Perth Airport and so were not assessed. Risk ratings for greenhouse gas impacts of each scenario are provided in Table 14-37. The risk of greenhouse gas impacts for all scenarios is low.

14.7.4 Impact Assessment - Construction

Greenhouse gas emissions from construction activities are expected to be emitted over a period of approximately four years and are summarised in Table 14-38. Annual emissions are approximately 13,600 t CO_{2-e}. The impact assessment for the construction period is summarised in Table 14-39. Negligible impacts are expected to result from construction greenhouse gas emissions.

Construction activity	Greenhouse Gas Emissions (t CO_{2-e})
Diesel combustion by construction vehicles and equipment	44,800
Vegetation clearance	9,540
Total	**55,340**

Table 14-38 Estimated total greenhouse gas emissions resulting from construction activities over the four-year construction period
Source: Aurecon 2017a

Parameter	Units	Value
Annual construction greenhouse gas emissions	t CO_{2-e}	13,600
$GHGI_{construction}$ (annual construction emissions relative to 2025 annual transport sector emissions)	per cent	0.01
$GHGI_{baseline}$	per cent	0.03
$GHGI_{construction}$ relative to $GHGI_{baseline}$		0.3
Significance of impact		**Negligible**

Table 14-39 Impact assessment of construction greenhouse gas emissions
Source: Aurecon 2017a

14.7.5 Mitigation

14.7.5.1 Operational Greenhouse Gas

Relevant abatement measures for reduction of Perth Airport's emissions are detailed below.

Perth Airport already operates a cogeneration plant that reduces the Scope 2 emissions. Implementation of additional abatement measures will allow Perth Airport to reduce impacts from greenhouse gas emissions.

Beyond Perth Airport's emissions, Perth Airport also has an opportunity to influence tenant's emissions-producing activities and reduce Scope 3 emissions from tenants' ground-based operations. These measures are also detailed below.

14.7.5.2 Additional Mitigation

To limit greenhouse gas emissions of all emissions scopes, the following mitigation measures will be investigated during the NRP operations phase:

- modernise fleet vehicles to use alternative fuels (i.e. compressed natural gas, hydrogen, or electric),
- modernise fleet vehicles to include/increase use of vehicles which employ the latest and most efficient combustion technology,
- provide education to Perth Airport employees on fuel conserving driving techniques,
- use of 'smart' and energy efficient technologies including LED (light-emitting diode) lighting and natural lighting,
- adopt renewable energy sources where practicable for generation, use or purchase of electricity, heating and cooling,
- provide education to tenant staff who control GSE and other motor vehicles on fuel conserving driving techniques,
- increase the availability of GPUs,
- impose a limit of APU operation time,
- optimise the layout of aprons and associated roadways to reduce the distance GSE vehicles are required to travel,
- work with relevant authorities to improve public transportation for airport passengers,
- encourage use of alternatively fuelled passenger vehicles (i.e. electric) to and from the airport, including provision of recharge stations and priority parking and/or queueing lanes, and
- implement a site-wide solid-waste management program that reduces volumes of waste going to landfills.

Implementing these measures will reduce the quantity of carbon emissions produced from combustion of fossil fuels, reduce the quantity of coal or gas-electricity needing to be purchased; reduce the quantity of carbon emissions produced from combustion of fossil fuels; and reduce the quantity of carbon emissions produced from transporting and disposing of waste off-site.

14.7.5.3 Construction Greenhouse Gas

Prior to construction, a CEMP including greenhouse gas emission management, will be prepared.

To limit greenhouse gas emissions of all emissions scopes, the following mitigation measures will be considered during the NRP construction phase:

- use of solar, or other renewable energy sources, to power site equipment,
- organising and scheduling of construction activities to minimise fuel consumption of site vehicles and equipment,
- use of biodiesel in-place of standard diesel (to be considered in line with manufacturer recommendations),
- minimising construction materials,
- use of materials with lower emissions intensity (including recycled materials such as crushed recycled concrete), and
- selection of material supplier to consider minimising distance between source and site.

14.8 Summary of Impacts

A summary of the impact assessment, including consideration of additional mitigation measures, is provided in Table 14-40. It is evident that with implementation of additional mitigation measures, all risks associated with construction and operation of the NRP are rated either very low, low or medium.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Ground-based operations (2025 with and without NRP, and 2045 with NRP)	Greenhouse gas emissions are excessive and do not reflect project changes in emissions for Australia's transport sector, contributing to global warming	Operation	None identified	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Ground-based operations (all scenarios)	Ground-based Total Volatile Organic Compound emissions result in odour complaints registered by the public	Operation	None identified	Negligible	Unlikely	Very low	No additional mitigation measures identified			
Construction dust-generating activities	Excessive levels of dust generated resulting in complaints and adverse air-quality impacts	Construction	Dust management as part of the CEMP, including watering	High Adverse	Possible	Medium	Increased levels of watering, sealed roads, covers on exposed areas and stockpiles	Minor Adverse	Possible	Low
Construction activities	Excessive emissions of greenhouse gases are produced by Perth Airport during this period, contributing to global warming	Construction	None identified	Negligible	Possible	Low	No additional mitigation measures identified			

Table 14-40 Summary of impacts, risks and mitigation measures - air quality and greenhouse gas
Source: Perth Airport

14.9 Conclusion

An assessment was conducted of air quality and greenhouse gas for existing and predicted future ground-based conditions at Perth Airport, including construction impacts. Establishment of baseline conditions was necessary to allow quantitative assessment of ground-based air and greenhouse gas impacts due to construction and operation of the NRP.

A baseline year of 2016 was adopted for this study, with assessment of future operational scenarios: expected opening year (2025) with and without the operation of the NRP and 20 years post-opening (2045). A range of activity data and corresponding emission factors was collated to calculate greenhouse gas and air emissions for each scenario. Air dispersion modelling was conducted based on operations considered to represent typical daily activities.

From the assessment of operational greenhouse gas emissions, it is apparent that current emissions exceed the NGER reporting threshold. Impacts for all future scenarios are classified as minor adverse or negligible due to the contribution of Perth Airport's emissions relative to national transport emissions. The only scenario whereby operation of the NRP was shown to produce a difference in greenhouse gas impacts was 2045, where minor adverse impacts occur with the NRP.

Emissions of operational air pollutants for baseline conditions do not result in exceedances of air-quality limits at any sensitive receptor (on-estate and off-estate). From assessment of future operational scenarios, some exceedances of the $PM_{2.5}$ 24-hour and NO_2 one-hour limit were predicted in 2045 at one receptor, which is located on-estate near the General Aviation area. However, these exceedances were found to be due to activity in this area rather than due to the new runway.

Operational odour impacts for the NRP were considered qualitatively by analysing emissions of TVOCs, particularly emissions from combustion of jet fuel by APUs. It is considered unlikely that operation of the NRP will create odour impacts as combustion of jet-fuel by APUs is expected to be lower in future years compared to current levels due to increased use of GPUs.

Construction impacts for air quality and greenhouse gases were also assessed. Results obtained from air dispersion modelling demonstrate that, unless suitable mitigation measures are implemented, high adverse impacts are possible resulting in a medium risk identified. Although negligible impacts are anticipated for construction greenhouse gas emissions, greenhouse gas mitigation measures will be implemented wherever possible during construction to minimise greenhouse gas emissions from construction and, therefore, the impact of the NRP on the environment.

15 Landscape and Visual

This section describes the impact of visual changes resulting from the construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:
- How are the visual impacts assessed?
- What parts of the NRP can be viewed from different locations around Perth Airport?
- What will be the mitigation strategies considered during construction to minimise the visual impact on surrounding areas?

15.1 Introduction

This section describes the impacts of changes to the visual landscape resulting from the construction and operation of the New Runway Project (NRP).

The NRP will impact the landscape and visual appearance as a result of:

- the development of 293 hectares of land,
- construction and operation of the new runway, and
- installation of lighting infrastructure.

A study was undertaken to examine the existing visual appearance of the NRP area, assess the impacts of the NRP by comparing the impact of changes from different viewpoints, and identify appropriate mitigation measures.

Additional information on construction of the new runway and associated infrastructure can be found in Section 6.

15.2 Key Findings

Key findings from investigations into the landscape and visual impact of the NRP include:

- Visually, the elevated areas approximately 20 kilometres to the east of Perth and in the Darling Escarpment have the most prominent views. These rural and semi-rural areas are most likely to be impacted by any reduction in visual amenity due to the visibility of the airport. All off estate visual impacts have been assessed as negligible.
- The NRP will alter the visual amenity through airside road and fencing, runway and associated pavements and the installation of high intensity approach lighting at the northern and southern extents of the new runway.
- The operation of the NRP will result in an incremental increase in the existing overall lighting impact to the airport area and its surrounds, which already contains stand out features such as the coloured 'Sky Ribbon' road lighting and the Gateway WA road network, terminal lighting and lighting from the surrounding industrial and distribution precinct.

15.3 Policy Context and Legislative Framework

In general, State and local legislation are not applicable at Perth Airport. However, for the purpose of this assessment, State and local legislation and policy have been used to inform the assessment of landscape and visual impacts.

In Western Australia, National Parks are administered under the *Reserves (National Parks and Conservation Parks) Act 2004*. The State Department of Biodiversity, Conservation and Attractions (DBCA) is responsible for the management and implementation of the state's conservation and environmental legislation and regulations and focuses on the management of state forests, national parks, marine parks and reserves.

The National Parks within the vicinity of the estate include Kalamunda National Park, Gooseberry Hill National Park and John Forrest National Park.

15.3.1 Local Government Policy

Local policies for the areas around the estate that are considered relevant to the assessment are described in the following sections.

15.3.1.1 City of Belmont

The City of Belmont Vision document highlights the aspiration for the city to be home to a diverse and harmonious community, and thriving due to the opportunities of this unique, riverside City. Diversity is key to the City of Belmont being able to ensure it remains sustainable and has the capacity to grow with the changing environment and community expectations. The diversity in amenity (with the airport, river, horse-racing industry and major transport infrastructure) is identified as a key benefit.

The City of Belmont Landscaping Plan information sheet (March 2017) acknowledges that landscaping has the potential to improve the visual amenity and environmental sustainability of urban areas. "Landscaping should not only complement the appearance of the proposed development but also that of the surrounding land use". The information sheet also acknowledges that native species offer many benefits including being 'waterwise,' having low fertiliser demand, attracting birds, and encouraging biodiversity. The City of Belmont encourages all new developments to use native vegetation species when preparing landscaping plans.

15.3.1.2 City of Kalamunda

The Kalamunda Centre is a low scale, low density and dispersed commercial area, with Haynes Street forming the major movement and activity axis. The town centre is laid out on a traditional but irregular grid pattern, with a wide variety of lot sizes and frontages. Of particular relevance to the NRP is the acknowledgment that the topography is distinctive, providing some sites with the potential for long views over the surrounding areas. However, it is acknowledged most buildings have been designed with little consideration for the terrain.

15.3.1.3 City of Swan

The City of Swan Local Planning Scheme No.17 classifies land with a zone or reserve. Each zone has a set of objectives to assist Council with determining the appropriateness of discretionary uses and development. The northern extent of the estate is situated within the City of Swan. Industrial, residential and rural land zones extend north and east beyond the Great Eastern Highway Bypass. The objectives of these planning zones that are relevant to the landscape and visual appraisal have been captured below.

General Rural Zone Objectives:

- ensure the use and development of land does not prejudice rural amenities, and to promote the enhancement of rural character, and
- ensure that development and land management are sustainable with reference to the capability of land and the natural resource values.

Residential Zone Objectives:

- promote a residential environment in each locality consistent with the form and density of residential development permissible in the locality, so as to enhance a sense of place and community identity,
- preserve and enhance those characteristics which contribute towards residential amenity, and to avoid those forms of development which have the potential to prejudice the development of a safe and attractive residential environment,
- provide for a limited range of ancillary development compatible with the form and density of residential development, and complementary to the needs of local communities, but which will not compromise residential amenity, and
- avoid development of land for any purpose or in any manner that would detract from the viability or integrity of development in either the Strategic Regional Centre or the commercial zones.

Industrial Zone Objectives:

- ensure development within the zone is complementary to development in other zones and to avoid development of land for any purposes or in any manner which would detract from the viability or integrity of development in either the Strategic Regional Centre or the commercial zones, and
- ensure environmental performance of industry does not detract from the amenity of adjacent sensitive areas and conforms with any relevant environmental standards applicable to the neighbourhood.

15.3.1.4 Town of Bassendean

The Town of Bassendean Local Planning Strategy (2014) ensures a suitable interface between industrial and residential land use both in terms of visual impact and potential amenity impact resulting from land use activity.

Planning Policy No.18 Landscaping with Local Plants (2010) captures the important role landscape can play in enhancing privacy by, acting as a natural cooling system for homes, softening the built form, creating visual relief, and generally improving the aesthetic appeal of new and existing developments.

The Policy also identifies that local native vegetation can help to protect biodiversity and natural heritage values, and contribute to a 'sense of place' for the area. Landscaping can be a major component of urban renewal programs providing a boost for the local economy by stimulating business. Local plant themes can be incorporated into the landscaping of major roads, shopping centres, public transport routes, civic buildings and new developments.

15.3.1.5 City of Bayswater

The objective of the City of Bayswater Character Protection Areas Policy is to ensure that new development is consistent with the character, rhythm, scale and visual amenity of existing residential streetscapes. The four Character Protection Areas include Maylands North, Mount Lawley, Bedford and Bayswater. The document focuses on the requirements character, context, form and massing of potential development; however, consideration should be given to the wider visual amenity and context of these character areas.

The City of Bayswater Town Planning Policy 5.1 – Landscaping, ensures that existing vegetation is maintained wherever possible and that landscape design improves the quality and amenity of built areas in commercial and industrial zones.

15.4 Methodology

15.4.1 Study Area

The study area has been defined through the preparation of a Visual Envelope Map (VEM) and includes areas within and external to the estate. Using the Geographic Information System (GIS), a VEM is generated using digital terrain data (including height information) and the three-dimensional computer aided design information associated with the NRP. This process helps to identify locations where the NRP area may be visible from. The VEM is by its nature approximate only and may exclude areas of existing intervening features such as built form, vegetation or localised variations in topography, representing the greatest extent of potential visual effect. The VEM has been reviewed and validated through an onsite field investigation. The VEM is provided in Figure 15-1.

15.4.2 Viewpoint Locations

Viewpoint locations were selected based on the terrain height identified by the VEM, to identify a range of locations from which the NRP could potentially be viewed. Eleven representative viewpoints were then selected, from which landscape and visual impacts have been assessed, and are shown in Figure 15-1.

15.4.3 Assessment of Visual Effects

The baseline conditions were identified through a process of a desktop study, field survey and a review of the relevant planning framework and policies.

A description of the existing visual conditions of the estate and surrounding study area was provided with reference to the VEM. This includes consideration of existing visual amenity and landscape character.

The visual amenity and scenic value within the study area is influenced by the topography, vegetation cover and land use.

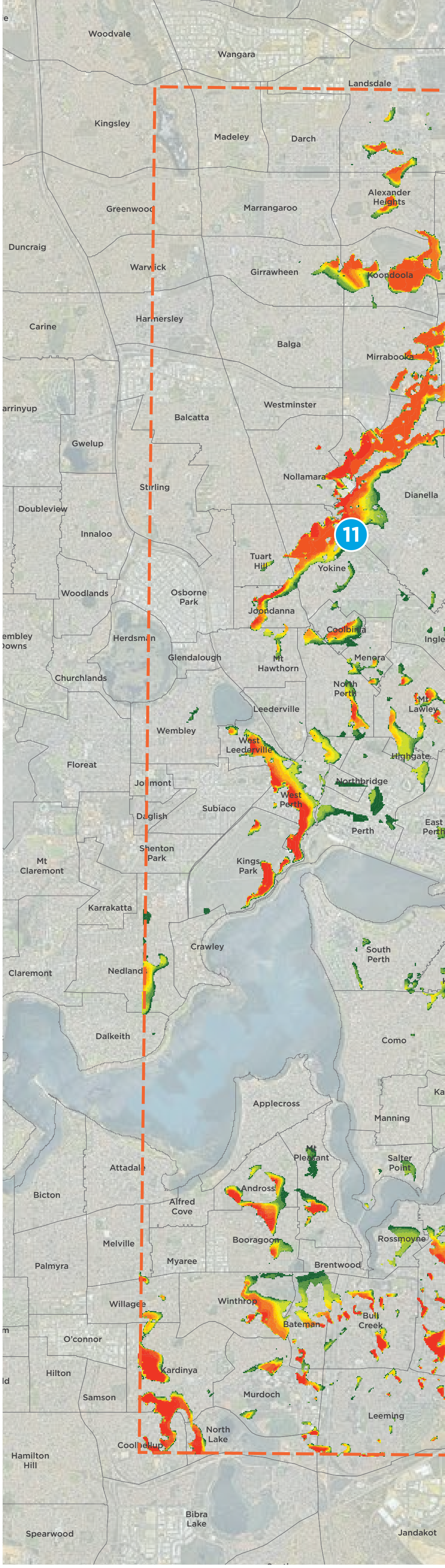
Landscape-character assessment seeks to divide the landscape into distinct, broadly homogenous units with defining characteristics. Each character area should be distinct from an adjoining area which will be defined by a different set of key parameters. A summary of the character of the landscape is provided, with a focus on the landscape characteristics that inform the extent of potential views, for example, the landform and extent of vegetation cover that could limit views as opposed to visually open landscapes where widespread inter-visibility between communities and visual features exists.

The assessment of visual effects relates to the changes from the baseline that would arise in the composition of available views because of the NRP. The two principal factors which influence the assessment of potential effects include the sensitivity of the view point and the magnitude of the anticipated change.

The visual-impact appraisal does not directly address the specific impact of increased aircraft activity or changes in flight paths to each viewpoint.

The assessment acknowledges that Perth Airport operates 24 hours a day, seven days per week and assumes that most of the impacts arising from additional lighting and operations related to increased activities will result in an incremental change to the existing activities.

The lighting design, including High Intensity Airport Lighting (HIAL) and associated airport infrastructure lighting, will be finalised as part of the detailed design. The appraisal acknowledges HIAL will be required and be viewed in the context of existing airport lighting.



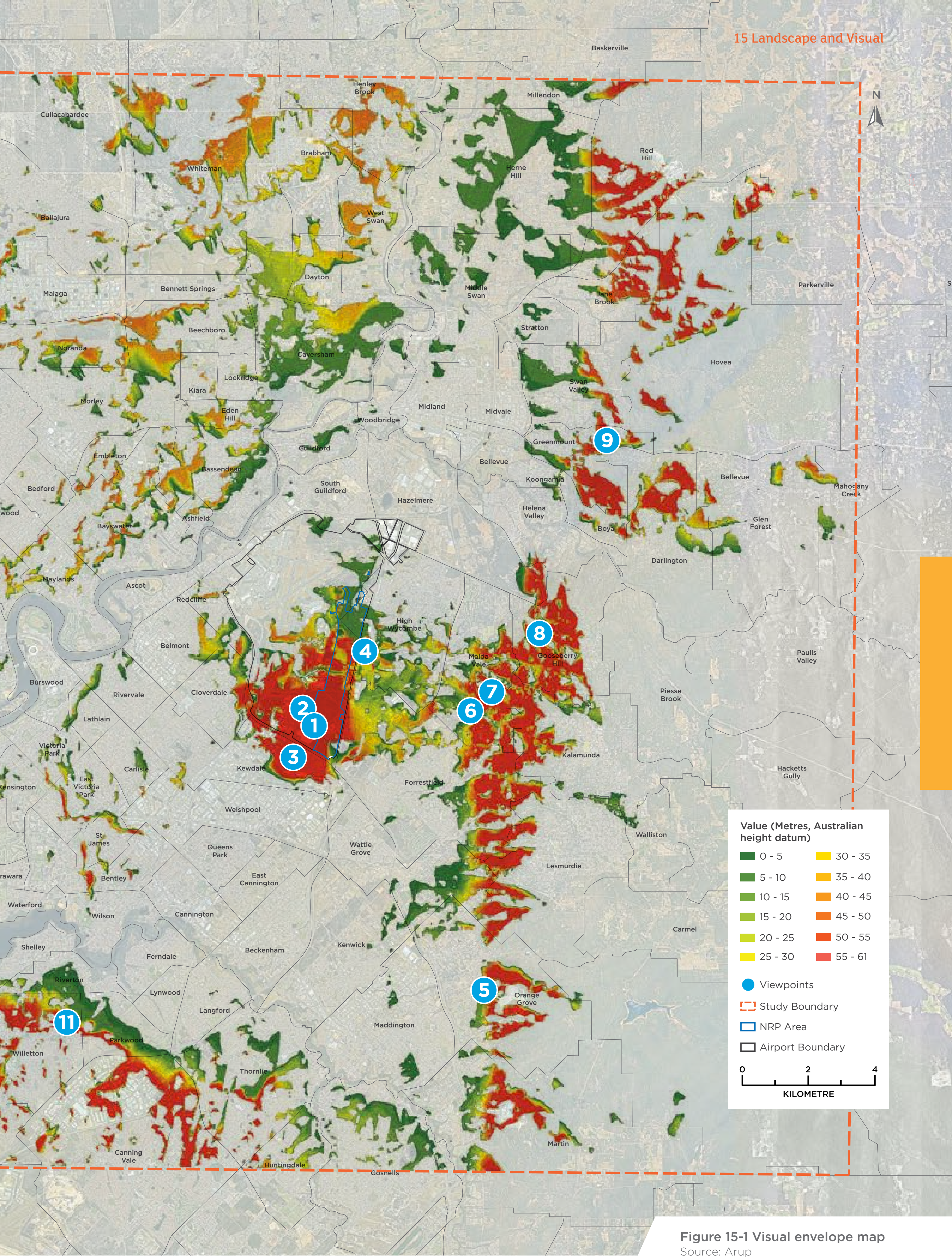


Figure 15-1 Visual envelope map
Source: Arup

15.5 Existing Condition

As outlined in the methodology, the visual study area has been defined through the preparation of a VEM to illustrate the potential extent of visibility of the NRP. The theoretical extent is based on the 3D centreline associated with the runway.

Eleven representative viewpoints were selected through a review of the sensitivity of the visual amenity and interrogation of the VEM.

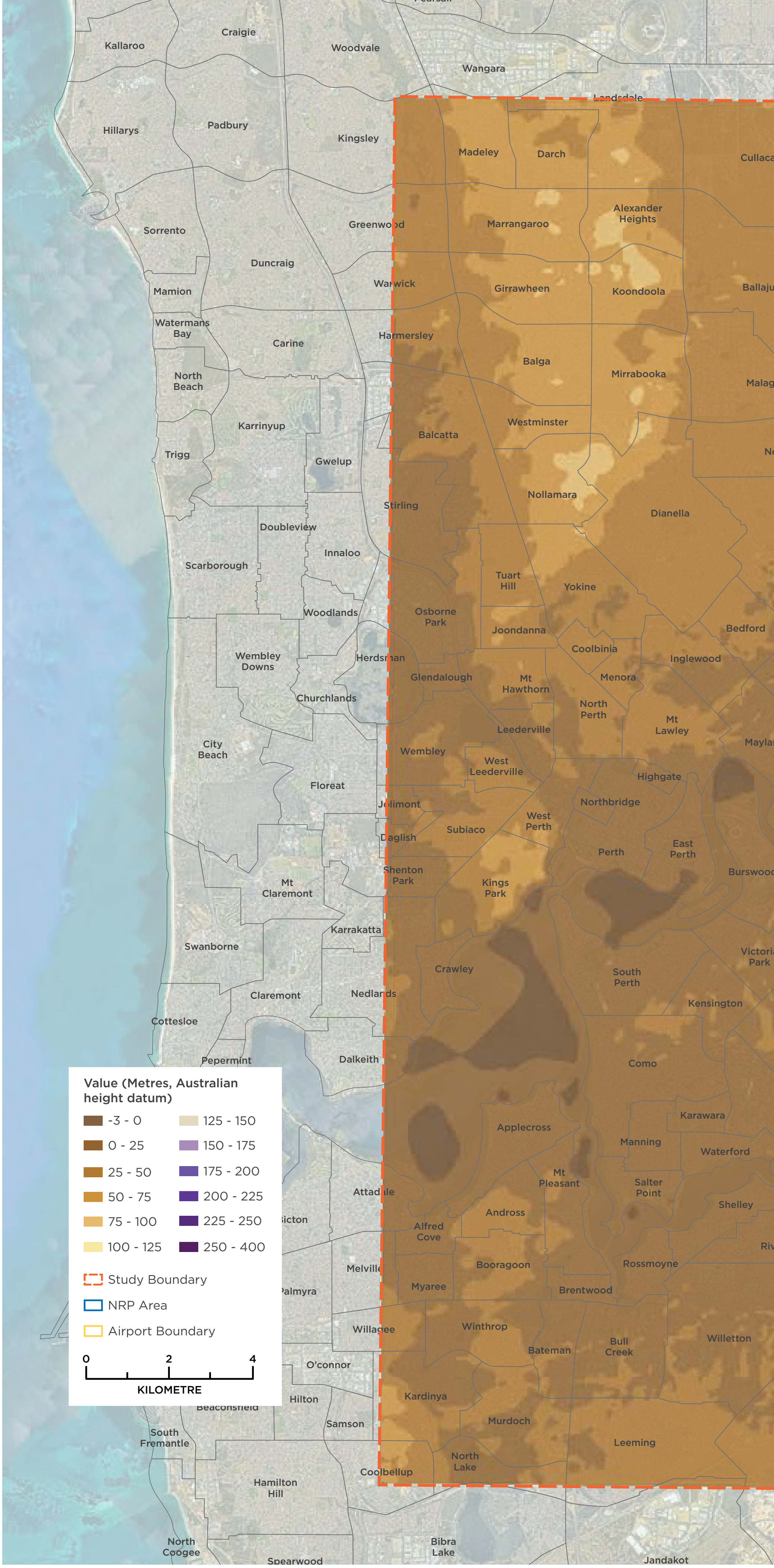
15.5.1 Visual Amenity

The visual amenity and scenic value within the study area is influenced by topography, vegetation cover and land use. A summary of these key components is provided below.

15.5.1.1 Topography

The terrain of the study area is shown in Figure 15-2 Key topographical features include:

- low lying landscape characterised by the Swan Coastal Plan that stretches west to the coastline and allows distant views to the City skyline to the west,
- the Darling Escarpment, which is covered in forested hills and reaches approximately 200 metres Australian Height Datum provides an important backdrop to the east,
- local roads within the residential areas of Orange Grove, Kalamunda, Gooseberry Hill and Greenmount which meander over the hillside and provide intermittent views across the low-lying Swan Coastal Plains to the west, and
- undulating terrain to the north and west which limit distant views to localised high points.



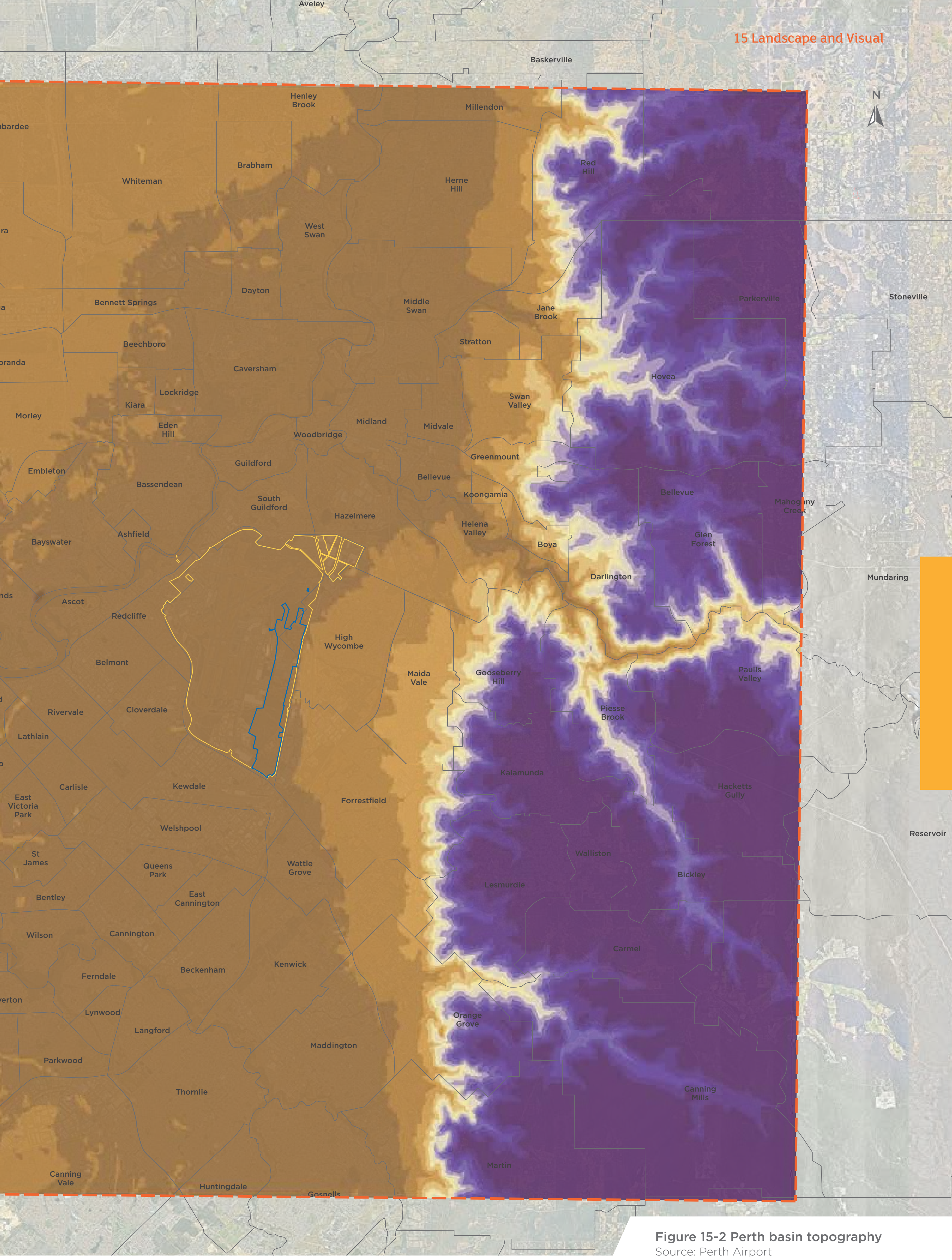
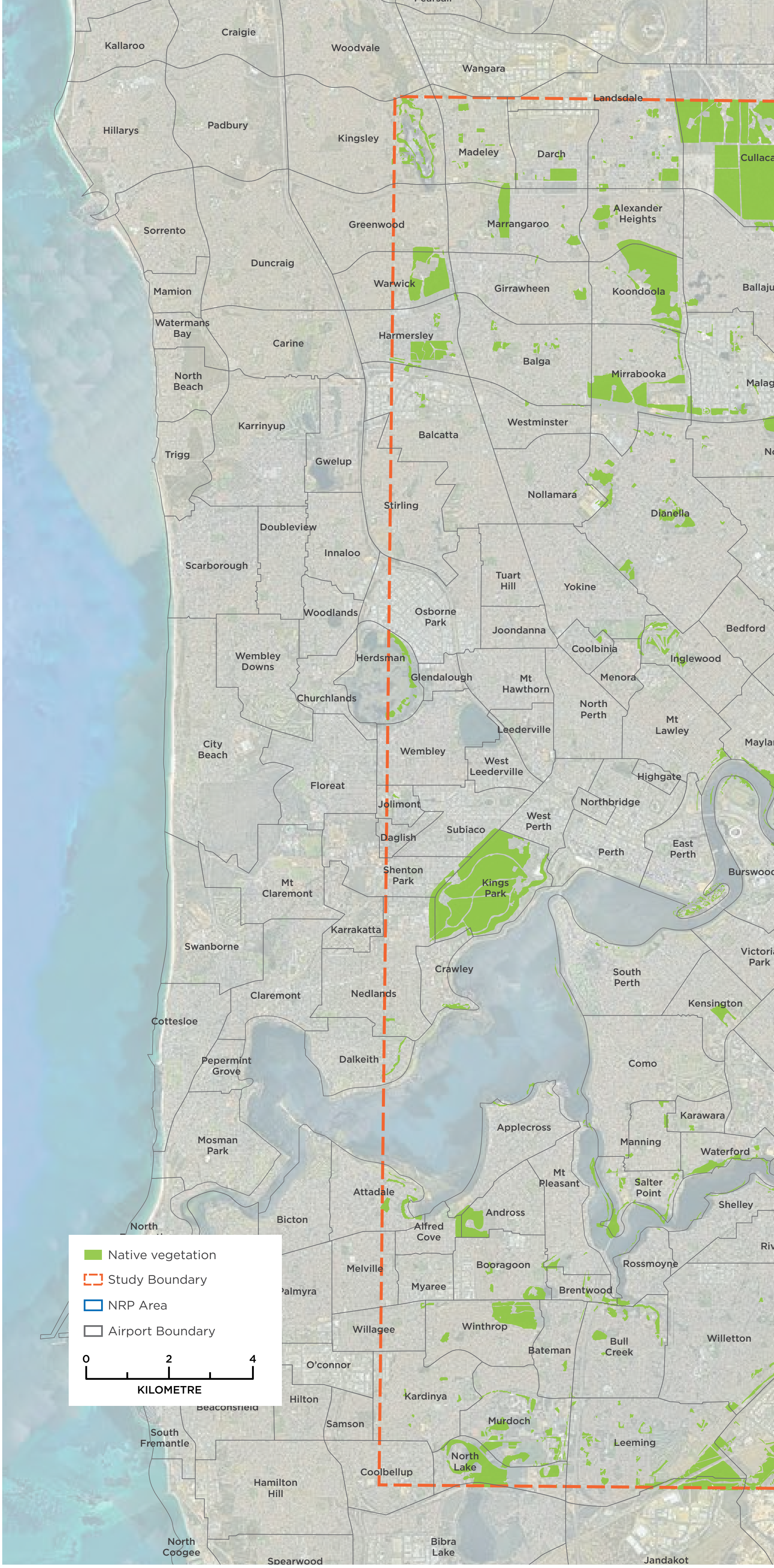


Figure 15-2 Perth basin topography
Source: Perth Airport

15.5.1.2 Vegetation Cover

Native vegetation is shown in Figure 15-3. Key vegetation characteristics include:

- seven vegetation community types, including Threatened Ecological Communities (TEC) and State Government and State listed priority species. The existing vegetation is relatively low lying, however the presence of vegetation limits low-level views towards the airport from adjacent roads,
- leafy suburbs which extend beyond the estate to the north, east and west, with tree lined streets and vegetated parklands that reduce the visual presence of the airport and associated infrastructure, and
- to the east, the blanketed hills of the Darling Escarpment, including Kalamunda National Park, Gooseberry Hill National Park and John Forrest National Park, which define the eastern extent, with occasional and intermittent views from elevated views and residential properties towards the estate.



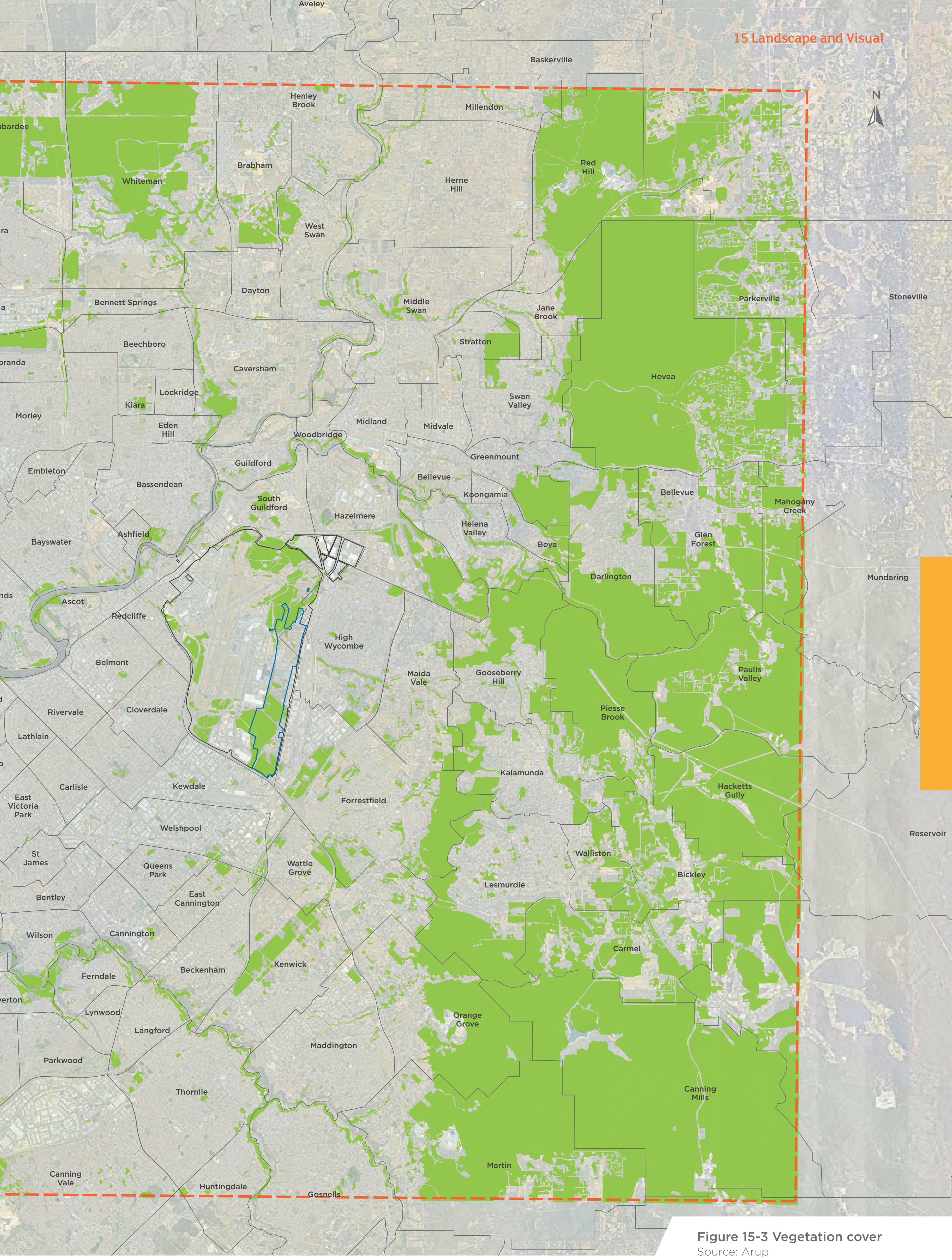


Figure 15-3 Vegetation cover
Source: Arup

15.5.1.3 Land Uses

The airport lies to the east of Perth CBD and sits within the urban footprint of the wider city. It is surrounded by suburbs and bounded by arterial roads critical for travel and freight logistics. Directly bordering the estate is a mix of large and small-scale businesses, and logistics and distribution facilities.

Predominate land use within and around the estate includes:

- airport passenger terminals, aviation support facilities, car parks, small linear parks between buildings, and associated ground transport and commercial facilities.
- the Air Traffic Control Tower which is the tallest and most visible structure within the estate,
- low lying land within which are several vegetated areas and wetlands including a small park with walking trails open to the public,
- important road transport routes including the Tonkin Highway, Abernethy Road and the adjacent freight train line, Kalamunda Road and the Great Eastern Highway Bypass. The mixed industrial and business areas continue to the south at Kewdale and Welshpool.
- low-lying residential suburbs of Cloverdale, Redcliffe, High Wycombe, Forrestfield, and South Guilford. The land starts to gently rise east of the estate before meeting the steeper Darling Escarpment, which is a mix of larger residential lots and national parks.

15.5.2 Landscape Character

The landscape character areas defined for the NRP are influenced by the preceding analysis of topography, vegetation cover and land use. The landscape character assessment is limited to the VEM as areas beyond this are unlikely to experience any change as a result of the NRP.

15.5.2.1 Perth Flats - Residential

The Perth Flats consists of:

- mostly one to two-storey houses on flat to slightly undulating ground with minimal views towards the airport or surrounds,
- largely considered landscapes, with mowed turf, high visual amenity medians and detailed garden beds,
- tall mature trees which are located within suburban parklands and the occasional busy roadway.

The focus in this area is on the foreground houses, gardens and medians as there are limited vistas except along long roads and streets.

15.5.2.2 Perth Scarp - Rural Residential

The Perth Scarp consists of:

- mostly two-storey houses on the western side of the Darling Escarpment,
- panoramic westwards views over the Perth flats which originate from along the red gravel lined roads, and
- lookouts which have been created beside roads at certain points where you will find evidence that locals or tourists have stopped to appreciate the view.

15.5.2.3 Natural Scarp - Natural Escarpment

The Natural Scarp consists of:

- uninhabited natural rocky escarpment landscape including eucalypts, dryandras and wattles in red iron-rich gravel, and
- gaps in trees and elevations.

15.5.2.4 Sandy Airport Flats - Airport Flats

The Sandy Airport Flats consists of:

- a flat industrial business precinct to the south and south east of the airport estate which is undergoing visible changes including earthworks. This area includes main arterial routes for road and rail logistics, and a mix of light industrial large and small warehouses and buildings and small businesses, and
- a small amount of contrasting natural wetland vegetated areas where nature is the main focus. There are areas of detailed landscaping along the main roadways and around the street frontage of businesses. This landscape is dominated by a background of small-to-large buildings and warehouses.

15.6 Impact Assessment

The assessment of visual effects relates to the changes that would arise in the views as a result of the NRP. The two principal factors which influence the assessment of potential effects include the sensitivity of the view point and the magnitude of the anticipated change.

15.6.1 Sensitivity

Visual sensitivity refers to the nature, duration and quality of a view. To assist in the assessment of visual effects, the sensitivity of a viewpoint is considered in the broadest context, from those of national importance through to those considered to have a local visual importance. The terminology in Table 15-1 describes the visual sensitivity criteria.

15.6.2 Magnitude of Change

Visual magnitude of change refers to the degree of change that could occur as a result of the NRP. A high magnitude of change could occur if the development contrasts strongly with the existing visual amenity. A low magnitude of change could occur if there is minimal visual contrast and a high-level of integration of form, line and scale between the proposed options and the existing environment. In this situation, the option may be noticeable but does not markedly contrast with the existing visual amenity. The terminology in Table 15-2 describes the visual magnitude of change criteria.

Level of Visual Sensitivity	Description
National	Heavily experienced, high-quality view to a national icon
State	Heavily experienced, high-quality view to a feature or landscape that is iconic to the State, e.g. views from National Parks and scenic lookouts, or views of state significance. May also be less frequently visited if the iconic visual feature is viewed from a designated viewpoint such as that included in a National Park.
Regional	Heavily experienced, high-quality view to a feature or landscape that is iconic to a major portion of a city or a non-metropolitan region, or an important view from an area of regional open space and regional park.
Local	High quality view experienced by concentrations of residents and/or local recreational users, and/or large numbers of road or rail users, e.g. expansive urban or bushland views from residential areas or local open space.
Neighbourhood	Views from locations where visual amenity is not a key feature or not important to the viewer; these may be lesser quality views, or where views are glimpsed. These may include views briefly glimpsed from roads, those which currently include visual detractors, places where there is no designated protection for visual amenity.

Table 15-1 Visual sensitivity criteria
Source: Arup

Magnitude of Change	Description
High	Considerable reduction or improvement in visual amenity. Substantial part of the view is altered.
Moderate	Noticeable reduction or improvement in visual amenity. Alteration to the view is clearly visible.
Low	No perceived reduction or improvement in visual amenity. Either the development is not visible, or if it is, the change in the view is generally unlikely to be perceived by viewers.

Table 15-2 Magnitude of change criteria
Source: Arup

15.6.3 Significance Criteria

Although there are no recognised standards for determining the significance of visual effect, there is a need to assign significance to this assessment so that there can be a clear and consistent means of evaluating visual effect. The significance criteria in Table 15-3 have been adapted from the generic criteria outlined in Section 8.

Table 15-4 shows how visual sensitivity and visual modification have been combined to determine significance of impacts specific to this assessment.

15.6.4 Potential Impacts

The following section summarises the key impacts and issues identified in the Visual Impact Appraisal.

15.6.4.1 Construction

The construction of the NRP has the potential to alter the visual amenity in the NRP area. The following processes will impact on the visual amenity:

- vegetation clearance,
- earthworks and transportation of materials, and
- construction access and pavement construction.

The industrial area directly adjacent to the eastern boundary of the estate will be visually impacted during construction. The area referred to in this assessment as the Sandy Airports Flats character area, is a mix of industrial, freight and transport, small businesses and the contrasting sandy wetlands. Users of this area, adjacent to the south of the estate will lose the green buffer to the airport during construction.

Visually, the elevated areas approximately 20 kilometres to the east of Perth in the Darling Escarpment have the most prominent views. These rural and semi-rural areas are most likely to be impacted by any reduction in visual amenity due to the visibility of the airport. However, the distance between the new runway and the existing runways within these views renders any visual change low or negligible.

Magnitude Description	Criteria
Major adverse	These impacts are considered critical to the decision-making process. They tend to be permanent, or irreversible, or otherwise long term, and can occur over large-scale areas. Receptors are extremely sensitive, and/or the impacts are of national significance.
High adverse	These impacts are likely to be of importance in the decision-making process. They tend to be permanent, or otherwise long to medium term, and can occur over large or medium-scale areas. Receptors are high to moderately sensitive, and/or the impacts are of state significance.
Moderate adverse	These impacts are relevant to decision making, particularly for determination of environmental management requirements. These impacts tend to range from long to short term, and occur over medium-scale areas or focused within a localised area. Receptors are moderately sensitive, and/or the impacts are of regional or local significance.
Minor adverse	These impacts are recognisable, but acceptable within the decision-making process. They are still important in the determination of environmental management requirements. These impacts tend to be short term, or temporary and at the local scale.
Negligible	Minimal change to the existing situation. No adverse or beneficial change is likely to be perceived by viewers.
Beneficial	The project results in an improvement in the baseline situation, for example, improved landscape and visual amenity.

Table 15-3 Significance criteria - visual assessment
Source: Arup

	Visual Sensitivity					
		National	State	Regional	Local	Neighbourhood
Visual Modification	Considerable reduction (High)	Major Adverse	Major Adverse	High Adverse	Moderate Adverse	Minor Adverse
	Noticeable reduction (Moderate)	Major Adverse	High Adverse	Moderate Adverse	Minor Adverse	Negligible
	No perceived reduction or improvement (Low)	Negligible	Negligible	Negligible	Negligible	Negligible
	Noticeable improvement (Moderate)	Very High Beneficial	High Beneficial	Moderate Beneficial	Minor Beneficial	Negligible
	Considerable improvement (High)	Very High Beneficial	Very High Beneficial	High Beneficial	Minor Beneficial	Minor Beneficial

Table 15-4 Visual assessment matrix
Source: Arup

15.6.4.2 Operation

The operation phase elements that have the potential to alter the visual amenity, (excluding the sight of aircraft on the ground or overflying) include:

- airside road and fencing,
- runway and taxiway pavement, and
- airfield lighting including the HIAL to the north and south.

Although the nature of the potential impact will vary between constructions to operation, from a construction working site to an operational runway, the assessment is anticipated to be broadly consistent, with potential for a reduction in impact as the landscape and grassed areas begin to mature and green over time, reducing the visibility of exposed earth and vertical elements such as construction equipment.

The operational impacts of the new runway will be an incremental increase in the existing overall lighting impact to the area and surrounds - which already contains stand out features such as the coloured 'Sky Ribbon' road lighting and the Gateway WA road network, terminal lighting and lighting from the surrounding industrial / distribution precinct.

15.6.5 Representative Viewpoint Assessment

Eleven representative viewpoints were selected to inform the visual assessment. The viewpoint assessment below identifies unmitigated effects that could arise from these viewpoint locations.

15.6.5.1 Viewpoint 1 - Airport South Precinct: Kwenda Marlark Wetland, corner of Tarlton Cres and Colquhoun Road

Baseline Description

Kwenda Marlark Wetland is a 9.5-hectare rehabilitated area within the Airport South Precinct comprising of a thick scrubby heath with occasional low dense trees. The view is relatively contained, with views above low vegetation to the rising terrain in the distance. The park includes a vegetated infiltration basin that receives inflows from drainage supporting the adjacent commercial precinct and a 900-metre walk comprised of sandy trails and wooden boardwalks. Entry to the park is informal and minimal with access at the corner of Tarlton Crescent and Colquhoun Road. Once within the park, the views are directed towards the natural vegetation at eye level and below, including specially designed information signage on plant species.

Sensitivity

Kwenda Marlark Wetland is a small local park. It is a natural landscape that has involved local school groups in its rehabilitation and has been a place of education regarding Aboriginal heritage. It has been rehabilitated into an area that promotes flora, Aboriginal history and a place to enjoy nature. The park is of value to local community groups and would be experienced by recreational footpath users. Sensitivity is *local*.

Magnitude of Change

Some reduction in visual amenity will occur during and after the construction of the new runway, however the Kwenda Marlark Wetland will stay intact. At the boundary, the new runway will encroach into the parklands area and slightly reduce the size of the parkland. Less than 0.7 hectares of the park is within the NRP area. It is therefore assumed the new runway will be visible and may affect some of the parkland's natural-landscape character. Where possible Perth Airport will investigate relocating the airside fence to maintain existing walking tracks. Magnitude of change is *moderate*.

Effect

The local sensitivity and moderate magnitude of change would result in a minor adverse effect. The impacts would be permanent in this area.

Figure 15-4 Kwenda Marlark Wetland, Airport South Precinct (March 2017).
Source: Arup

15.6.5.2 Viewpoint 2 - Airport South Precinct: Corner of Tarlton Crescent and Horrie Miller Drive

Baseline Description

View towards the new runway with cleared vegetation and earthworks in the foreground. The character of the area is a busy roadway within an industrial area in the Airport South Precinct. The vegetation adjacent to the cleared land currently acts as a visual buffer between the new runway and the industrial area. Views to the east extend to the Darling Escarpment.

Sensitivity

The viewpoint is situated adjacent to an industrial area and roadway with footpaths. Views would primarily be experienced from passing vehicles. Passing motorists would experience the view as a representation of the nearby Kwenda Marlark destination. Sensitivity is *neighbourhood*.

Magnitude of Change

Site preparation has been undertaken for further industrial development. It is anticipated that views towards the NRP would be fully or partially screened by industrial buildings, however the building will determine whether sightlines towards the new runway would be visible. For the purposes of this appraisal, it is assumed that development will be of a similar form and scale to the adjacent buildings. Magnitude of change is *low*.

Effect

The neighbourhood sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-5 Corner of Tarlton Crescent and Horrie Miller Drive, Airport South Precinct (March 2017).
Source: Arup

15.6.5.3 Viewpoint 3 - Kewdale Industrial Park

Baseline Description

Facing north towards the airport with Tonkin Highway and Woolworths Distribution Centre in the foreground, this is a framed view enclosed by built structures on both sides and in the distance. The view taken from the corner of Reggio and Kingscoat roads is of smaller service roads leading to a mix of large and small business and industry estates. The road verges are turfed with some feature landscaping at intersections and boundaries of estates, with intermittent lesser maintained verges of sandy turf. The framed view towards the airport is obstructed by the Woolworths Distribution Centre warehouse in the middle of the view and between this viewpoint and the new runway. The distribution warehouse dominates the horizon.

Sensitivity

Views would be experienced by local industrial users and employees in the context of existing industrial, warehouse buildings. Views towards the estate are obstructed by Tonkin Highway in the foreground and existing large distribution warehouses in the distance. Sensitivity is *neighbourhood*.

Magnitude of Change

It is assumed there will be no reduction or improvement in visual amenity with the construction and operation of the new runway. The airport is not visible from this area and is obstructed by the large Woolworths Distribution Centre and elevated Tonkin Highway. Magnitude of change is *low*.

Effect

The neighbourhood sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-6 Kewdale Industrial Park: Corner of Reggie and Kingscoat Street (March 2017).
Source: Arup

15.6.5.4 Viewpoint 4 - High Wycombe: 1000 Abernethy Road

Baseline Description

This open view is between Abernethy Road and the freight line, in an area dominated by light-industrial, small and large buildings and warehouses. There are extended views across and down the railway line from Abernethy Road away from the airport towards storage facilities, industrial buildings and a vegetation buffer between the rail and the residents of High Wycombe to the east. The Air Traffic Control Tower is visible to the north west, above trees in the foreground along Abernethy Road. The tree-lined median and light-industry large and small buildings on the opposite side of Abernethy Road towards the airport allow glimpses to the Air Traffic Control Tower.

Sensitivity

Views toward the airport are obstructed by Tonkin Highway in the foreground and existing large distribution warehouses in the distance. The area is primarily business and industrial and views would be experienced by industrial employees in the context of the existing industrial, warehouse buildings. Sensitivity is *neighbourhood*.

Magnitude of Change

It is assumed there will be no reduction or improvement in visual amenity with the construction and operation of the new runway. Magnitude of change is *low*.

Effect

The neighbourhood sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-7 High Wycombe: 1000 Abernethy Road, on a side road adjacent to the train line (March 2017)
Source: Arup

15.6.5.5 Viewpoint 5 - Mills Road East, Martin

Baseline Description

View from a stationary point along Mills Road within an elevated eastern rural suburb of Perth facing west. Views towards the airport from accessible locations are largely limited by thickets of trees and taller natural vegetation. It is a confined view bounded by vegetation either side. The area is non-residential and within the Banyowla Regional Park. The area is natural in character punctuated by the odd building, path and road. Just below this viewpoint lies large residential plots on the lower part of the escarpment.

Sensitivity

The elevated view provides a point of interest for local motorists and cyclists using the road. Narrow vistas are possible through gaps in the trees of the flatter area of Perth City and the suburbs to the West. Sensitivity is *local*.

Magnitude of Change

The canopy of the parkland vegetation prevents wide vistas towards the new runway. It is anticipated that there will be no perceived reduction or improvement in visual amenity. Magnitude of change is *low*.

Effect

The local sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-8 Mills Road East, Martin (approximately 18 kilometres east of Perth Airport) (March 2017).
Source: Arup

15.6.5.6 Viewpoint 6 - Maud Road, Maida Vale

Baseline Description

This view is experienced by rural residential properties on the east of the Darling Escarpment with extensive views west towards the city, the suburbs, the airport and the warehouses surrounding the airport. The view was taken from a suburb consisting of generally two storey houses on large allotments. The red iron rich gravel is evident on the verges of the roads. The area is suburban with focus on the more natural scenery and vistas provided by the elevation. The Air Traffic Control Tower, terminals and the adjacent commercial precinct is visible in the view.

Sensitivity

The elevated view is representative of local residential properties. Expansive views are possible over the tops of roofs and tree canopies due to the steep slope with the airport, Perth City, suburban areas and the industrial warehouses near the airport evident in the view. Sensitivity is *local*.

Magnitude of Change

The new runway would be visible in the view due to the extent of vegetation clearance. The change would be evident during construction and operation with earthworks and additional lighting. However due to the panoramic nature of the view and the distance from the airport, change would be a small component of the view and is unlikely to be perceived by the viewer. Magnitude of change is *low*.

Effect

The local sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-9 Maida Vale: Maud Road, (approximately 13 kilometres from the Perth Airport) (March 2017)
Source: Arup

15.6.5.7 Viewpoint 7 - Kalamunda Road, Gooseberry Hill

Baseline Description

This panoramic view is taken from a residential area on the east of the Darling Escarpment. Sequential views emerge while driving down from the higher points of Kalamunda Road between breaks in tall trees planted on the low side of Kalamunda Road. Two main panoramic views occur at this viewpoint:

- an encompassing view west towards the city, the large industrial warehouses near the airport and a clear view of the existing runways behind the warehouses, and
- a view consisting of the warehouses to the south of the airport and the suburbs beyond.

The suburb consists primarily of two-storey houses on large lots of land set back from the road with long driveways. The red iron-rich gravel is evident on the verges of the roads.

Sensitivity

Expansive views are possible over the tops of roofs and canopy due to the steep slope. The view includes the airport, Perth City, warehouses around the airport and the roofs of the Perth suburban sprawl and is representative of views from residential properties. Sensitivity is *local*.

Magnitude of Change

The NRP would be visible in the middle of the view with the City skyline in the distance. The change would be evident during construction and operation with earthworks and additional lighting. However due to the panoramic nature of the view and the distance from the airport, change would be a small component of the view and is unlikely to be perceived by the viewer. Magnitude of change is *low*.

Effect

The local sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-10 Gooseberry Hill: Kalamunda Drive (under ten kilometres east of Perth Airport) (March 2017)
Source: Arup

15.6.5.8 Viewpoint 8 - Lascelles Parade Lookout, Gooseberry Hill

Baseline Description

The viewpoint sits between a natural vegetated escarpment and rural residential properties which are in the foreground but are barely visible. A small, informal, gravel pullover bay has been developed as a stopping point for those in cars to admire the panoramic view east. The lower trees and height allow for expansive views which look to the city, the airport and surrounding warehouses, and leafy suburbs in the Perth flats.

Sensitivity

The viewpoint provides high-quality views for both locals and tourists who use this lookout as a vantage point. It could be part of a scenic driving route including the Zig Zag track further north. Sensitivity is regional.

Magnitude of Change

The extent of vegetation clearance and anticipated earthworks would be noticeable in the middle of the view with vegetation in the foreground and the Perth City skyline in the distance. The magnitude is low due to the distance from the airport and other elements in the view that are of interest such as the Perth City skyline and surrounding wildlife. The warehouses and industrial precincts stand out against the contrasting green landscape of the suburbs. Magnitude of change is *low*.

Effect

The regional sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-11 Viewpoint 8 - Gooseberry Hill: Lascelles Parade Lookout (March 2017)
Source: Arup

15.6.5.9 Viewpoint 9 - 12 Boorabilla Way, Greenmount

Baseline Description

The location is a leafy residential area close to the John Forrest National Park. The houses are mostly two storeys on larger plots at the base of the Darling Escarpment allowing views towards Perth City, the airport, and industrial precincts seen above the mature trees. The scenic area has a focus on the natural landscape, native-style gardens and road verges where the laterite gravel is visible. The area is under the fight path, with planes departing from the airport at the time of the assessment.

Sensitivity

Elevated representative view from residential properties on the escarpment. Expansive views are possible over the tops of roofs and canopy due to the steep slope with panoramic views including the airport, Perth City, suburban sprawl of Perth, and the industrial warehouses near the airport. Sensitivity is *local*.

Magnitude of Change

The extent of vegetation clearance and anticipated earthworks would be visible in the middle of the view with vegetation in the foreground and the city skyline in the distance although the change in the view is unlikely to be perceived. The warehouses and industrial precincts stand out against the contrasting green landscape of the suburbs. Magnitude of change is *low*.

Effect

The local sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-12 Viewpoint 9 – Greenmount: 12 Boorabilla Way (March 2017)
Source: Arup

15.6.5.10 Viewpoint 10 - Aspley Road, Willetton

Baseline Description

Aspley Road undulates slightly over small hills. It lies within a neighbourhood comprising mostly of single storey homes. There are minimal views east towards the airport due to roof tops and tall eucalypts in the distance from parklands and Canning River vegetation which lies in the foreground of the airport. Small glimpses of the Darling Escarpment are possible over the tops of houses. The view is confined and framed by vegetation and houses.

Sensitivity

Representative view of residential properties and local road users. There are glimpses of the higher Darling Escarpment to the east through gaps in trees and at the top of undulating hills, but views are predominantly focused on the imminent surrounds such as houses and gardens and landscaped medians. Sensitivity is *neighbourhood*.

Magnitude of Change

It is assumed there will be no perceived reduction or improvement in visual amenity with the construction and operation of the new runway. Magnitude of change is *low*.

Effect

The neighbourhood sensitivity and negligible magnitude of change would result in a negligible effect.

Figure 15-13 Willetton: Aspley Road (March 2017)
Source: Arup

15.6.5.11 Viewpoint 11 - Corner of Morley Drive and Hayes Avenue, Dianella

Baseline Description

The area is a busy suburban road close to the Mt Yokine Reservoir which sits on the top of a small hill. The slightly elevated viewpoint allows vistas south east towards the Swan River and the airport, down Morley Drive. Houses are predominantly two storeys with naturally landscaped road medians and verges. There were no clear sightlines of the airport or Air Traffic Control Tower and the views are confined by trees and houses.

Sensitivity

There are glimpses of the lower Perth suburban flats and industrial warehouses of the airport through gaps in trees, but views are predominantly focused on the imminent surrounds such as houses and the roads. Sensitivity is *neighbourhood*.

Magnitude of Change

Views towards the airport from this viewpoint are not clear enough for a noticeable change to be perceived. Views may be captured from surrounding houses on the upper storey however the distance from the airport, and having the terminals between this point and the new runway make the magnitude negligible. There is no perceived reduction or improvement in visual amenity with the construction and operation of the new runway. Magnitude of change is *low*.

Effect

The neighbourhood sensitivity and low magnitude of change would result in a negligible effect.

Figure 15-14 Dianella: Corner of Morley Drive and Hayes Avenue (20 kilometres North West of the Airport) (March 2017)
Source: Arup

15.7 Mitigation

Standard mitigation measures will be implemented during the design, construction and operational phases to minimise impacts and risks to landscape and visual.

During the construction phase of the NRP, site hoarding may minimise visual impacts to neighbouring areas. Workers will also seek to minimise light spill and glare associated with construction lighting by ensuring the layout of the construction site minimises visual impacts where possible.

The design of the runway will consider the visual impact of airfield and approach lighting to visual amenity and will ensure compliance with the safety regulations. Perth Airport will also investigate moving the airside fence adjacent to walking tracks in Kewenda Marlark to minimise the projects impacts. Also, overtime, as grass matures, the landscape of the runway should soften the edge of the NRP area.

15.8 Summary of Impacts

A summary of the impacts on landscape and visual and an impact risk assessment is provided in Table 15-5.

15.9 Conclusion

Visual impacts from the NRP will be derived not only from the runway itself, but from the clearing of vegetation, the runway light system and construction activities. These impacts will vary from day to night.

Through the use of publicly accessible viewpoints around the airport the visual impacts of the NRP on local residents, workers and road users has been considered.

Overall the visual impact is low from the majority of viewpoints assessed.

		Initial assessment				Residual Assessment			
Impacting process	Impact detail	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Landscape and visual impacts during construction	Loss of visual amenity due to: vegetation clearing, earthworks, transport of materials, and construction	Site hoarding where necessary minimise light spill and glare, and layout of construction site	Minor Adverse (Viewpoint 1),	Likely	Medium	(Viewpoint 1) Airside fence position will be considered during design to minimise impact on walking trails	Minor Adverse	Possible	Low
			Negligible (Viewpoints 2-11)		Low				
Landscape and visual impacts during operation - day	Loss of amenity from permanent; airside road and fencing, runway and taxiway pavement, and airfield lighting including the HIAL to the north and south	Landscaping following construction Directional lighting where feasible	Minor adverse (Viewpoint 1)	Likely	Medium	(Viewpoint 1) Airside fence position will be considered during design to minimise impact on walking trails			Low
			Negligible (Viewpoints 2-11)		Low				
Landscape and visual impacts during operation - night	Increased visibility of aircraft lights during flight and an increase in runway lighting and approach lighting	Design completed as per safety standards	Negligible	Likely	Low	No additional mitigation measures identified			

Table 15-5 Summary of impacts, risks and mitigation measures - landscape and visual
Source: Perth Airport

16 Heritage

This section describes the impacts on the Aboriginal, European and natural heritage values associated with the New Runway Project (NRP) area.

Detail is provided on the following areas:

- How does Perth Airport manage heritage on the estate?
- What are the Aboriginal, European and natural heritage values within the NRP area?
- How will the NRP manage heritage impacts?

16.1 Introduction

This section provides information regarding the Aboriginal, European and natural heritage values associated with the NRP area.

To quantify and understand heritage values, Perth Airport has undertaken a number of studies, including numerous ethnographic and archaeological assessments.

The NRP will impact heritage values in and around the NRP area as a result of:
- clearing and site preparation of the NRP area,
- realignment of drainage channels and conduits for service, and
- the construction, operation and ongoing maintenance of the new runway and associated infrastructure.

This section details the existing values associated with Aboriginal and European heritage, and describes the impacts from the NRP.

Detailed information on the construction of the new runway and associated infrastructure can be found in Section 6.

16.2 Key Findings

Key findings from investigations into heritage values within the NRP area include:
- The NRP area contains two known Aboriginal heritage sites that meet the definition of an Aboriginal site under the *Aboriginal Heritage Act 1972* (AH Act) and are listed as ethnographic and archaeological sites on the State Department of Planning, Lands and Heritage (DPLH) Register of Aboriginal Sites.
- European heritage is linked to the establishment of the Swan River Colony in 1829 and there is one place of historical age within the NRP area: a stockyard. The stockyard is not considered to be of significance, is in poor condition and provides little potential for any additional historic, scientific or social values to be revealed.
- Two sites within the vicinity of the NRP area have been classified as Indicative Places on the Commonwealth Heritage List in relation to natural heritage values.
- In recognition of the Aboriginal heritage values within the estate, Perth Airport has made significant adjustments to the location and length of the new runway, design of taxiways, boundary fences, roads, drainage and approach lighting to minimise the impacts on heritage areas within the estate. A range of measures will be applied throughout the construction of the NRP to further minimise and mitigate impacts.
- Perth Airport has received approval from the State Government, under section 18 of the AH Act, to develop, maintain and operate the new runway.
- Perth Airport remains committed to ongoing engagement with the Traditional Custodians, under the guidance of Perth Airport's Heritage Management Framework, in a manner that recognises the significance of the area to the Noongar community and acknowledges the strong link that exists between them and the land on which Perth Airport is situated.

16.3 Policy Context and Legislative Framework

16.3.1 Commonwealth

16.3.1.1 *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*

Australia's State and Territory Governments are generally responsible for the recognition and protection of Australia's Indigenous heritage places. All States and Territories have laws that protect various types of cultural heritage.

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (ATSIHP Act) enables the Commonwealth to respond to requests to protect important Indigenous areas and objects that are under threat if it appears that State or Territory laws have not provided effective protection.

It is intended to be used as a 'last resort' where State or Territory laws and processes prove ineffective. Under the ATSIHP Act, the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The ATSIHP Act also encourages heritage protection through mediated negotiation and agreement between land users, developers and Aboriginal or Torres Strait Islander people.

There are no nationally protected heritage sites on Perth Airport.

16.3.1.2 *Native Title Act 1993*

The *Native Title Act 1993* (NT Act) recognises and protects native title rights and interests. Native title refers to the communal, group or individual rights and interests of Aboriginal peoples or Torres Strait Islanders in relation to land or waters.

Native title has been extinguished where land was granted freehold status prior to 23 December 1996. Land titles on the airport estate were granted freehold status prior to this date and, thus, native title has been extinguished. As a result, native title claims over the estate have been unsuccessful.

16.3.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides criteria for evaluating, identifying and assessing the Commonwealth heritage values of a place.

The EPBC Act defines the 'heritage value' of a place based on the inclusion of aesthetic, historic, scientific or social significance, or other significance for current and future Australians.

In addition, the EPBC Act defines the 'Indigenous heritage value' of a place as referring to a heritage value of a place that is of significance to Indigenous persons in accordance with their practices, observances, customs, traditions, beliefs or history.

16.3.2 State

16.3.2.1 *Aboriginal Heritage Act 1972*

Perth Airport is located on Commonwealth land, so State legislation generally only applies for activities for which Commonwealth legislation does not exist. The AH Act is the key State legislation applicable to the Aboriginal heritage values associated with the NRP.

The AH Act and associated regulations provide for the preservation (on behalf of the community) of places and objects customarily used by, or traditional to, the original inhabitants of Australia or their descendants. In the absence of any prescriptive Commonwealth legislation, the AH Act bears direct relevance, particularly where the DPLH Register of Aboriginal Sites indicates the presence of sites.

The primary sections of the AH Act that need to be considered are section 5 which defines the term 'Aboriginal site', and section 39 (2) which details what the Aboriginal Cultural Materials Committee (ACMC) should have regard to when considering the importance of objects and places.

Under section 17 of the AH Act, it is an offence to disturb an Aboriginal site without prior written permission.

Section 18 Approval

Section 18 of the AH Act requires the owner of any land (including a lessee from the Crown) to obtain approval to use land for a purpose which, unless the Minister gives consent, would likely result in a breach of section 17 of the AH Act in respect of any Aboriginal heritage site that may be on the land.

In June 2017, Perth Airport submitted an application under section 18 of the AH Act for the purpose of obtaining approval to develop, maintain and operate the NRP including:

- clearing and fill of the site,
- new runway 3,000 metres in length,
- runway shoulders and other associated pavement areas,
- aprons and taxiways,
- airfield lighting,
- visual guidance systems,
- underground infrastructure services,
- vehicle access roads including those required for security and firefighting service vehicles,
- security fencing and conservation fencing,
- drainage systems including, but not limited to, open drains, pipes, retention basins and filtration basins,
- navigation systems, and
- associated infrastructure including a new fire station.

The application was subsequently approved by the State Government in May 2018.

16.4 Methodology

Archaeological and ethnographic assessments of the NRP area were undertaken from July 2015 through to March 2017. Undertaken in accordance with the AH Act site identification standards, the assessments identified Aboriginal heritage values within the NRP area in sufficient detail to assess the significance of any Aboriginal heritage places likely to meet the criteria of a site under section 5 and section 39 of the AH Act (Terra Rosa 2015, Terra Rosa 2016a and Terra Rosa 2016b). In addition, investigations were aimed at confirming the presence and status of pre-recorded sites and identifying any additional archaeological sites or sites that may require further sub-surface investigation.

Sub-surface investigation, including auger testing and archaeological excavation, quantified the heritage values by investigating the potential sub-surface archaeological deposits identified in order to:

- further quantify Aboriginal heritage values present within the NRP,
- identify and quantify the value of auger testing in the planning of open-air excavations,
- identify sub-surface material not visible during surface inspection of the Munday Swamp area,
- determine whether sub-surface objects exist in intact portions of previously salvaged sites, and
- better understand the cultural past of the estate to inform any future development works.

In 2016, following State approvals via a AH Act section 16 approval to disturb an Aboriginal site, sub-surface investigations were undertaken (Terra Rosa, 2017b).

Registered Aboriginal Sites and Other Heritage Places (OHP) were subjected to targeted inspections and the registered boundaries assessed for accuracy (Terra Rosa, 2016a).

An archaeological European heritage survey was undertaken in 2017 (Terra Rosa, 2017a). Prior to field work, a desktop assessment was undertaken to review heritage research previously undertaken within the NRP area and to identify any registered European heritage sites. Archaeologists then completed a targeted inspection of likely sites within the project area to assess the physical attributes and make an assessment of cultural significance.

Natural heritage values were identified through the Commonwealth Heritage List database. The assessment of fauna, flora and vegetation values are detailed in Section 11 and Section 12.

16.5 Existing Condition

16.5.1 Heritage Management

The Perth Airport Master Plan 2014 is a blue print for the future development and operation of Perth Airport. The Master Plan 2014 outlines Perth Airport's key heritage management objectives as:

- proactively engage with members of the Aboriginal community to promote cultural awareness within the Perth Airport estate and users of Perth Airport,
- in consultation with members of the Aboriginal community, identify and implement initiatives that promote Aboriginal culture and reconciliation, and
- manage listed Aboriginal sites in a culturally sensitive manner and in accordance with relevant legislation.

These objectives are being achieved through a number of key areas.

16.5.1.1 Partnership Agreement Group

Perth Airport formed a partnership with seven families who have a longstanding interest in heritage issues in the Perth metropolitan region. A Partnership Agreement was signed in 2009 and recognises the willingness of the signatories, representing Perth Airport, the Traditional Custodians and other Aboriginal Elders, to engage in good faith for the ongoing development of the airport and Aboriginal heritage.

Through the Agreement, Perth Airport commits to, but is not limited to:

- establish and facilitate a high level Aboriginal heritage steering group to facilitate on-going communication, with meetings held at least three times per year,
- include the Traditional Custodians and other Aboriginal Elders in the land use planning process as part of the regular steering group,
- implement an annual schedule of events to celebrate and enhance awareness of Aboriginal heritage and culture at Perth Airport,
- continue to undertake activities in a manner that complies with the AH Act,
- continue to make Munday Swamp available to Traditional Custodians for cultural activities,
- sponsor projects to benefit the local Aboriginal community,
- employ members of the Aboriginal community in cultural heritage awareness and land management planning activities, and
- provide scholarships for Aboriginal students undertaking university study.

16.5.1.2 Heritage Management Framework

Perth Airport's Heritage Management Framework outlines the management of Aboriginal cultural heritage within the estate (Perth Airport, 2016c).

Through the framework, Perth Airport is committed to proactively engaging with members of the Noongar community in relation to:

- projects and developments on the estate,
- suitable storage for artefacts found on the estate,
- cultural awareness activities,
- ongoing compliance with the AH Act,
- facilitating economic opportunities for the Aboriginal community,
- recognition of Country,
- land management, and
- continued access to heritage sites for cultural activities.

Figure 16-1 outlines the framework which guides Perth Airport's heritage management.

Perth Airport is in the process of reviewing this framework and incorporating the management of European and natural heritage values so all heritage values on the estate are managed in an efficient and consistent manner.

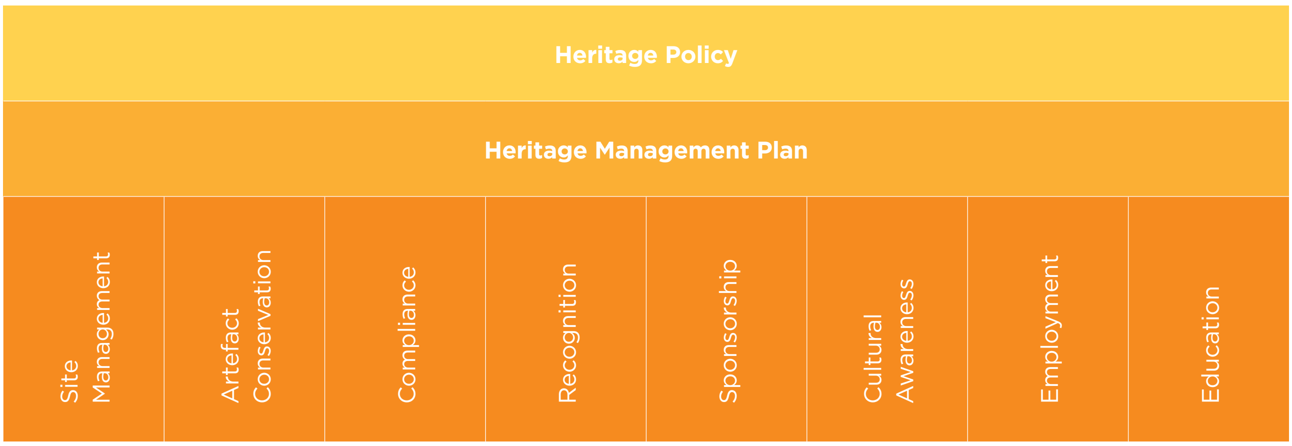


Figure 16-1 Perth Airport Draft Heritage Management Framework
Source: Perth Airport, 2016

16.5.1.3 Master Plan 2014 Initiatives

The Master Plan 2014 identifies a five-year action program for Aboriginal heritage and engagement. Important heritage outcomes that are currently being implemented include:

- updating Perth Airport's Aboriginal heritage and engagement framework,
- implementing outcomes of the Aboriginal Oral History project, which has recorded historical stories relating to the airport land,
- formalising cultural awareness training for key Perth Airport staff,
- developing an Aboriginal employment and training program to provide employment opportunities for the local Aboriginal community, and
- investigating options to archive and house artefacts recovered from sites on the airport estate and advancing arrangements for the return of artefacts from the Western Australia Museum for display.

16.5.2 Aboriginal Heritage

The land on which Perth Airport is located forms part of the traditional network of communication routes, meeting places and camping sites of the Noongar people. The Noongar groups traditionally lived throughout the south-west corner of Western Australia, from the Jurien Bay area.

Today, Noongar Country is divided into six regions, Ballardong; Ngaala Karla Booja; South West Boojarah; Wagyl Kaip and Southern Noongar; Whadjuk: and Yued. The airport estate lies on Whadjuk Country. Whadjuk are the Traditional Custodians of the Derbal Yerrigan (Swan River), its tributaries and the surrounding hills, wetlands and flood plain. The Whadjuk people and wider Noongar community maintain a strong interest in the airport and its operations.

The estate has been the subject of ongoing archaeological and ethnographic investigation for the last three decades.

To understand the Aboriginal heritage values associated with the estate, a number of assessments have been undertaken identifying the location and extent of sites and heritage places. Twenty-two archaeological and ethnographic reports of relevance to the estate, and specifically the NRP area, are held by the DPLH.

The following sections detail the Aboriginal heritage values recorded to date within, or associated with, the NRP area.

16.5.2.1 Heritage Values

The NRP area contains two Registered Aboriginal Sites that meet the definition of an 'Aboriginal site' under section 5 of the AH Act and applies to achaeological and ethongraphic values as follows:

(a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present, and

(b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent.

A third Registered Aboriginal Site (Site 25023 Poison Gully Creek) is also shown as being within the NRP area. However, due to cultural sensitivities the boundary shown on public records is indicative only, as the location of the site is restricted knowledge. The true boundary of the site is not within the NRP area.

Eight Other Heritage Places (OHP) are found within the NRP area. These are places that do not, or no longer, meet the definition of an Aboriginal site under section 5 of the AH Act. This includes places that have been previously catalogued by the DPLH but are not included on the Register of Aboriginal Sites. All eight OHPs have been classified as 'stored data - not a site' after an ACMC assessment determined that the place did not meet the evaluation criteria for a Registered Aboriginal Site.

OHP that were previously Registered Aboriginal Sites but that no longer meet the criteria for a site as outlined by section 5 of the AH Act could be due to:

- no cultural material being observed within the boundary of the then Registered Aboriginal Site,
- the condition of the site was poor and the heritage values had been heavily impacted by activities such as complete surface salvage, clearing of land and vehicle activity,
- there is a low likelihood for temporal context to be defined as a result of the absence of heritage objects and a low likelihood of an intact subsurface deposit to exist within the site area due to the disturbance sustained, and/or
- Traditional Custodians consider the area to possess a metaphysical relationship with the other artefact scatters previously identified within the region. Though this relationship offers insight into a broader cultural landscape which reflects where past Aboriginal people may once have camped, the relationship between objects and place, and this place with other places, has now been tangibly removed.

Records on the State's Register of Aboriginal Sites that are within the NRP area are listed in Table 16-1 and shown in Figure 16-2.

ID and Name	Status	Identified Values	Type	Comment
3719 Munday Swamp	Registered Aboriginal Site	Ethnographic	Artefact scatter Ceremonial, mythological, camp, hunting place, plant resource, other	No gender restrictions Restricted file and boundary
3888 Munday Swamp: Poison Gully	Registered Aboriginal Site	Archaeological	Artefact scatter Archaeological deposit, camp	No gender restrictions
25023* Poison Gully Creek	Registered Aboriginal Site	Ethnographic	Birth place, water source	Female access only Restricted file and boundary
3935 Airport: Zante Road A-D	Other Heritage Place (stored data - not a site)	Archaeological	Artefact scatter	No gender restrictions
3995 Newburn: Epsom Avenue	Other Heritage Place (stored data - not a site)	Archaeological	Artefact scatter	No gender restrictions
4001 Airport: Boronia/Phillips	Other Heritage Place (stored data – not a site)	Archaeological	Artefact scatter Archaeological deposit	No gender restrictions
4091 Newburn: Keymer Street	Other Heritage Place (stored data - not a site)	Archaeological	Artefact scatter	No gender restrictions
4121 Airport: Boronia/Epsom A-C	Other Heritage Place (stored data – not a site)	Archaeological	Artefact scatter Camp, ochre	No gender restrictions
4408 Newburn: Bingham Street	Other Heritage Place (stored data - not a site)	Archaeological	Artefact scatter Archaeological deposit, camp	No gender restrictions
15876 Wittenoom Road South	Other Heritage Place (stored data - not a site)	Archaeological	Artefact scatter	No gender restrictions
37111 Potential Heritage Place 3	Other Heritage Place (stored data - not a site)	Archaeological	Modified tree	No gender restrictions

*Note: Site 25023 Poison Gully Creek restricted site boundary is not within the NRP area.

Table 16-1 Registered Aboriginal Sites and Other Heritage Places within the New Runway Project area
Source: Department of Planning, Lands and Heritage, 2018

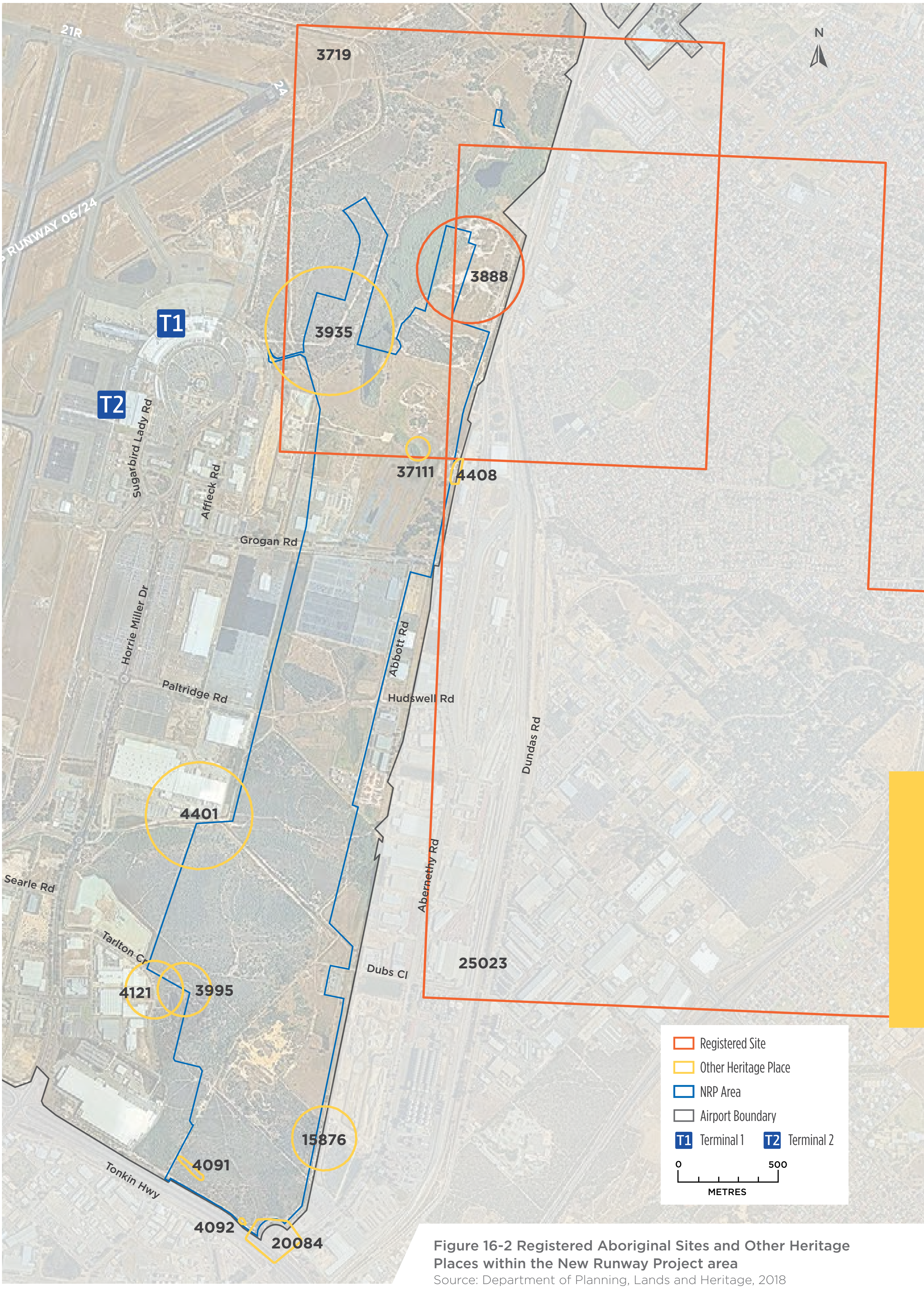


Figure 16-2 Registered Aboriginal Sites and Other Heritage Places within the New Runway Project area
Source: Department of Planning, Lands and Heritage, 2018

Site 3719 Munday Swamp

Site 3719 Munday Swamp is a wetland that covers approximately 20 hectares in the east of the estate. While Figure 16-2 provides the indicative location of Site 3719, due to cultural sensitivities the actual site boundary is restricted knowledge and no further information can be provided.

The site was originally recorded by archaeologists in 1979 and has since been the subject of numerous archaeological and ethnographic surveys. The DPLH Register of Aboriginal Sites identifies Site 3719 as a site with ceremonial, mythological, hunting and camp ground, and plant resource values. It is also listed as an artefact scatter, indicating that archaeological material has been recorded at the site at a point in time, and may have been salvaged or may remain in situ.

The most common type of archaeological material recorded on the estate is quartz. Quartz was originally sourced from coastal areas and was a popular material used by Noongar communities, particularly in the manufacturing of cutting tools.

In addition, charcoal was recovered within Site 3719, allowing carbon dating to be undertaken. Dating indicated that Aboriginal occupation of the area ranged from 453 to 4,581 years before present. Results obtained from the archaeological survey and subsequent investigations were used to inform the design of the NRP.

It is believed that Munday Swamp was named in 1829, after 'Mundy' the young tribal leader of the Beeloo people. In 1831, Mundy was present when Midgegooroo, an Elder and father of Yagan, speared white settler Erin Entwhistle who had shot a young Noongar man. Midgegooroo was subsequently sentenced to death. In retaliation, Mundy took on a leadership role within the Noongar community. Mundy covered a significant amount of territory but was normally found south of Guildford near Munday Swamp.

Mundy had earned the status of 'king' through his commitment to the wellbeing of his people. He is a recognised historical figure, and during European occupation he negotiated for the rights of his people. According to Whadjuk creation stories, Mundy was responsible for bringing fire to his people from the hills near present-day Kalamunda. The Noongar word for fire is *karla* and the literal translation of 'Kalamunda' is 'Mundy's fire'.

An alternative view of the origin of the swamp's name suggests that Munday Swamp relates to the Noongar word 'munda', meaning forest.

The cosmology of Munday Swamp is deeply connected to the landscape and a number of creation or dreaming stories are linked to the network of places surrounding the area, including Poison Gully Creek (Site 25023 and Site 3719).

The way that the Traditional Custodians conceptualise 'sites' is not wholly compatible with how the AH Act defines what can be registered as a sacred or religious site. Rather, the cultural landscape is viewed as a network of interconnected places that cannot be separated or bounded, either socially, physically, spiritually or temporally.

The Traditional Custodians view the network of heritage places and artefactual material surrounding Munday Swamp as a clear indication that people congregated in this area as a result of Mundy's pervasive influence and respect in the area.

Ancestral Aboriginal communities would engage in semi-nomadic hunting and gathering and be supported by large fresh-water sources like Munday Swamp. People would move around the main swamp area using the natural resources gradually and systematically, allowing them to replenish before using the area again many seasons later. The maintenance of complex ecosystems is necessary to sustain species that are culturally important to Traditional Custodians.

Munday Swamp supports a healthy population of western long necked turtle Turtles (*Chelodina oblonga*). Traditionally a stick was used to poke around and find the turtles in the mud, and their neck was then twisted to kill them quickly. Once the turtle had been cooked in hot ashes, it was prepared for eating in a special way; a sharp piece of shell from the front of the breastplate was broken off and used to carve. Traditional Custodians continue to hunt for turtle at Munday Swamp and collect paper-bark for painting. Perth Airport is committed to maintaining access to Munday Swamp for Traditional Custodians.

Since colonisation, Munday Swamp has been disturbed as a result of historical surrounding land-use that has included cattle grazing, and more recently, repeated illegal four-wheel drive and trail bike access. Overall, the various environmental values remain intact. Figure 16-3 and Figure 16-4 provide an aerial comparison of the area for 1948 and 2018.

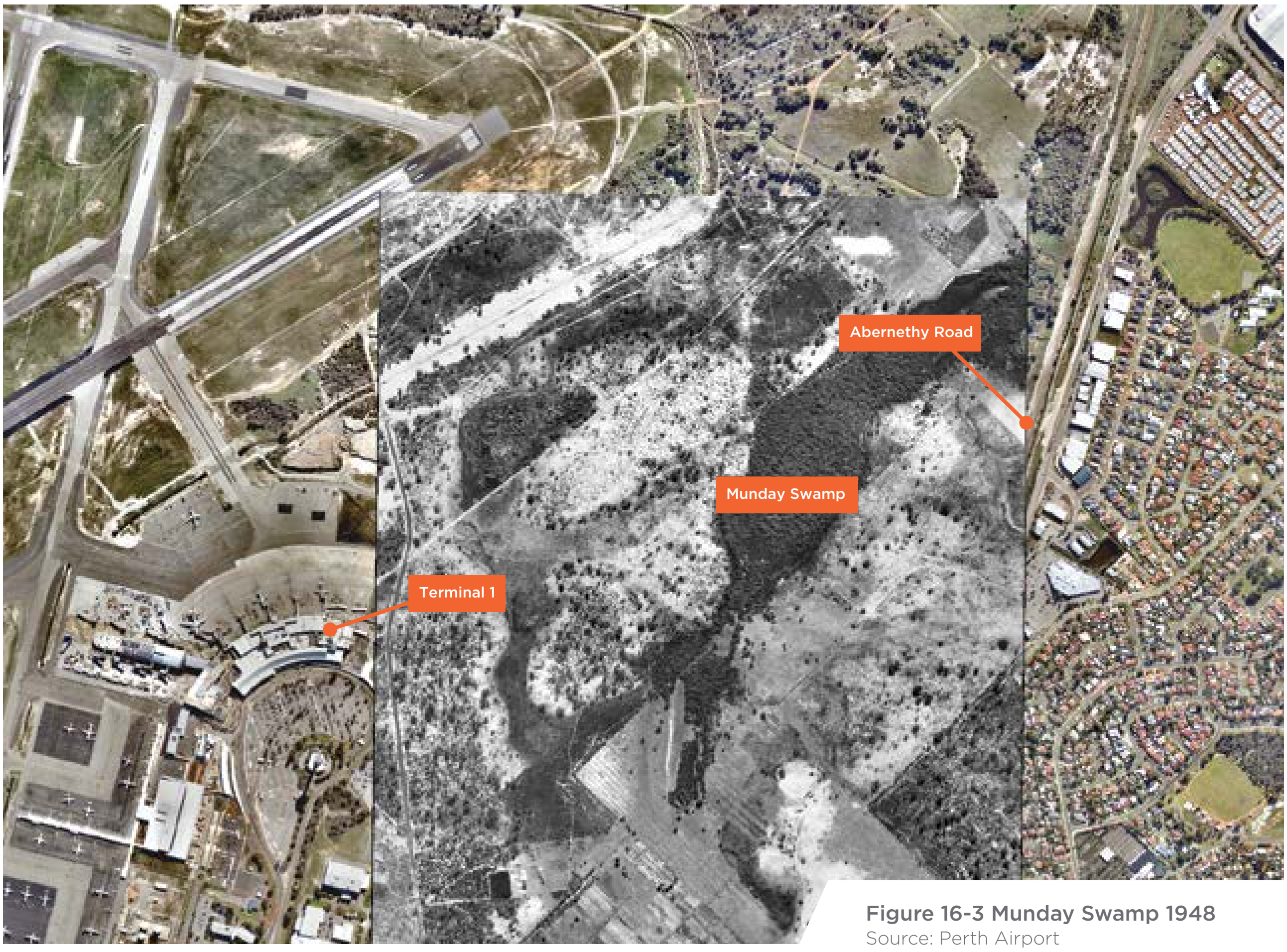


Figure 16-3 Munday Swamp 1948
Source: Perth Airport

Figure 16-4 Munday Swamp 2018
Source: Perth Airport

Site 3888 Munday Swamp: Poison Gully

Site 3888 Munday Swamp: Poison Gully was first recorded in the 1970s as an archaeological deposit and camp site. During the initial recording, the place comprised of four discrete artefact scatters located on an eroding flat ridge.

The site was revisited in 1983 by archaeologist Dr Sylvia Hallam. The four artefact scatters were re-identified with an estimated assemblage of 950 artefacts comprising quartz, fossiliferous chert, silcrete, dolerite and mylonite. At this time, the recorded assemblage contained a range of stone tool types including scrapers, adzes, flakes, flake fragments, blades, macroblades, and grinding implements.

In 2008, Artefaxion conducted an audit on heritage places within the airport estate and an attempt was made to relocate the heritage values of the site. During this assessment, it was noted that the area had been substantially disturbed by vehicle access and livestock. Two of the originally identified artefact scatters were relocated. No artefacts were located in the two other scatter sites.

The site was assessed in 2015 to ascertain its condition and evaluate its excavation potential. Consistent with the 2008 observations, no artefactual material was found in the location of the four discrete artefact scatters. A small concentration of artefacts was identified in the northeast of the place consisting predominately of quartz and fossiliferous chert flakes, flake fragments and debris. Two grinding implements were also identified within the site boundary. Despite the grinding implements and few stone tools identified, no cultural material was observed outside the concentration of artefacts in the northeast of the site.

The condition of Site 3888 has been influenced by a number of natural or anthropogenic factors. Overall the condition of the site is poor, however a small portion of the site remains relatively intact.

OHP 3935 Airport: Zante Road A-D

The boundary of OHP 3935 Airport: Zante Road A-D was first established in 1980 and delineated four distinct artefact scatters. In 1983, the boundary was amended to incorporate an additional artefact scatter into the boundary.

A complete surface salvage of the cultural material (artefacts) was conducted in 1983. Since then, the area where artefact scatter was located was heavily destroyed by the construction of a security fence and maintenance of a firebreak.

OHP 3935 was previously a Registered Aboriginal Site, however it no longer meets the criteria for an Aboriginal site as outlined under s5(a) of the AH Act.

An excavation of the site in 2016 did not identify any new information. Traditional Custodians determined that the condition of the site remained unchanged from the previous assessment in 2015.

OHP 3995 Newburn: Epsom Avenue

OHP ID 3995 Newburn: Epsom Avenue was initially recorded in 1974 as an artefact scatter on flat but heavily disturbed ground. A total of 21 artefacts were located, comprising of quartz with few additional chert and dolerite objects.

In 2008, OHP 3995 was assessed with no cultural material identified. It was noted that substantial disturbance to the site, because of erosion, most likely destroyed the OHP. Also, no cultural material was located during an assessment of the area in 2015.

OHP 4001 Airport: Boronia/Phillips

The existing boundary for OHP 4001 Airport: Boronia/Phillips was first established in 1973 and demarcated two artefact scatters. In 1983, the area was revisited by Dr Sylvia Hallam and the boundary amended to capture a larger area as well as two artefact scatters.

The recorded assemblage for the whole site comprised of quarts, dolerite flakes, blades, chert, fossilferous chert debitage, and adzes.

In 2008, an attempt was made to locate OHP 4001. Two artefacts were located. The place was noted as being disturbed at the location of the artefact scatters as a result of clearing vegetation and mounds of excavated sand from the construction of the drainage channel that dissects the site.

The heavily disturbed site was assessed in 2015 and a single artefact located. No other cultural material was identified within the site.

OHP 4001 was previously a Registered Aboriginal Site, however the place no longer meets the criteria for an Aboriginal site as outlined under Section 5(a) of the AH Act.

OHP 4091 Newburn: Keymer Road

OHP 4091 Newburn: Keymer Road was initially recorded in 1982 as a light artefacts scatter, comprising of 15 artefacts identified on a disturbed, sandy track.

No cultural material was observed during a 2008 attempt to locate the OHP. An assessment of the area in 2015 could not identify any cultural material.

OHP 4121 Airport: Boronia/Epsom A-C

The first recording of OHP 4121 Airport: Boronia/Epsom A-C was in 1973 and comprised of three individual artefact scatters. Between 1973 and 1975 a surface salvage was conducted of the three artefact scatters and a sample collection of remaining artefacts was further conducted in 1989.

In 2007 an attempt was made to locate OHP 4121. The place was noted as being heavily disturbed by development and clearing, and no cultural material was identified. The area was assessed in 2015 and no cultural material was identified within the site.

OHP 4121 was previously a Registered Aboriginal Site, however the place no longer meets the criteria for an Aboriginal site as outlined under Section 5(a) of the AH Act.

OHP 4408 Newburn: Bingham Street

OHP 4408 Newburn: Bingham Street was initially recorded in 1974 and comprised of three distinct artefact scatters. At the time of the recording, a surface salvage was conducted of approximately 200 artefacts including flakes, grinding material, scrapers, backed blades, and retouched blades. The artefacts were manufactured from quartz, chert, and silcrete. In 1975, the remaining cultural material was salvaged during an excavation by the Western Australian Museum.

An attempt to locate OHP 4408 was made in 2008. Despite the place being heavily disturbed due to the construction of a four-wheel drive vehicle course, a single silcrete flake and several quarts pieces were identified within the site boundary. It was concluded the artefacts were most likely remnant material of OHP 4408.

OHP 4408 was previously a Registered Aboriginal Site, however the place no longer meets the criteria for an Aboriginal site as outlined under Section 5(a) of the AH Act.

OHP 15876 Wittenoom Road South

Garry Quatermaine initially recorded OHP 15876 Wittenoom Road South in 1996 as an artefact scatter containing six quarts artefacts.

In 2008, an attempt was made to locate OHP 15876. No cultural material was identified. Severe disturbance to the site was noted due to vehicle movement, clearing and construction. No cultural material was located during the 2015 assessment of the area.

OHP 37111 Potential Heritage Place 3

During ground surveys in 2017, a possible scar tree to the north of the NRP area was noted by a Noongar member. A confirmed scar tree may suggest evidence of prior Aboriginal occupation and the use of natural materials like bark to manufacture canoes, shelters, shields, containers and/or artwork. An archaeological assessment of the potential scar tree noted there was no evidence of cut marks. A subsequent arboricultural assessment of the tree (*Melaleuca preissiana*) determined that the scar on the tree is the result of a historic fire, and has formed in such a way as a result of the cambial tissue formation around a wound caused by the fire. Therefore, it was concluded that the scar is the result of environmental effects rather than direct human actions and no further action was taken.

Other Findings

During a 2015 assessment, a number of sites were identified as having some potential for archaeological deposits to exist. The areas were identified in collaboration with the Traditional Custodians.

State approval was gained for sub-surface investigations under section 16 of the AH Act to disturb an Aboriginal site. At the request of the Whadjuk Working Party the application was amended to ensure that, if found any artefactual material would be repatriated to its original location.

Archaeological material recovered during investigations comprised a mixture of quartz, fossiliferous chert and granite, all representative of the domestic activities undertaken throughout Noongar occupation. All artefacts identified during the sub-surface excavations were recorded and analysed on site and returned to the test pit before the backfilling process.

16.5.3 European Heritage

Early European occupation of the land within the vicinity of the estate dates to the mid-late 1800's and is intrinsically related to the establishment of the Swan River Colony in 1829. The foundation of Guildford to the north-west of the estate occurred within the first years of the colony. It was chosen for its ideal location between the Swan and Helena Rivers. Due to its location, the town site served as an inland river port and market centre for the surrounding agricultural districts.

The estate is located on land that was originally granted by Governor James Stirling to John Scott, a farmer who arrived from Scotland in 1831. Prior to the establishment of Perth Airport as it currently stands, civilian air services were provided from Langley Park (prior to 1924) and Maylands Aerodrome from 1924. However, by the late 1930's the infrastructure of the Maylands aerodrome was not able to accommodate increasing demand for civilian air traffic.

In 1938, South Guildford was selected as the future site for Perth Airport. Four years later, in early 1942, the land was converted from the Dunreath Golf Course and Market Garden to RAAF base that operated until the end of World War II.

In September 1952, the Guildford Aerodrome officially became Perth International Airport. The suburb of Newburn (originally known as Red Gum Forest), which is a small rural community situated east of Redcliffe, was resumed by the Commonwealth Government during the 1970's and 1980s as the site for the future new runway.

Today evidence exists of historical land use within the NRP area in the form of building foundations, wells, farming paraphernalia and pastoral land. Despite this, a search of the Australian Heritage Database has revealed no-built form places of heritage significance exist within the NRP area.

Recent surveys confirmed that one place of historical age occurred within the NRP area: a stockyard. The stockyard exhibited a post-war agricultural structure on the northern side of Dubs Close (Figure 16-5). It measures approximately 26 metres long by 16 meters wide with an approximate height of 0.5 metres. The construction materials consist of components that vary in age from the post-war period to recent decades. The surrounding area has been heavily disturbed by industrial development, with an area of landfill located directly northwest, a deep drainage ditch that runs along the northern fence, and a pipeline that runs through the western side of the stockyard.

Aerial photographs from 1953 onwards show that the area surrounding the stockyard was used for agricultural purposes, with the location of the stockyard adjacent to a track until the 1960's. The structure is visible in aerial images from the 1970's onwards.

The stockyard is not considered to be of significance as defined by the Australian International Council on Monuments and Sites (ICOMOS) Charter for Places of Cultural Significance (The Burra Charter, 2013). It is in poor condition and provides little potential for any additional historic, scientific or social values to be revealed. It is not considered to hold any spiritual values.

Further detail on the history of Perth Airport is provided in Section 1.

16.5.4 Natural Heritage

A search of the Commonwealth Heritage List identified two places in the vicinity of the NRP area:

- Forrestfield Bushland, Horrie Miller Drive, Newburn via Perth Airport, and
- Munday Swamp and surrounding bushland, Kalamunda Road, Perth Airport.

Both sites are classified as indicative places on the Commonwealth Heritage List, meaning that data in relation to both potential sites have been provided to or obtained by the Heritage Division and been entered into the database. However, a formal nomination has not been made and the Australian Heritage Council has not received the data for assessment. The data in an indicative place does not necessarily represent the views of the Australian Heritage Council or the Minister.

Sections 11 and 12 provide information regarding fauna, flora and vegetation in the NRP area.

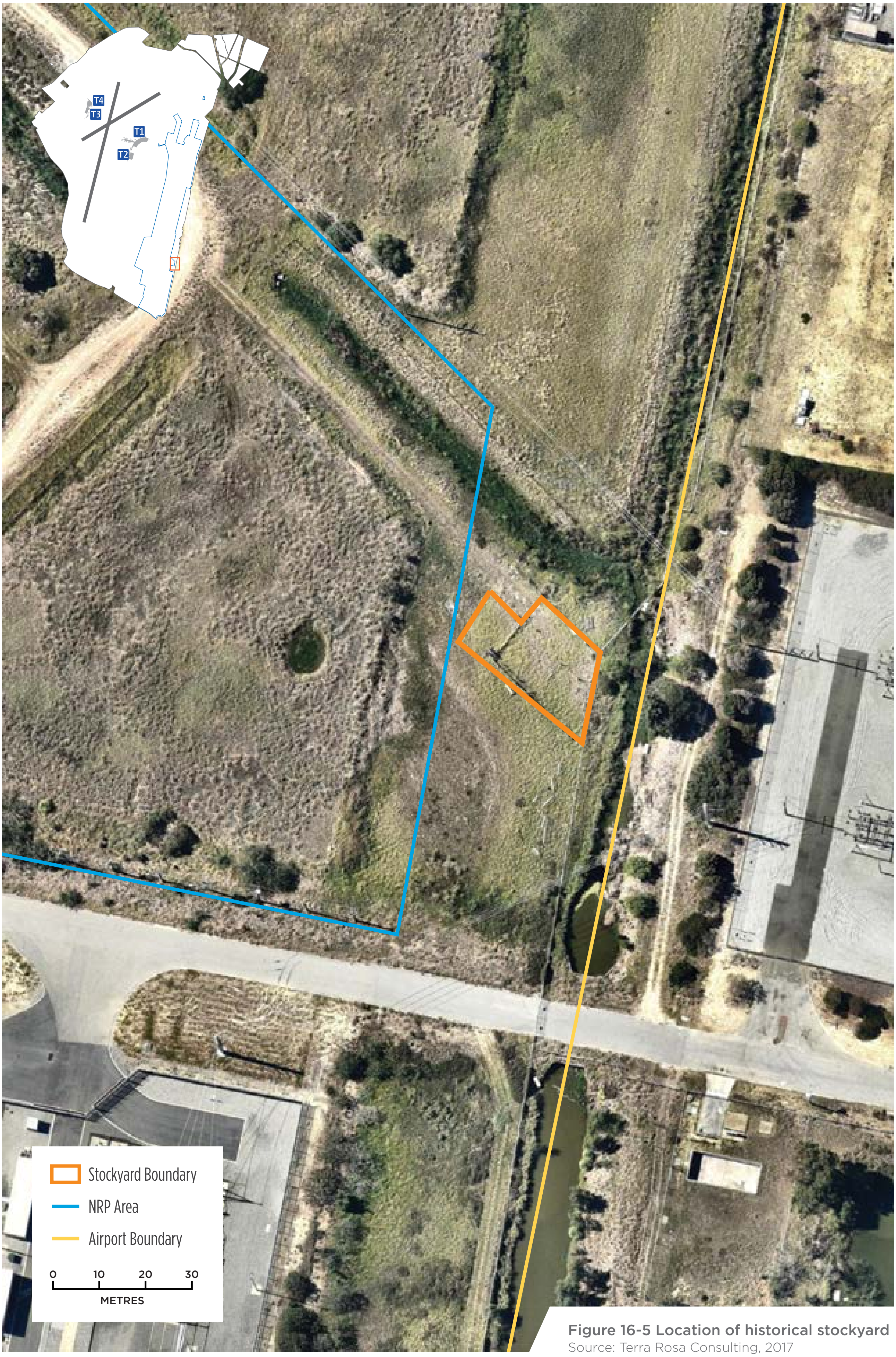


Figure 16-5 Location of historical stockyard
Source: Terra Rosa Consulting, 2017

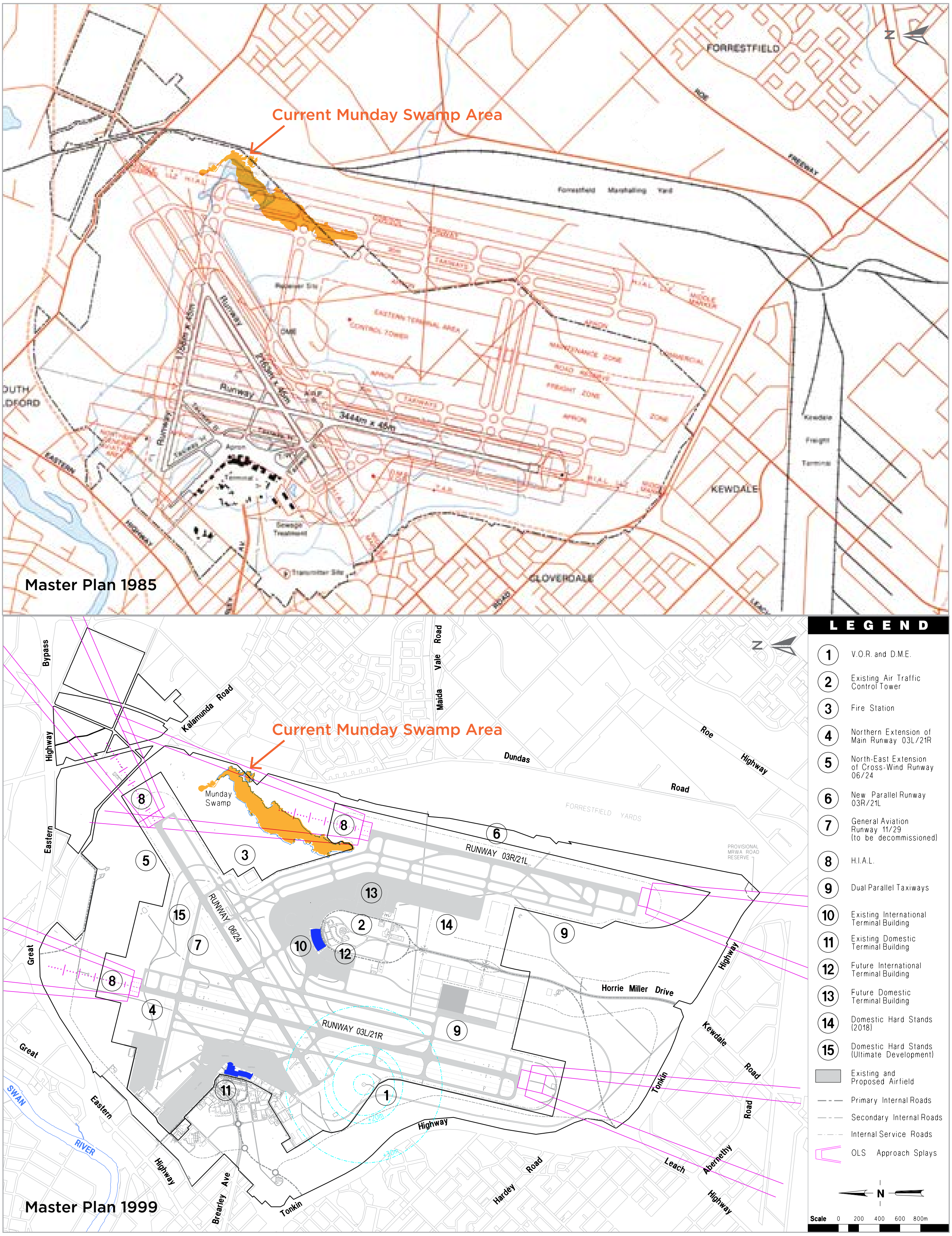


Figure 16-6 Master Plan 1985 and 1999 comparisons showing the reduced impact to Munday Swamp
Source: Perth Airport, 2014

16.6 Impact Assessment

Where practical, the design of the NRP has minimised impacts to heritage values while still ensuring the new runway can be developed and operated in a safe and effective manner.

16.6.1 Planning for the New Runway

The new runway has been planned since the 1970s, with the location published in the first public Perth Airport master plan, Master Plan 1985. The original length of the runway was 3,800 metres, which would have resulted in the complete destruction of Munday Swamp.

Recognising the importance of Munday Swamp to the Noongar community, the design of the new runway was significantly amended in 1999. The runway threshold was shifted south and the overall length of the runway was reduced from 3,800 metres to 2,700 metres. This reduced the proposed impact to Munday Swamp and resulted in the swamp being materially retained.

Figure 16-6 shows a comparison of the original position and length of the new runway in the Master Plan 1985, and the change made to the runway length for the Master Plan 1999.

Following a review, the runway was lengthened by 300 metres to the south. Subsequently, in more recent project design development, to further minimise impacts to Munday Swamp, Perth Airport has made significant adjustments to taxiways, boundary and security fences, roads and drainage infrastructure. Refer to Section 6 for a detailed design description.

16.6.2 Construction Impacts

Following the significant changes to the location and length of the new runway as well as the recent project design development which worked to minimise the impacts to heritage values, there still remains unavoidable impacts.

The unavoidable heritage impacts associated with the NRP that have been included in the AH Act section 18 application are outlined below.

Figure 16-7 illustrates the NRP construction impacts to Munday Swamp and associated Aboriginal heritage values. Further information on each of the listed infrastructure elements is provided in Section 6.

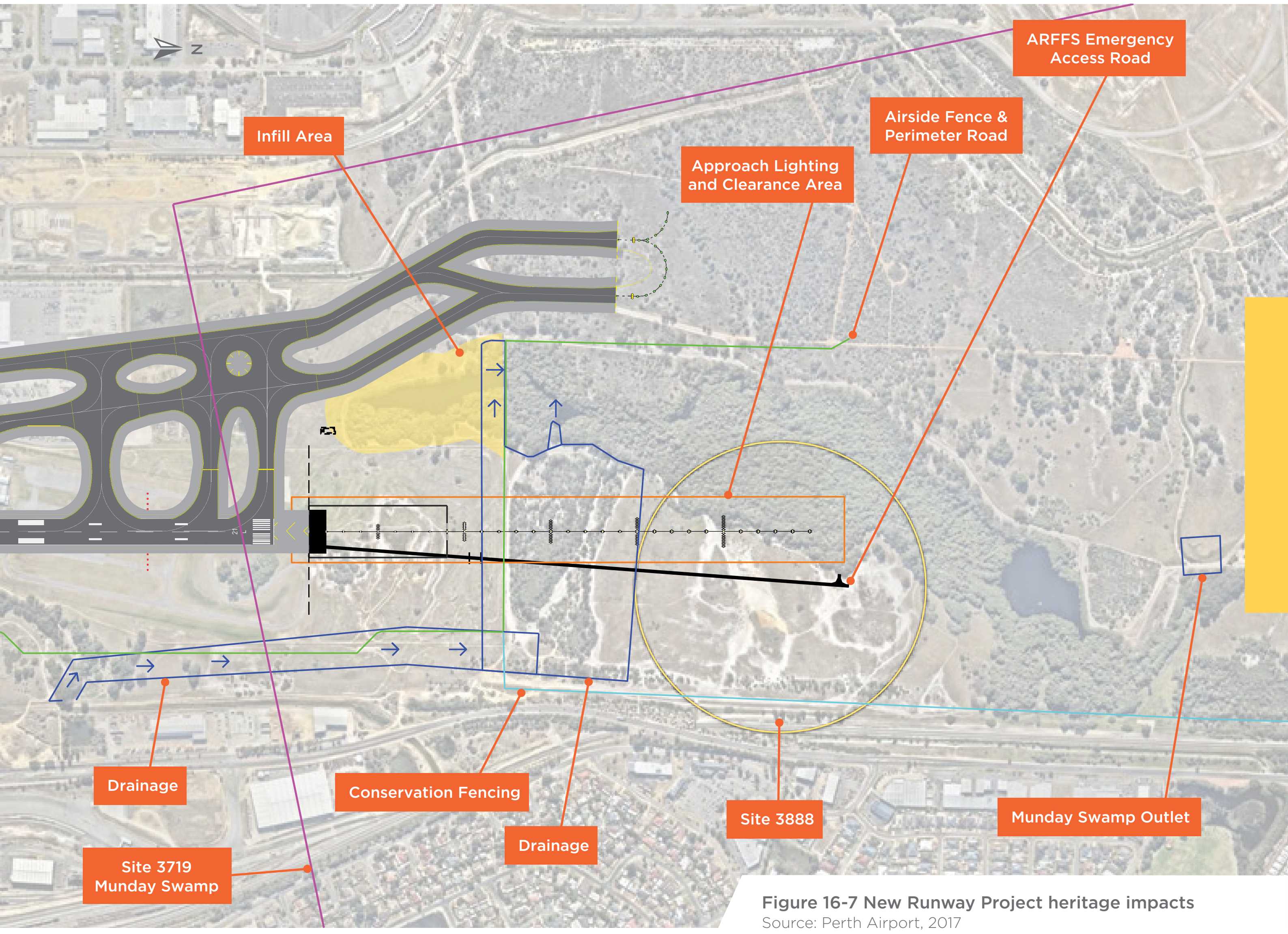


Figure 16-7 New Runway Project heritage impacts
Source: Perth Airport, 2017

Approach lighting

The installation of approach lighting including High Intensity Approach Lighting (HIAL), which is used by pilots to visually identify the runway and align the aircraft prior to landing, is required at both ends of the runway.

The installation of the HIAL will be in the vicinity, or footprint, of Site 3719 and Site 3888.

The HIAL comprises rows of lighting that extend at least 720 metres from the end of the runway. An example of the approach lighting is shown in Figure 16-8.

Design standards require a clearance zone, where 60 meters either side of each pole is kept free from obstacles that are higher than the light masts (to avoid shielding the lights from pilots). This will involve the removal of plants and regular pruning of trees ensure the clearance zone is maintained.

Some light poles and trenching for electrical cables will penetrate the ground within Munday Swamp.

Perimeter road

A perimeter road is required around the new runway for security, operational, maintenance and emergency response.

The perimeter road for the NRP proposed will be at least eight metres in width and designed to cater for all types of vehicles, including Ultra Large Aviation Rescue and Fire Fighting (ARFF) tenders. To provide a safe, all-weather surface, it is anticipated that the road will be sealed with asphalt as per current airside perimeter roads.

The construction of the perimeter road will require vegetation clearing within the vicinity of Site 3719. Impacts will be minimised to avoid as much as practicable the dense vegetation within the swamp area.

Emergency access road

Emergency access roads are generally graded gravel roads that allow emergency vehicles to access the area at the end of the runway in the event of an emergency. They are designed to minimise aircraft crash response times.

Vehicles, such as the Ultra Large ARFF tenders, are required to be able to access Munday Swamp in the event of an emergency (referred to within Perth Airport's AH Act section 18 application as 'operational activities').

The roads extend from the end of each runway threshold by up to 1,000 metres, or to the extent they are within the airport boundary. These roads require regular maintenance to ensure emergency response access is available at all times.

Figure 16-8 High Intensity Approach Lighting at Perth Airport Example
Source: Perth Airport

Figure 16-9 Infiltration basin (Liege Street Wetland, City of Canning)
Source: Syriux Environmental, 2017

Figure 16-10 Example drainage outlet
Source: Perth Airport

Security fencing

A new airside security fence and electronic security system is required to meet aviation security requirements. The security fencing forms the boundary between publicly-accessible landside areas and restricted airside areas, including around the approach lighting located at each end of the new runway. Installation of the fencing will impact the southern and south-western portion of Site 3719. Either side of the fence is required to be kept cleared, with a minimum area of three metres landside and two meters airside from the fence.

Drainage

The NRP requires the realignment of the drainage infrastructure within the estate. The construction of an infiltration basin is proposed to the southeast of Site 3719. It will allow water to flow into and soak into the ground or evaporate. When full (e.g. in large rainfall events), water will flow from the basin across an overland flow area into Munday Swamp. The overland flow area will be designed to keep flow velocities low and prevent erosion of both the immediate area and the edge of Munday Swamp.

The design of the drainage system will minimise the impact of the NRP on Munday Swamp. The planting of native varieties of select vegetation will assist with the filtration of the water, improving the water quality. Water quality forms an aspect of the protection of heritage values.

An example of an infiltration basin is shown in Figure 16-9.

Munday Swamp Outlet

An engineered drainage outlet, similar to the image shown in Figure 16-10, will be constructed to the north of Site 3719 to allow water to flow through Munday Swamp and into the airport drainage network.

This will control the peak water levels and maintain the frequency and duration of inundation within Munday Swamp to be similar to what currently occurs. Maintaining the existing hydrological regime is important so that species that have limited tolerance to prolonged inundation or soil saturation due to root oxygen deprivation and lack of adaptive mechanisms are not negatively affected.

Munday Swamp Infill Area

The southern portion of Site 3719 will be filled in to support taxiway and fence infrastructure. The Civil Aviation Safety Regulations 1998 (Manual of Standards Part 139) determines the distances and clearances required around the taxiways, which are required to connect the new runway with the terminals and the existing airfield.

The area being cleared and infilled is shown in Figure 16-7.

Conservation fencing

New conservation fencing will partially intersect the boundary of Site 3888.

A portion of the fencing will be installed along the eastern boundary of the estate, parallel with Abernethy Road. This fencing is required to prevent unauthorised access within the estate and mitigate further impact to Munday Swamp by illegal trespassers operating trail bikes and four-wheel drives.

Although not located within the NRP area, the fencing has been included within Perth Airport's application under section 18 of the AH Act to construct, maintain and operate a new runway, and is detailed in this MDP for context only. The fencing will be installed once the section 18 application is approved by the State Minister.

16.6.3 Operational Impact

The operation of the new runway may pose ongoing impacts to heritage values for which Perth Airport has received the necessary approvals under section 18 of the AH Act.

Impacts relate to the operation of aircraft within close proximity to Munday Swamp during landing and take-off, and the ongoing maintenance needs to facilitate safe operation of the new runway. Emergency training activities may also be conducted regularly to familiarise personnel with emergency access and response arrangements, including within and around Munday Swamp.

16.7 Consultation

The Commonwealth Government has provided guidance for best practice Aboriginal engagement through its Engage Early (DEE, 2016) and Ask First (Australian Heritage Commission, 2002) guidelines. Best practice consultation includes:

- identifying and acknowledging all relevant affected Aboriginal peoples and communities,
- committing to early engagement at the pre-referral stage,
- building trust through early and ongoing communication for the duration of the project, including approvals, implementation and future management,
- setting appropriate timeframes for consultation, and
- demonstrating cultural awareness.

Prior to submission of the application under section 18 of the AH Act, Perth Airport undertook extensive consultation with Traditional Custodians and relevant organisations.

Meetings were held with staff at the State Department of Aboriginal Affairs (now DPLH) and the South West Aboriginal Land and Sea Council (SWALSC). Workshops were held with Traditional Custodians and other cultural knowledge holders with an interest in Munday Swamp and the Perth Airport/ Swan River area, including members of the Perth Airport Partnership Agreement Group.

A total of 43 Traditional Custodians and cultural knowledge holders, comprising Partnership Agreement Group members, Whadjuk Working Party members and others recommended by SWALSC, were consulted over three workshops, held on Country at Munday Swamp, during April and May 2017.

Consultation elicited various positions and no clear consensus was reached. Responses recorded during consultation varied from objection to the project having any impact on Munday Swamp, through to conditional support subject to measures to minimise impacts where possible.

A summary of Perth Airport's response to key issues raised by the Traditional Custodians and cultural knowledge holders during consultation is provided in Table 16-2.

Key Issues Raised	Perth Airport Response
The land and waters are sacred and significant to the Aboriginal people	In recognising the significant value and connection the Noongar community have to Munday Swamp, the new runway was significantly amended in 1999 to shift from completely destroying Munday Swamp to materially retaining the swamp and minimising impacts as much as practical by moving the runway south and shortening it.
Should the project proceed, Perth Airport would need to maintain water quality and natural variances in water levels. Maintaining existing swamp conditions is needed for the hunting of turtles at times when water levels recede exposing mud flats.	Perth Airport has undertaken extensive modelling and analysis in the planning and design phases of the project to seek to retain and, where practical and possible, improve and restore the natural functions, quality and variability of the Munday Swamp ecosystem. The project works include reconnecting surface water flows from Poison Gully to Munday Swamp to restore the natural system and better water quality flowing into the Swan River.
Response and disclosure of artefact finds during construction.	Perth Airport has an established process for artefacts being found during works on the estate. Both Master Plan 2014 and Master Plan 2020 identify Perth Airport's commitment to investigate options for storing the artefacts.
Regular meetings with Traditional Custodians.	Perth Airport's Partnership Agreement Group was formed with Traditional Custodians who were nominated by the [then] State Government. Perth Airport acknowledges that it is not a complete list of relevant representatives. The make-up of the group membership will be reviewed to be more inclusive.
Wildlife and vegetation is important to the land and Munday Swamp. Animals come from the dreamtime and are the totems of Aboriginal people.	Fauna trapping will be undertaken before the clearing of bushland. There is a need to actively manage the possible impacts of bird strikes, and bird mitigation measures are actively undertaken across the estate to reduce the risk to aircraft.
Recognition of Aboriginal people and of the estate being on Whadjuk land	Perth Airport is currently looking at opportunities to recognise the history of the land, including Welcome to Country signage for the International Terminal.
Opportunities for Aboriginal people, such as employment, contracts/procurement, interpretative cultural centre, involvement in artwork selection and commitment to source from Whadjuk artists, financial contribution from airport revenue.	Perth Airport acknowledges the need to offer a range of suitable and practical Heritage Management Plan commitments to address relevant impacts. A series of initiatives which could be considered were discussed during consultation, including the development of an artefact storage and cultural awareness facility, opportunities for procurement and employment. An example is a proposal to create walking link and living stream from High Wycombe, through Poison Gully and around Munday Swamp, with interpretative signage along the way to educate people about the Whadjuk culture. There is the potential opportunity for Aboriginal businesses to have long term contact to maintain and look after the trail once it is established.
Direct communication between the Commonwealth and State Governments and affected and interested families and communities, to address their request for compensation for land taken from them following European colonisation including subsequent government action i.e. the development of the airport in 1942 and subsequent land acquisitions which occurred prior to the airport privatisation in 1997.	This is an issue that Perth Airport cannot resolve, as it sits outside of its jurisdiction.
Maintained access to Munday Swamp to hunt turtles and for cultural activities.	Perth Airport is committed to maintaining Traditional Custodian access to Munday Swamp. Perth Airport has acknowledged the importance of the continuation and preservation of Traditional Customs and activities as it provides an important medium for the performance of identity and the assertion of Indigenous cultural identity.
Airport staff do not understand the history of the land and how important the land is to the Aboriginal people.	Cultural awareness training is currently being developed for key Perth Airport staff.
Illegal access into Munday Swamp and damage being caused by trail bikes and four-wheel drives (getting in through Abernethy Road).	Perth Airport will install a fence between Grogan Road and Abernethy Road to keep out the trail bike riders and four-wheel drives. There is an area on top of the Dampier Bunbury Natural Gas Pipeline that may be difficult to fence off.

Table 16-2 Key heritage issues raised during consultation for the New Runway Project
Source: Perth Airport

16.7.1 Consultation Outcomes

As a result of the consultation with the Traditional Custodians, as part of the NRP project Perth Airport is committed to:

- minimising impacts to Munday Swamp, including;
  - constructing secure fencing between Munday Swamp and Abernethy Road to control illegal access, camping and dumping in the area,
  - installing water quality and nutrient stripping basins to improve water quality entering into Munday Swamp, and
  - reconnecting surface water flows from Poison Gully to Munday Swamp to restore the natural system
- maintaining access for Traditional Custodians to Munday Swamp for traditional activities such as hunting for turtles,
- engaging Traditional Custodians to monitor project works, in accordance with Perth Airport's standard practice, during works related to disturbances of ground or vegetation,
- developing an Aboriginal business participation programme which seeks to:
  - deliver levels of Aboriginal employment (total project work hours),
  - encourage access to Aboriginal business for maintenance and land management works, and
  - work with the relevant groups, such as the Noongar Chamber of Commerce, South West Aboriginal Land and Sea Council and the Partnership Agreement Group, to provide Aboriginal business participation information and support,
- providing opportunities for cultural ceremonies at key milestones of the project such as commencement of works and formal opening.

16.7.2 Ongoing Commitment to Consultation

Perth Airport remains committed to ongoing engagement with the Traditional Custodians, under the guidance of Perth Airport's Heritage Management Framework, in a manner that recognises the significance of the area to the Noongar community and acknowledges the strong link that exists between them and the land on which Perth Airport is situated.

Further to discussions throughout the NRP consultation, Perth Airport is exploring a number of additional opportunities with Traditional Custodians to enhance the cultural awareness and experience on the estate.

In early 2018, modelled on the leading work completed by the State Government at the Metropolitan Redevelopment Authority, Perth Airport in consultation with Traditional Custodians commenced the development of a cultural narrative framework. The framework will promote the integration of a heritage narrative into the development of future projects, such as artwork and a Welcome to Country message being designed for the Terminal 1 (International) arrivals concourse, and the Forrestfield-Airport Link 'Skybridge' pedestrian walkway linking the Airport Central rail station to Terminal 1.

16.8 Mitigation

The NRP will be designed, constructed and operated in line with the AH Act section 18 commitments and conditions placed on the approval.

Standard mitigation measures, including the implementation of Perth Airport's Heritage Management Framework, will ensure that potential impacts to archaeological and ethnographic Aboriginal heritage values from the development and ongoing operation of the airport are considered, managed and mitigated.

The Perth Airport Aboriginal Heritage Monitoring Procedure was developed in consideration of the Aboriginal Heritage Due Diligence Guidelines and the Guidelines for the Engagement of Aboriginal Heritage Monitors, published by the State Department of Aboriginal Affairs (now DPLH) and State Department of the Premier and Cabinet in 2013. Consistent with this Monitoring Procedure, Perth Airport engages Noongar knowledge holders as Aboriginal heritage monitors to observe project works where there is risk of disturbance to heritage values, and to confirm the presence or absence of suspected heritage values.

Building activity on the estate requires approval under the *Airports Act 1996*. Depending on the scope of works, this approval process generally consists of a Perth Airport Consent which is considered in the Airport Building Permit approval from the Airport Building Controller (employed by the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications (DITRDC). For ground disturbing works within the vicinity of heritage sites, the Perth Airport Consent requires works to cease immediately if there is the discovery or suspected discovery of any Aboriginal artefacts.

A Heritage Management Plan will be developed prior to the commencement of construction to ensure that:

- the NRP is compliant with the AH Act section 18 approval, and associated commitments and conditions attached to the approval,
- the NRP does not impact on known Aboriginal, European or natural heritage values outside of approvals,
- the risk of disturbing unknown Aboriginal heritage values is minimised,
- engagement with Traditional Custodians regarding the ongoing management of Aboriginal heritage values on the estate continues throughout construction,
- all staff associated with the NRP undertake cultural awareness training and are aware of the heritage values synonymous with the project, and
- that Traditional Custodians and other cultural knowledge holders will be engaged to monitor project works involving ground disturbance in accordance with the Aboriginal Heritage Monitoring Procedure.

Additional investigations will be undertaken and management strategies developed as the design and construction plan are finalised if required.

16.9 Summary of Impacts

Table 16-3 presents a summary of the impacts assessed as part of heritage assessment as well as standard and additional mitigation measures and associated risk rankings.

			Initial Assessment				Residual Assessment			
Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likelihood	Initial Risk	Additional Mitigation	Significance	Likelihood	Residual Risk
Unauthorised Activities	Disturbance of known values	Construction	WA AH Act - s18 approval and Ministerial conditions Perth Airport Consent DITCRD Airport Building Permit Aboriginal Heritage Monitors	High Adverse	Possible	Medium	Inductions – heritage Onsite spot checks and auditing	Moderate Adverse	Unlikely	Low
	Disturbance of unknown values	Construction	Inductions – heritage Onsite spot checks and auditing	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Authorised ground-disturbing works	Disturbance of known values	Construction, Operation and Maintenance	Perth Airport Consent DITCRD Airport Building Permit Aboriginal Heritage Monitors Inductions – heritage Onsite spot checks and auditing	High Adverse	Almost Certain	High	WA AH Act - s18 Ministerial conditions Heritage Management Plan	Moderate Adverse	Almost Certain	High
	Disturbance of unknown values	Construction	Inductions – heritage Onsite spot checks and auditing	Moderate Adverse	Possible	Medium	WA AH Act - s18 approval and Ministerial conditions Heritage Management Plan	Minor Adverse	Possible	Low
Erosion and Sediment Mobilisation	Drainage realignment through Munday Swamp. Increased sediment loads, turbidity reporting to Munday Swamp impacting local water dependant flora and fauna	Operation	Integration of a sediment control basin and infiltration basin upstream of Munday Swamp in the design Sediment to be captured in sediment basin prior to entering infiltration basin Regular monitoring and maintenance of sediment basin Regular monitoring of surface water downstream of the sediment basin i.e. within Munday Swamp	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			
Hydrology and groundwater impacts	Localised drawdown may impact on Munday Swamp	Construction	Preparation and implementation of Dewatering Management Plan in accordance with DWER Guides	Minor Adverse	Possible	Low	No additional mitigation measures identified			
Drainage realignment through Munday Swamp	Introduction and spread of weeds in Munday Swamp affecting native flora and fauna habitat	Operation	Ongoing operational weed management Engagement with upstream stakeholders	Moderate Adverse	Unlikely	Low	No additional mitigation measures identified			

Table 16-3 Summary of impacts, risks and mitigation measures - heritage
Source: Perth Airport

16.10 Conclusion

Perth Airport is guided by both State and Commonwealth legislation on matters pertaining to heritage management. Aboriginal and natural heritage values are most relevant to Perth Airport and the NRP area.

Perth Airport recognises that the land on which Perth Airport is located forms part of the traditional network of communication routes, meeting places and camping sites of the Noongar people. Aboriginal heritage values within the NRP area comprise both archaeological and ethnographic sites indicative of prior occupation. The NRP area also comprises natural values with Munday Swamp.

In recognition of the heritage values present on the estate, as part of the NRP design, Perth Airport has made significant adjustments to runway length and location, taxiways, boundary fences, roads, drainage and approach lighting while still preserving the basis for a safe and efficient runway system critical to the future economic and social growth of Western Australia.

Throughout construction and operation of the new runway, measures will be applied to manage heritage values including engagement of Traditional Custodians to monitor construction works and ongoing cultural awareness training for workers involved in the project.

Approval for impacts to heritage is governed by the AH Act. Following consultation with the Traditional Custodians and relevant organisations, Perth Airport submitted an application under section 18 of the AH Act to seek approval to develop, maintain and operate the new runway. The application was subsequently approved by the Sate Government in May 2018.

Perth Airport remains committed to ongoing engagement with the Traditional Custodians, under the guidance of Perth Airport's Heritage Management Framework, in a manner that recognises the significance of the area to the Aboriginal community and acknowledges their strong ties to the land on which Perth Airport is situated.

17 Environment and Heritage Management

This Section outlines how environment and heritage management will be implemented throughout the New Runway Project (NRP) to minimise impacts and achieve regulatory compliance.

Detail is also provided on the following areas:

- How will the environmental and heritage impacts of operations and construction be managed?
- What is the proposed environmental offset strategy?

17.1 Introduction

It is Perth Airport's objective that all environment and heritage impacts during construction and operation of the NRP are avoided or minimised as far as practicable. Extensive analysis and assessment has occurred in the planning and design of the NRP to achieve this outcome. However, there will be an unavoidable level of environment and heritage impact and disturbance attributable to the delivery and operation of the NRP.

To enable the construction contractor and Perth Airport to develop an appropriate construction environmental management plan (CEMP) and operational environmental management plan (OEMP) for the NRP, the following section outlines the key environmental and heritage issues to be addressed and the structure of the CEMP.

17.2 Summary of High and Medium Impacts

17.2.1 Environmental Impact Assessment

To effectively manage environmental impacts associated with the NRP, it was necessary to identify relevant environmental aspects and assess the significance of potential impacts. Environmental aspects and impacts are identified and described in the individual sections. A summary of potential impacts is summarised in Table 17-1.

The assessment of impacts of the NRP was first undertaken with standard mitigation applied (e.g. statutory compliance) to determine the initial risk. If the initial risk was found to be medium, high or very high the same assessment was repeated but with additional mitigation measures applied to determine the residual impacts, and hence the overall risk level.

A summary of the medium, high and very high levels of initial risk for the NRP is provided in Table 17-2. Impacts with low risk ratings are still addressed during the development of mitigation and management measures including appropriate measures to be included in future managements plans.

Aspects	Impacts	MDP Section
Geology and Soils	Disturbance of acid sulfate soils resulting in impacts to surface water, groundwater or ecological receptors	9
	Ground movement from dewatering, excavation or soil loading	
	Erosion and sedimentation	
	Impacts to surface or groundwater and ecological receptors from disturbance of existing hydrocarbon contaminants	
	Disturbance of asbestos containing material	
	Exposure of contaminated groundwater (Per- and poly fluoroalkyl substances (PFAS) or acid sulfate soils) with impacts to works or ecological receptors	
	Contamination from spills during construction or operation	
	Contaminated runoff from pavement areas during operation	
Wetlands and Hydrology	Clearing and filling wetlands	10
	Infill of southern section of Munday Swamp	
	Pruning/clearing of Munday Swamp wetland vegetation for construction of high intensity approach lighting	
	Acidification of surface or groundwater due to dewatering	
	Erosion and sedimentation from opening of new drains, vegetation clearing or earthworks	
	Lowering of groundwater affecting vegetation or structures	
	Introduction of weeds, pollutants or sediment to Munday Swamp due to realignment of Northern Main Drain (NMD)	
	Change to hydroperiod and storage area in Munday Swamp affecting flora and fauna	
	Rise in groundwater levels due to vegetation clearing	
	Change in rainfall recharge pattern resulting in groundwater drawdown	
	Spills or leaks during construction or operation causing contamination of stormwater	
Flora and vegetation	Loss of Commonwealth-listed flora species and ecological communities from clearing of vegetation	11
	Flora habitat fragmentation leading to change in microclimate	
	Potential spread of weeds and dieback	
Fauna	Loss of fauna habitats from clearing	12
	Loss of biodiversity from clearing	
	Possible fragmentation of populations from clearing linked areas	
	Possible change in species interactions leading to possible population declines and behaviour of species	
Ground-based noise	Growth in aircraft movements following construction of runway may lead to increased noise exposure for sensitive receivers	13
Air quality and greenhouse gas	Excessive levels of dust generated by construction activities	14, 23
Heritage	Possible disturbance of known heritage values from unauthorised activities and ground works	16
	Possible disturbance of unknown heritage values from ground works	

Table 17-1 Summary of medium, high and very high risk environmental aspects and impacts of the New Runway Project
Source: Perth Airport

Section Number	Impacting Process	Impact Detail	Project Phase	Initial Assessment: Standard Mitigation	Significance/ Consequence	Likeli-hood	Initial Risk	Residual Assessment: Additional Mitigation	Significance	Likeli-hood	Residual Risk
Section 9 Geology and Soils	Construction of new Northern Main Drain and Southern Main Drain	Disturbance, management and treatment of acid sulfate soils resulting in acidification of surface or groundwater or impacts to ecological receptors	Construction	Preparation and implementation of Acid Sulfate Soil and Dewatering Management Plan in accordance with DWER guidance	Moderate Adverse	Almost Certain	High	Further investigation prior to construction to delineate area of higher risk of acid sulfate soils along Northern Main Drain and Southern Main Drain so that management can be targeted	Minor Adverse	Unlikely	Low
Section 9 Geology and Soils	Contaminated groundwater encountered during dewatering and groundwater management activities	Exposure of PFAS contaminants to surface water runoff which may impact surface-water and or groundwater quality and construction workers or ecological receptors	Construction	Preparation and implementation of an Acid Sulfate Soils and Dewatering Management Plan including: • re-injection of groundwater to align with proposed groundwater management strategies	Moderate Adverse	Possible	Medium	PFAS evaluation and risk assessment of soil concentration and leachability, and of groundwater and surface water that may be impacted Consideration of soil placement to ensure no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water Consideration of water extraction, handling and placement to ensure no unacceptable increase in contamination risk, no increase in off-site release risk, and no increase in risk to groundwater and surface water Conformance with the PFAS National Environmental Management Plan and other relevant guidance documents Ongoing monitoring of PFAS concentrations in groundwater and surface water throughout construction Reporting of evaluation, risk assessment, management activities and monitoring results to the Airport Environment Officer (AEO) Submission of the CEMP and ASSDMP to the AEO for review prior to commencement of bulk earthworks and dewatering activities	Moderate Adverse	Unlikely	Low

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher)
Source: Perth Airport

				Initial Assessment				Residual Assessment			
Section Number	Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likeli-hood	Initial Risk	Additional Mitigation	Significance	Likeli-hood	Residual Risk
Section 9 Geology and Soils	Contamination spills (Early works and construction phase)	Storage and use of fuels, oils etc. resulting in the release of substances to soil, surface water or groundwater which may impact on ecological and social receptors	Construction	Preparation and implementation of a CEMP to include: • appropriate measures for the storage and use of hazardous substances as per statutory requirements • spill response procedures • regular maintenance of vehicles to prevent leaks or spills • monitoring of construction water quality-control measures	Moderate Adverse	Possible	Medium	Select low impact or low toxicity chemicals during construction Physical spill containment bunds/ barriers Pumping options to remove contaminated surface waters Incident register to be monitored to identify recurring problems which can then inform maintenance programs	Minor adverse	Possible	Low
Section 10 Wetlands and Hydrology	Clearing and filling wetlands	Loss of 98 hectares of priority wetlands (80 hectares of CCW and 18 hectares of REW) including areas considered part of the Perth Airport Woodlands Swamp listing on the Directory of Important Wetlands in Australia.	Construction	Restrict clearing footprint to NRP area, demarcate clearing extent and exclusion zones.	High Adverse	Almost certain	High	No additional mitigation measures identified	High Adverse	Almost certain	High
Section 10 Wetlands and Hydrology	Infill of southern section of Munday Swamp	Changes to hydrochemistry affecting vegetation and faunal communities	Construction	Design of infill areas to minimise area as far as practicable	High Adverse	Likely	Medium	Sourcing, testing and verification of suitable soils free from chemical or biological contaminants including weeds and pathogens and compatible with existing wetland hydrochemistry.	High Adverse	Highly Unlikely	Low
Section 10 Wetlands and Hydrology	Pruning/ clearing of Munday Swamp wetland vegetation for construction of high intensity approach lighting	Changes to wetland ecology due to increased exposure to sunlight, evaporation, and artificial light.	Construction	Detailed design will seek to minimise area of disturbance as far as practicable. Pruning will be employed in preference to clearing.	High Adverse	Likely	Medium	Guidance on tree pruning to be developed focussing on minimisation of potential impacts. Revegetation of cleared areas with low vegetation compatible with the approach lighting to ensure continued groundcover.	High Adverse	Possible	Medium

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher) (Continued)

				Initial Assessment				Residual Assessment			
Section Number	Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likeli-hood	Initial Risk	Additional Mitigation	Significance	Likeli-hood	Residual Risk
Section 10 Wetlands and Hydrology	Realignment of open channel (NMD) – Munday Swamp	Introduction and spread of weeds in Munday Swamp affecting native flora and fauna habitat	Operation	Upstream treatment train to include a contaminant basin and a vegetated infiltration basin sized to fully infiltrate up to one exceedance per year storm to capture weed propagules	Moderate Adverse	Possible	Medium	Engagement with upstream stakeholders Active weed management of the NMD, gross pollutant, contaminant and infiltration basins post development	Moderate Adverse	Unlikely	Low
Section 10 Wetlands and Hydrology	Realignment of open channels (NMD)	Groundwater level fluctuations at Munday Swamp negatively affecting flora and fauna	Operation	Design: Drain levels to be at or above Master Drainage Strategy 2017 concept design levels	High Adverse	Unlikely	Medium	Detailed groundwater modelling specifically for the Munday Swamp area to be undertaken to a sufficient degree of detail to inform design	High Adverse	Highly Unlikely	Low
Section 10 Wetlands and Hydrology	NMD - Contamination of surface water from upstream sources	Major (based on volume) oil/ chemical spills, most likely from upstream sources entering Munday Swamp	Operation	Engineered treatment train as described in the 'Infiltration Storage' section	Major Adverse	Highly Unlikely	Medium	Incident to be notified to Airport Control Centre (ACC) to action a spill response procedure which includes emergency services	High Adverse	Highly Unlikely	Low
Section 10 Wetlands and Hydrology	Realignment of open channels (NMD)	NMD realignment with increased sediment loads, turbidity reporting to Munday Swamp impacting local water dependent flora and fauna	Operation	Integration of a gross pollutant control basin and infiltration basin upstream of Munday Swamp. Sediment to be captured in gross pollutant basin prior to entering infiltration basin Regular monitoring and maintenance of gross pollutant basin via PAPL MMS system Regular monitoring of surface water downstream of the gross pollutant basin i.e. within Munday Swamp via PAPL MMS system Design to consider plant species and other requirements to minimise bird strike risk	High Adverse	Unlikely	Medium	Maintenance of the treatment train pollution capturing elements to help ensure that capacity is available for pollutants Design of area between infiltration storage and swamp to be bioengineered to provide a high Manning value to keep stormwater velocity low enough to avoid sands and gravels being carried by water	Moderate Adverse	Highly unlikely	Low

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher) (Continued)

				Initial Assessment				Residual Assessment			
Section Number	**Impacting Process**	**Impact Detail**	**Project Phase**	**Standard Mitigation**	**Significance/ Consequence**	**Likeli-hood**	**Initial Risk**	**Additional Mitigation**	**Significance**	**Likeli-hood**	**Residual Risk**
Section 10 Wetlands and Hydrology	Normal construction operations - Accidental chemical, fuel spills or other dangerous goods	Accidental spills or leaks from construction equipment mobilised by stormwater runoff into the surface-water drainage system	Construction	CEMP to include: • appropriate measures for the storage and use of hazardous substances as per statutory requirements • spill response procedures • regular maintenance of vehicles to prevent leaks or spills • monitoring of construction water quality control measures	Moderate Adverse (dependent upon nature, quantity and timing of spill or leak)	Possible	Medium	Select low impact or low toxicity chemicals during construction Physical spill containment bunds/ barriers Pumping options to remove contaminated surface waters Incident register to be monitored to identify recurring problems which can then inform maintenance programs	Minor Adverse	Possible	Low
Section 10 Wetlands and Hydrology	Normal construction operations - Excavations	Exposure of ASS and other contaminants to surface-water runoff which may impact surface water and groundwater quality and ecological receptors	Construction	Acid Sulfate Soils and Dewatering Management Plan including: Release of treated groundwater to align with proposed groundwater management strategies	Moderate Adverse	Possible	Medium	PFAS strategy to be developed based on latest guidelines	Moderate Adverse	Unlikely	Low
Section 11 Flora and Vegetation	Vegetation clearance	Loss of EPBC-listed Banksia Woodlands TEC	Construction	Restrict clearing footprint to NRP area, demarcate vegetation clearing extent and exclusion zones	Major Adverse	Almost Certain	Very High	Offsets in accordance with EPBC environmental offsets policy Collection of plants, rootstock and seedbank Exclusion of predators, weed control *Phytophthora* management Fire management Conservation significant flora and vegetation management plan	Moderate Adverse	Almost Certain	High
		Loss of habitat for species of conservation significance (Commonwealth) (*Conospermum undulatum, Macarthuria keigheryi*)	Construction		High Adverse to Major Adverse	Almost Certain	High		High Adverse	Almost Certain	High
		Removal of regionally significant vegetation and loss of habitat for species of conservation significance (State)	Construction		Moderate Adverse (all Priority listed species)	Almost Certain	High		Moderate Adverse	Likely	Medium
Section 11 Flora and Vegetation	Flora habitat fragmentation and edge effect	Change of microclimate (i.e. more light and higher climate in remaining habitat)	Construction	Restrict clearing footprint to NRP area	Minor Adverse	Likely	Medium	No additional mitigation measures identified	Minor Adverse	Likely	Medium

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher) (Continued)

				Initial Assessment				Residual Assessment			
Section Number	Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likeli-hood	Initial Risk	Additional Mitigation	Significance	Likeli-hood	Residual Risk
Section 11 Flora and Vegetation	Movement or introduction of dieback disease	New infestations of dieback in previously uninfested areas due to movement of vehicles, soil or water	Construction and operation	Demarcation of Infested areas Dieback management plan to be prepared to include vehicle movement and wash-down management procedures, stockpile management, active treatment if required during construction, dieback assessments and hygiene management Imported soil to be dieback free	Moderate adverse	Possible	Medium	Fence off dieback free areas not impacted by the NRP Location of stockpiles considered e.g. infested soil to be located downslope of uninfested areas Stockpile areas are away from drainage channels Test soil prior to importation as dieback free	Moderate adverse	Unlikely	Low
Section 12 Fauna	Loss of habitat	Decline in population survival	Construction	Well-defined and rationalised clearing footprint that avoids sensitive habitat where possible,	Moderate Adverse	Almost certain	High	Offset in accordance with EPBC offset policy. Acquire offsets	Moderate Adverse	Possible	Medium
Section 12 Fauna	Loss of habitat	Population fragmentation	Construction and Operation	Clearing designed to retain linkage where possible, Restrict clearing footprint to NRP area Minimise edge effects through air quality (dust) and weed management	Moderate Adverse	Almost certain	High	Where possible replace or enhance connectivity	Moderate Adverse	Likely	Medium
Section 12 Fauna	Loss of habitat	Increased mortality	Operation	Wildlife Management Plan in place	Minor Adverse	Likely	Medium	Avoid Black Cockatoo forage trees along high-speed roads	Minor Adverse	Possible	Low
Section 12 Fauna	Species interactions	Predation and competition leading to population decline	Operation	Existing control of feral species as per Perth Airport's estate-wide plan. Dieback management	Moderate Adverse	Likely	Medium	Extend fox control to target feral cats	Moderate Adverse	Possible	Medium
Section 12 Fauna	Dust, light, noise and vibration	Impacts to predator-prey interactions, changes to mating and nesting behaviour, increased competition and predation within and between invertebrates, frogs, birds and mammals	Construction and Operation	Management plans to incorporate measures to manage dust, light, noise and vibration in accordance with legal environmental limits	Moderate Adverse (invertebrates)	Likely	Medium	CEMP to include requirement to direct construction lighting away from retained native vegetation Further macroinvertebrate surveys/monitoring during and after construction	Moderate Adverse (invertebrates)	Possible	Medium
Section 13 Ground-based Noise	Growth in aircraft movements following new runway construction	Increase in aircraft taxiing in line with growth in movements will impact on sensitive receivers	Operation	Taxiway design is undertaken in accordance with Manual of Standards (MOS) 139 - Aerodromes Part 6.3 Taxiways	Moderate Adverse	Likely	Medium	Improved communication of information to surrounding residents on ground-based noise	Minor Adverse	Possible	Low

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher) (Continued)

				Initial Assessment				Residual Assessment			
Section Number	Impacting Process	Impact Detail	Project Phase	Standard Mitigation	Significance/ Consequence	Likeli-hood	Initial Risk	Additional Mitigation	Significance	Likeli-hood	Residual Risk
Section 14 Air quality and greenhouse gas (ground)	Construction dust-generating activities	Excessive levels of dust generated resulting in complaints and adverse air-quality impacts	Construction	Dust management as part of the CEMP, including watering	High Adverse	Possible	Medium	Increased levels of watering, sealed roads, covers on exposed areas and stockpiles	Minor Adverse	Possible	Low
Section 16 Heritage	Unauthorised Activities	Disturbance of known values	Construction	WA AH Act - S18 approval and Ministerial conditions Perth Airport Consent DIRDC Airport Building Permit Aboriginal Heritage Monitors	High Adverse	Possible	Medium	Inductions – heritage Inductions – consents Onsite spot checks and auditing	Moderate Adverse	Unlikely	Low
Section 16 Heritage	Authorised ground-disturbing works	Disturbance of known values	Construction, Operation and Maintenance	Perth Airport Consent DIRDC Airport Building Permit Aboriginal Heritage Monitors Inductions – heritage Inductions – consents Onsite spot checks and auditing	High Adverse	Almost Certain	High	WA AH Act - S18 Ministerial conditions Heritage Management Plan	Moderate Adverse	Almost Certain	High
Section 16 Heritage	Authorised ground-disturbing works	Disturbance of unknown values	Construction	Inductions – heritage Onsite spot checks and auditing	Moderate Adverse	Possible	Medium	WA AH Act - S18 approval and Ministerial conditions Heritage Management Plan	Minor Adverse	Possible	Low

Table 17-2 Summary of environmental and heritage impacts and mitigation measures (with initial risk of medium or higher) (Continued)

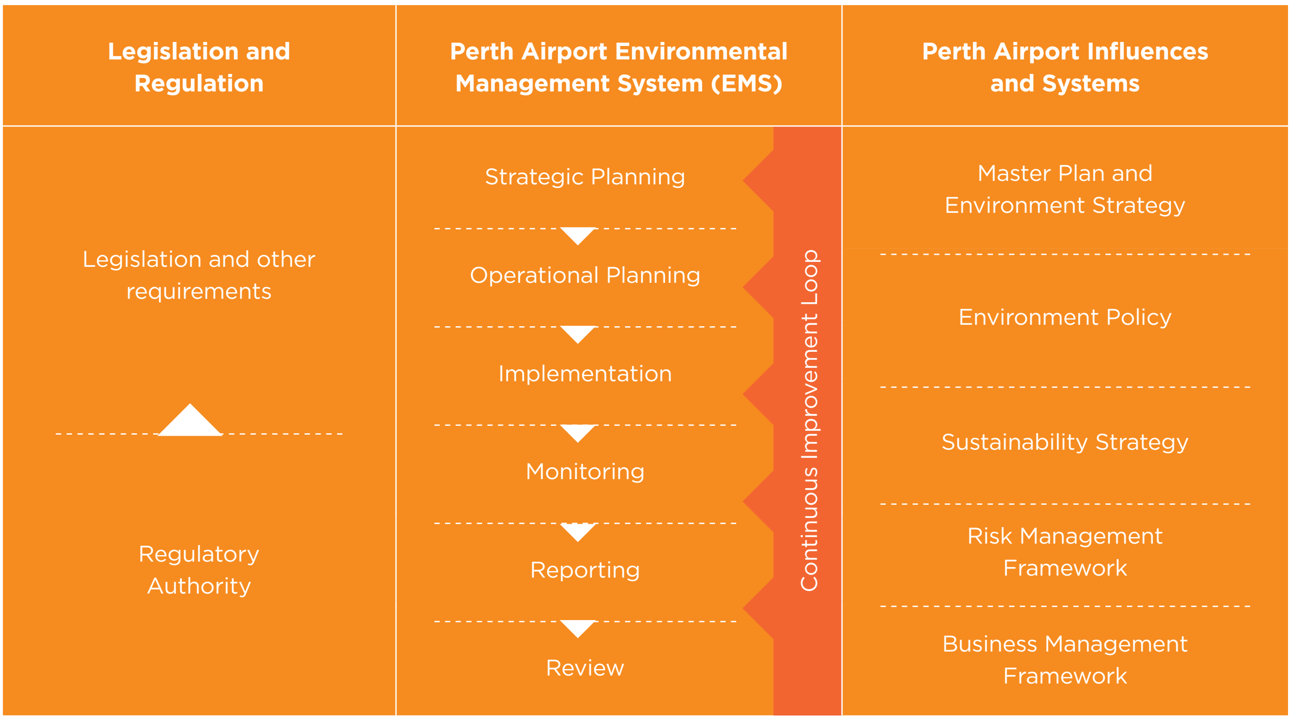


Figure 17-1 Perth Airport Environment Management Framework
Source: Perth Airport

17.3 Consistency with Perth Airport Environment Strategy

Perth Airport has an Environment Strategy which is detailed in the approved Perth Airport Master Plan. The Environment Strategy encompasses an Environmental Management Framework (EMF) which sets out how Perth Airport seeks to meet its obligations under Commonwealth and State legislation.

The Perth Airport EMF is presented in Figure 17-1.

Perth Airport expects the principles of the EMF to be incorporated into the CEMP during construction and the OEMP during operation of the NRP.

17.4 Construction Environment Management Plan

This section outlines the intended structure of the CEMP, which the construction contractor is expected to develop and implement during construction activities for the NRP. The CEMP must address the environmental aspects and develop mitigation measures for the impacts identified throughout this MDP and within Tables 17-1 and Tables 17-2.

The construction contractor is expected to familiarise themselves with the background, context and environmental impact assessment described in the relevant technical chapters to assist with development of mitigation measures.

The CEMP must also address the consultative and reporting aspects for the NRP as follows:

- project management structure,
- environmental incidents,
- community complaints and consultation,
- performance monitoring, reporting and compliance with all aspects of the Perth Airport EMF,
- identify management measures for construction of the NRP that are in accordance with relevant legislation and policy, and with accepted Perth Airport standards. Details of these documents are provided in the relevant sections of the EMF and may be accessed through the Perth Airport web site, and
- address community and government expectations of transparency and accountability by identifying management actions.

Following approval of the MDP, further detailed design of the infrastructure and airspace will be undertaken. As design progresses to more detailed stages, as far as possible, impacts to the environment will be minimised. These changes will be reflected in the CEMP.

The CEMP may be developed in stages or increments to account for the different phases on the project:

- preliminary works such as drainage infrastructure and services location,
- site works and preparation including clearing, and
- construction.

The following sections outline the implementation requirements of the CEMP, such as details on the project management structure, training, risk assessment and management review expectations.

17.4.1 Project Management Structure

All Perth Airport personnel and contractors are responsible for the environmental performance of their activities and for complying with their general environmental duty. A project management structure which identifies roles and responsibilities will be included in the CEMP to inform its successful implementation.

17.4.2 Training and Awareness Program

Perth Airport will maintain a high level of on-site supervision of the construction contractors. Environmental performance of potential contractors will be reviewed as part of the tender evaluation process.

Individuals will also be responsible and accountable for their conduct through their conditions of employment or contract. Training and induction of all personnel involved in the NRP will be conducted to ensure all individuals are aware of their environmental responsibilities.

17.4.3 Risk Assessment

A risk assessment and identification of possible incidents which could arise will be undertaken by the construction contractor in consultation with Perth Airport and included in the CEMP. The risk assessment will be informed by the impacts and levels of risk identified in the MDP, but further developed to account for the specific construction methodology. The risk assessment will inform the development of appropriate mitigation measures based on the identified level of risk.

17.4.4 Contingency Management

The CEMP will include management actions and contingency strategies, which will be taken should proposed mitigation measures be compromised and cause significant and detrimental environmental or health impacts. The CEMP will also be aligned with Perth Airport's contingency management measures.

17.5 Operational Environmental Management Plan

Perth Airport will develop an OEMP for the NRP. The OEMP will be aligned with Perth Airport's EMF and will include the following:

- risk assessment and review,
- environmental incidents and reporting,
- community complaints and consultation,
- performance monitoring, reporting and compliance with all aspects of the Perth Airport EMF and legislative requirements,
- actions to be undertaken to manage the environmental impacts during operation of the runway, in accordance with legislative requirements and accepted Perth Airport standards,
- management and reporting structure, roles and responsibilities, training, monitoring and management review expectations, and
- contingency management.

17.6 Process for Heritage Management

Perth Airport has developed an Aboriginal Heritage Management Framework so that potential impacts to archaeological and ethnographic Aboriginal heritage values from the development and ongoing operation of the airport are considered, managed and mitigated. This framework is outlined in Section 16.

Perth Airport is in the process of incorporating the management of non-Aboriginal heritage values into this framework so that all Aboriginal and non-Aboriginal heritage values on the estate are managed in an efficient and consistent manner.

The Heritage Management Framework will be continuously reviewed and updated as necessary, including throughout the project development and construction.

Approval to impact on heritage sites is obtained through approval under section 18 of the State's *Aboriginal Heritage Act 1972* (AH Act). Approval by the State Government was granted in May 2018.

17.8 Reporting and Incident Management

17.8.1 Environment

Environmental reporting will be included as part of the management framework for the NRP to inform the relevant regulators of the progress of the project, and compliance with approvals conditions and legislative requirements.

As part of Perth Airport's obligation to complete an Annual Environment Report, the relevant information will be also passed on to the Commonwealth Government in sufficient detail to allow for the impact of development activities on Perth Airport to be assessed.

Environmental Risk Register

Perth Airport will maintain an Environmental Risk Register for the NRP to summarise key risks identified in the MDP (and others identified as the project progresses) to inform and track the implementation of appropriate management measures.

It is proposed that the register is reviewed on a regular basis for relevance, timely close out and management of risks.

Environmental Management Review

The Perth Airport project manager, in consultation with the construction contractor, will have oversight for the review of environmental performance and compliance with environmental and heritage requirements at planned intervals. This review will consider the suitability, adequacy and effectiveness of environmental and heritage management strategies being implemented through the CEMP, and additional work instructions and procedures which may be required.

Management reviews by both Perth Airport and the construction contractor will include opportunities for assessing improvement opportunities in environmental management and conservation at planned intervals. Records of the management reviews will be retained as part of the NRP reporting process.

The following information will be used to inform management review:

- results of internal and external audits,
- evaluation of compliance with legal and other requirements,
- communications from external parties (including complaints),
- environmental performance report assessing compliance with management objectives and mitigation measures,
- status of corrective and preventive actions,
- follow up actions from previous management reviews,
- changing circumstances, including development of legal and other requirements related to environmental aspects are identified, and
- recommendations for improvement.

17.8.2 Heritage

In keeping with the conditions set by the State in relation to the application made under section 18 of the AH Act, a written report will be provided to the Registrar of Aboriginal Sites within 60 days of the completion of the NRP and will detail:

- the extent of the impact on an Aboriginal site, including the level, effect and type of impact, and supported by photographs taken before and after the impact,
- any archaeological or cultural salvage undertaken on an Aboriginal site, including when and how such salvage took place, who was present at the salvage, where the material was relocated, and the results of the salvage and any subsequent analysis conducted, and
- the results and findings of any monitoring of ground distributing works.

As part of Perth Airport's obligation to complete an Annual Environment Report, the relevant information will be also passed on to the Commonwealth Government in sufficient detail to allow for the impact of development activities on Perth Airport to be assessed.

Incident Management

Environment and heritage incidents include events that directly or indirectly cause environment and heritage impacts or harm (physical or non-physical e.g. reputational). Events involving non-compliance with project procedures and 'near-miss' events, which may or may not have resulted in an actual environment or heritage impact, are required to be reported and managed. The CEMP and OEMP will outline specific incident-reporting procedures that will be adopted for the NRP, including notification of State or Commonwealth regulators where applicable.

Compliance Management

To review that environment and heritage management measures continue to be relevant and appropriate, a project audit and inspection program will be developed to assess project compliance with management strategies, any conditions of approval for the application submitted under section 18 of the *Aboriginal Heritage Act 1972*, and project performance to agreed objectives.

17.9 Draft Offset Proposal

Residual impacts of the NRP to one Threatened Ecological Community (TEC) and 5 protected species will require consideration in terms of offset. These comprise:

- Banksia Woodland of the Swan Coastal Plain Threatened Ecological Community (Banksia Woodland TEC),
- Wavy-leaved smokebush (*Conospermum undulatum*),
- Keigheryi's Macarthuria (*Marcarthuria keigheryi*),
- Carnaby's Black Cockatoo,
- Baudin's Black Cockatoo, and
- Forest Red-tailed Black Cockatoo.

Offsets in relation to the above have been identified in keeping with the requirements of the:

- Department of Agriculture, Water and Environment (DAWE) Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (the Offsets Policy) (DSEWPaC 2012a),
- Department of Environment and Conservation (DEC) Keighery's Macarthuria (*Macarthuria keigheryi*) Recovery Plan, (2009a),
- Department of Environment and Conservation Wavy-leaved smokebush (*Conospermum undulatum*) Recovery Plan, (2009b),
- Offsets Assessment Guide and how to use the Offsets Guide (DSEWPaC 2012b),
- Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community (Conservation Advice for Banksia Woodland TEC) (Threatened Species Scientific Committee, 2016), and
- EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Black Cockatoo, *Calyptorhynchus latirostris* (Endangered), Baudin's Black Cockatoo, *Calyptorhynchus baudinii*, (Endangered) and Forest Red-tailed Black Cockatoo, *Calyptorhynchus banksii naso* (Vulnerable) (DSEWPaC. 2012c).

This section of the document outlines the Offsets Guide inputs and outputs for the proposed offsets for the following residual impacts resulting from the NRP:

- the loss of 41.4 hectares of Banksia Woodland TEC,
- the loss of Threatened Flora species *Macarthuria keigheryi* , (855 inidividuals),
- the loss of Threatened Flora species *Conospermum undulatum*, (206 individuals),
- the loss of 232.7 hectares of Carnaby's Black Cockatoo foraging habitat, and
- the loss of 63.9 hectares of Baudin's and Forest Red-tailed Black Cockatoo foraging habitat.

Carnaby's Black Cockatoos can forage on a larger range of plant species than Baudin's and Red-tailed Black Cockatoos, and as such, impacts for Carnaby's Black Cockatoo have been considered separately to the other two Black Cockatoo species.

The proposed offsets for the NRP include an offsite restoration component for residual impacts to the Banksia Woodland TEC, with this offset also contributing to the offset for residual impacts to Black Cockatoos. In addition, a land purchase offset will comprise the remaining requirements to address the residual impacts to the Black Cockatoos. Further to this, the proposed offsets for impacts to the threatened flora species include translocation and propagation programmes as well as research funding to improve scientific knowledge, as illustrated in Figure 17-2.

Impacts to Environmental Values and Proposed Offsets

Environmental Value: **Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community**

Environmental Value: **Black Cockatoos**
1. Carnaby's Black Cockatoo
2. Baudin's Black Cockatoo
3. Forest Red-tailed Black Cockatoo

Environmental Value: ***Conospermum undulatum***

Environmental Value: ***Macarthuria keigheryi***

Restoration Offset - for loss of Threatened Ecological Community and for Black Cockatoo foraging habitat

Land Purchase Offset – balance of area required to offset Black Cockatoo foraging habitat impacts

Offset for removal of individual plants:
- Translocation and propagation programmes
- Research funding to DBCA

Offset for removal of individual plants:
- Translocation and propagation programmes
- Research funding to DBCA

Figure 17-2 Overview of Proposed Offsets to mitigate residual impacts from the NRP

17.9.1 Applicaton of Offsets Guide

The Offsets Guide (DSEWPaC 2012b) is used to support application of the EPBC Offsets Policy (DSEWPaC 2012a). It is a calculation tool to assist in determining the suitability of offset strategies. It includes four parts:

- Matter of National Environmental Significance (MNES) assessment table,
- Impact Calculator,
- Offset Calculator, and
- Summary Box.

The document 'How to use the Offset Assessment Guide' (DSEWPaC 2012c), together with consultation with the DEE on various elements during the process of calculating the offsets, has been used to inform inputs to the Offsets Guide. Table 1 summarises the inputs required for completing the Offsets Guide.

Guide Part	Input Item	Explanation
MNES Table	MNES Table	The Offsets Guide requires the name and conservation status of the impacted protected matter as listed under the EPBC Act. Separate worksheets are required for each impacted protected matter. The Offsets Guide allows for overlapping offset requirements for multiple species/ecological communities if one offset can compensate for impacts to more than one species/ecological community.
Impact Calculator	Protected Matter Attributes	Protected matter attributes show the various options to calculate a suitable offset depending on a protected matter's habitat or ecology that a proposed action may be likely to impact. For example, area of habitat, area of community or birth rate. The attribute that most effectively captures the nature of the residual impact should be selected. The same attribute should be selected in both the impact calculator and the offset calculator.
	Impact Description Column	This column requires a description of the impacts that the proposed action is likely to have on the species/ecological community to be offset.
	Quantum of Impact	The quantum of impact assesses how big the impact is. It integrates considerations of the area of impact and quality of habitat to provide a total quantum of impact. Quality of habitat is based on the Habitat Quality Score.
	Information Source	This section requires a list of information sources on which the conclusions are based. These may include consultancy reports, vegetation mapping, scientific articles or field data. It does not affect the offset calculation but provides an important reference point.

Table 17-3 Required Inputs for the Offsets Assessment Guide

Guide Part	Input Item	Explanation
Offset Calculator	Protected Matter Attributes	The same attribute should be selected in both the impact and offset calculators. Once selected, the total quantum of impact column is automatically populated from the impact calculator.
	Offset Description Column	The Offsets Guide requires a description of the proposed offset. This does not affect the calculation but provides important information about the proposed offset.
	Time Horizon Over Which Loss is Averted	This captures the time over which averted loss can be calculated. This is capped at 20 years or the life of an offset, whichever is shorter.
	Time until Ecological Benefit	This is the estimated time that it will take for the habitat quality improvement of the proposed offset to be realised. Shorter time frames until ecological benefits are realised are valued more highly than longer timeframes.
	Offset Start Area and Quality	This is the current area and quality of the proposed offset. It is based on the Habitat Quality Score (HQS) of the offset.
	Risk of Loss	This considers risk of loss under two scenarios (with and without offset). Risk of Loss (per cent) without offset: This is a percentage figure that describes the chance that the habitat on the proposed offset site will be completely lost over the foreseeable future (either the life of the offset or 20 years, whichever is shorter). Risk of Loss (per cent) with offset: This describes the chance that the habitat on the proposed offset site will be lost over the foreseeable future (either the life of the offset or 20 years, whichever is shorter), if the site becomes an offset. Perth Airport has developed a Risk of Loss methodology and provided this to the DEE in 2018. This methodology meets the requirements of Section F of the How to use the Offsets Assessment Guide (DSEWPaC 2012b).
	Confidence in Result	Confidence in result is a percentage that records the level of certainty regarding the success of the proposed offset. Proposed offset actions that are designed to have a lower risk of failure should have a higher confidence in result score. For the “area of community” and “area of habitat” attributes, there are two components to which confidence in result relates: Change in habitat quality: the confidence in result captures the level of certainty about the successful achievement of the proposed change in quality. Averted loss: the confidence in result captures the level of certainty about the strength and effectiveness of the proposed risk-mitigation measures and the capacity of these measures to mitigate the risk of loss of the site.
	Net Present Value (adjusted hectares)	The Offsets Guide calculates the net present value of the proposed offset taking into account the annual probability of extinction, the time horizon and the adjusted gain. It is used to reflect the fact that a given benefit (i.e. improving habitat quality or averting loss) today holds more value for a protected matter than the same benefit realised in the future.
Summary of Inputs	Summary Box	The summary box incorporates the cost of the direct offset and the percentage of impact that has been offset to determine the cost associated with other compensatory measures. All values are automatically populated from the offset calculator.

Table 17-3 Required Inputs for the Offsets Assessment Guide (Continued)

17.9.2 Habitat Quality Score

A key input for the Offsets Guide is the Habitat Quality Score (HQS) for both the impact site and the proposed offset site. The HQS is a measure of how well a particular site supports a specific ecological community or threatened species and contributes to its ongoing viability. It needs to be assessed consistently on both the Impact and Offset Calculators of the Offsets Guide.

The HQS assessment methodology is shown in Figure 17-3, and is based on the following three components as per the Offsets Guide:

- Site condition is the condition of a site in relation to the ecological requirements of an ecological community or threatened species. This includes considerations such as vegetation condition and structure, the diversity of habitat species present, and the number of relevant habitat features.
- Site context is the relative importance of a site in terms of its position in the landscape, taking into account the connectivity needs of an ecological community. This includes the proximity of the site in relation to other areas of suitable habitat, and the role of the site in relation to the overall population or extent of a species or community.
- Species stocking rate is the usage and/or density of a species at a particular site. This principle acknowledges that a particular site may have a high value for a particular threatened species, despite appearing to have poor condition and/or context. It includes considerations such as survey data for a site for a particular species population or, in the case of a threatened ecological community, a number of different populations. It also includes consideration of the role of the site population with regard to the overall species population viability or community extent.

These components contribute to the final HQS, however, the application of and weighting given to each component is dependent on the ecological requirements of the impacted species or ecological community.

Overall, key considerations in determining the habitat quality of threatened species or an ecological community include:

- Evaluation of the key ecological attributes of the species or ecological community (habitat requirements and variability, lifecycle and population dynamics, movement and distribution patters, and threatening processes); and
- Determination of site characteristics in relation to the species or ecological community ecology (site condition, site context and species stocking rate).

Further discussion on the HQS methodology that has been developed specifically for the Banksia Woodland TEC is provided in Section 17.9.3.1 and for Black Cockatoos in Section 17.9.5.1 in line with requirements of the Offsets Guide.

17.9.3 Offset for Banksia Woodland TEC

This sub section describes the habitat quality score methodology for Banksia Woodlands TEC and how it has been applied at both impact and offset sites. This is followed by application of the offset guide to Banksia Woodlands impacts and how the proposed offset is consistent with EPBC offset policy.

17.9.3.1 Habitat Quality Score Methodology for Banksia Woodland TEC

In accordance with the requirements of the Offsets Guide, land offsets are assessed in terms of their HQS in supporting and contributing to the ongoing viability of the ecological community to be offset. A method to derive the HQS for the Banksia Woodland TEC was developed by Woodman Environmental Consulting (WEC) in accordance with the Offsets Guide, relevant EPBC Act guidelines, the Conservation Advice for the Banksia Woodland TEC, and in consultation with the DEE.

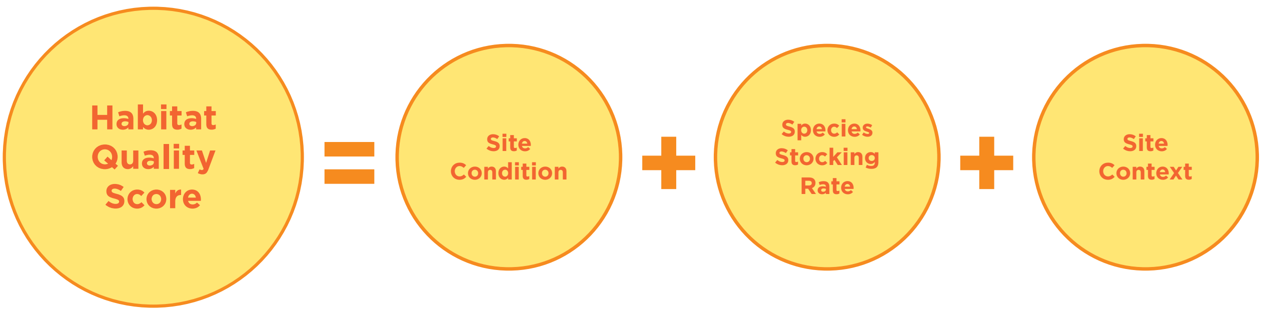


Figure 17-3 Required components of a Habitat Quality Score (HQS)

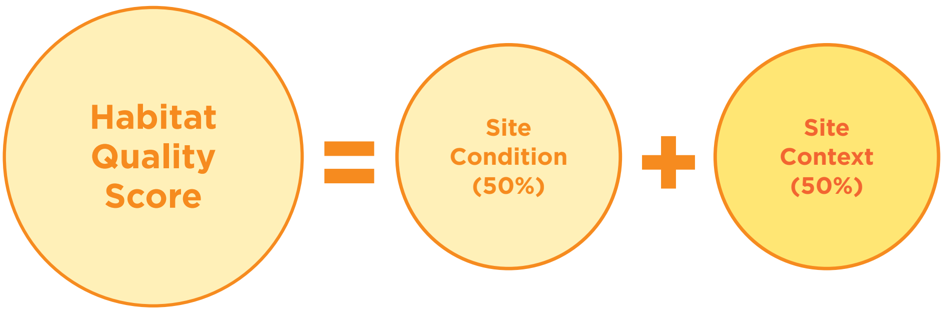


Figure 17-4 Components of Banksia Woodlands TEC Habitat Quality Score

The Banksia Woodlands TEC was approved for inclusion as an Endangered Threatened Ecological Community under the EPBC Act on 16 September 2016, as per the Approved Conservation Advice (incorporating listing advice) (DEE 2016). This methodology has been developed to determine HQS for Banksia Woodland TEC located in the project impact and offset sites.

As required by the Offsets Guide, HQS for the project impact and offset sites are calculated using three components, as shown in Figure 17-3. This has been modified for the TEC HQS methodology as stocking rate does not apply to ecological communities. For Banksia Woodlands TEC in Western Australia context has equal weight to condition. Therefore, HQS for Banksia Woodlands TEC is calculated as shown in Figure 17-4.

Table 17-4 shows the scoring system applied to the Banksia Woodland TEC when calculating the HQS. As per the Offsets Guide, the scoring system addresses the requirement for a HQS ranging from zero to 10. The scoring system has been developed by suitably qualified botanists from WEC, includes feedback from DAWE and incorporates requirements of the conservation advice.

Component	Sub Component
Site Condition 50 per cent	**Vegetation condition (Keighery 1994)** • Pristine (100 • Excellent (80) • Very Good (60) • Good (40) • Degraded (20) • Completely Degraded (0)
	Species richness • Average native species richness within the top half of recorded range for the TEC (10) • Average native species richness not within the top half of recorded range for the TEC (0)
	Presence of Threatened taxa • Patch is critical habitat for and hosts Threatened taxa (10) • Patch is critical habitat for Threatened taxa (5)
	Contain State listed TEC/PEC Patch contains WA Floristic Community Type (FCT) listed as a State TEC (20) Patch contains WA Floristic Community Type (FCT) listed as a State PEC (10)
	Presence Dieback • Patch is dieback Free (10) • Patch is partly dieback free (5) • Patch is dieback infested (0)
	Condition Total (150)
	Condition Total 150/3
Site Context 50 per cent	**Connectivity** • Patch is continuous with remnant native vegetation and forms a corridor that links different landscape units (30) • Patch is continuous with remnant native vegetation that forms a medium to large local remnant (20) • Patch is in close proximity to (within 1 km) of other medium to large remnants (10) • Patch is within 12 km*[3] of other significant remnants and contributes to support of significant avifauna (i.e. known Black Cockatoo Breeding sites are located within 12km of the patch) (5)
	Patch size • 20 hectares (50) • 10 - 20 hectares (40) • 5 -10 hectares (30) • 2 - 5 hectares (20) • <2 hectares (10)
	Site location and risk • Patch located in an area where the TEC has been extensively cleared (10) • Patch located at the geographical edge of the recorded range (10)
	Site Context Total (100)
Total Site Context (100/2)	Site Context total 100/2 = 50
Quality total (out of 100)	100
Quality (above /10)	10

Table 17-4 Banksia Woodlands TEC Scoring Methodology for the Offsets Guide

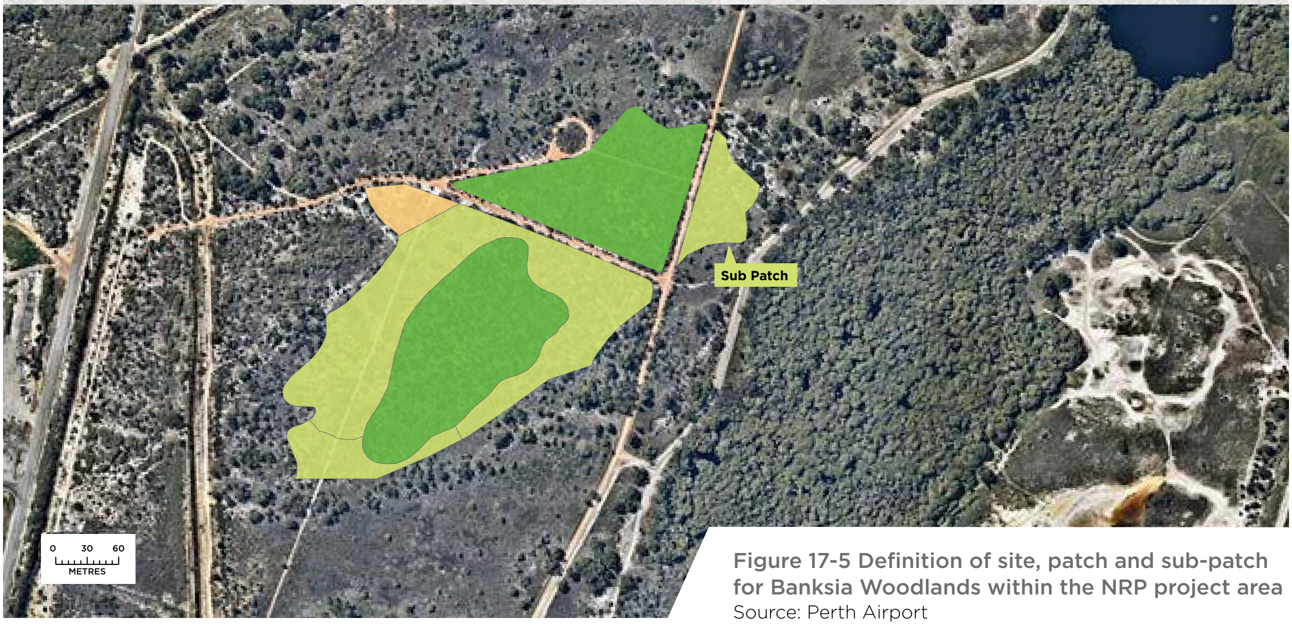


Figure 17-5 Definition of site, patch and sub-patch for Banksia Woodlands within the NRP project area
Source: Perth Airport

Areas of Banksia Woodland TEC within impact and offset sites are assessed in accordance with the criteria outlined in the Approved Conservation Advice (incorporating listing advice) (DEE 2016) and as described in WEC (2019). Where this assessment process confirms presence of the Banksia Woodland TEC, Floristic Community Types (FCTs) will be determined and mapped.

For the purposes of this methodology, the Banksia Woodland TEC is categorised into Sites, Patches and Sub-patches (refer to Figure 17-5):

- "Site" refers to the overall impact or offset area such as the Perth Airport estate.
- "Patch" refers to discrete areas of Banksia Woodland TEC within the site as defined by the Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (DEE 2016);
- "Sub-patch" refers to discrete areas within a patch that differ in vegetation condition scores.

Figure 17-6 describes the methodology for determining HQS for the Banksia Woodlands TEC. In summary, the HQS is determined at the patch level and the weighted average of all the patches provides the overall site HQS.

17.9.3.2 Banksia Woodland TEC Habitat Quality Score of the Impact Area

The NRP project will result in the clearing of 41.4 hectares of Banksia Woodland TEC which is comprised of 12 TEC patches as defined by the Conservation Advice for Banksia Woodland TEC. Woodman Environmental has conducted an estate-wide survey and assessment of the TEC and assigned estate-wide patch numbers for those areas that meet the requirements of a patch as defined by the Conservation Advice for the Bankia Woodland TEC. These estate-wide patch numbers are used throughout this section. Table 17-5 and Figure 17-6 provides the HQS of each of the Banksia Woodland TEC patch interesting the the project area.

The overall HQS of Banksia Woodlands for NRP based on individual patch habitat quality and weighted by area is 5 out of ten as shown in Table 17-6

1. Calculate Patch Condition Score	2. Calculate Patch Habitat Quality Score	3. Calculate Site Habitat Quality Score
1.1 Each patch is broken down into sub-patches according to vegetation condition	2.1 Assign a Context Score to each patch (refer to Table 17-4)	3.1 Calculate weighted average of all Patch Habitat Quality Scores to determine the overall site Habitat Quality Score
1.2 Each sub-patch is given a Condition Score in accordance with Table 17-4		
1.3 The weighted average of all sub-patch Condition Scores is calculated to determine the Patch Condition Score		
1.4 Add other condition score (refer to Table 17-4)		

Figure 17-6 Habitat Quality Score Methodology for the Banksia Woodland TEC

Component	DoEE sub-components	1	2	3	4	5	6	7	8	9	10	11	12
Site Condition (50 per cent)	*Vegetation condition* (Keighery 1994) • Pristine (100) • Excellent (80) • Very Good (60) • Good (40) • Degraded (20) • Completely Degraded (0)	30	50	59	80	60	57	51	41	32	60	50	60
	Species richness Average native species richness within the top half of recorded range for the TEC (10)	0	0	0	0	0	0	0	0	0	0	0	0
	Presence of Threatened taxa • Patch is critical habitat for and hosts Threatened taxa (10) Patch is critical habitat for Threatened taxa (5)	10	10	10	0	0	0	10	0	0	0	0	0
	Contain State listed TEC/PEC • Patch contains WA Floristic Community Type (FCT) listed as a State TEC (20) Patch contains WA Floristic Community Type (FCT) listed as a State PEC (10)	10	10	10	10	10	10	10	10	10	10	10	10
	Presence Dieback • Patch is dieback Free (10) • Patch is partly dieback free (5) Patch is dieback infested (0)	5	5	5	5	5	5	5	5	5	5	5	5
	Condition Total (150)	55	75	84	95	75	72	76	56	47	75	65	75
	Condition Total 150/3	18	25	28	32	25	24	25	19	16	25	22	25
Site Context (50 per cent)	*Connectivity* • Patch is continuous with remnant native vegetation and forms a corridor that links different landscape units (30) • Patch is continuous with remnant native vegetation that forms a medium to large local remnant (20) • Patch is in close proximity to (within 1 km) of other medium to large remnants (10) • Patch is within 12 km[*3] of other significant remnants and contributes to support of significant avifauna (i.e. known Black Cockatoo Breeding sites are located within 12km of the patch) (5)	20	20	20	20	20	20	20	20	10	20	20	20
	Patch size • 20 hectares (50) • 10 - 20 hectares (40) • 5 -10 hectares (30) • 2 - 5 hectares (20) • <2 hectares (10)	20	30	30	10	30	20	20	20	20	20	20	40
	Site location and risk • Patch located in an area where the TEC has been extensively cleared (10) Patch located at the geographical edge of the recorded range (10)	10	10	10	10	10	10	10	10	10	10	10	10
	Context total(100)	50	60	60	40	60	50	50	50	40	50	50	70
	Context total (50)	25	30	30	20	30	25	25	25	20	25	25	35
Quality total (100)		43	55	58	52	55	49	50	44	36	50	47	60
Quality (10)		4	6	6	5	6	5	5	4	4	5	5	6

Table 17-5 Habitat Quality Score for Banksia Woodland TEC at Impact Sites

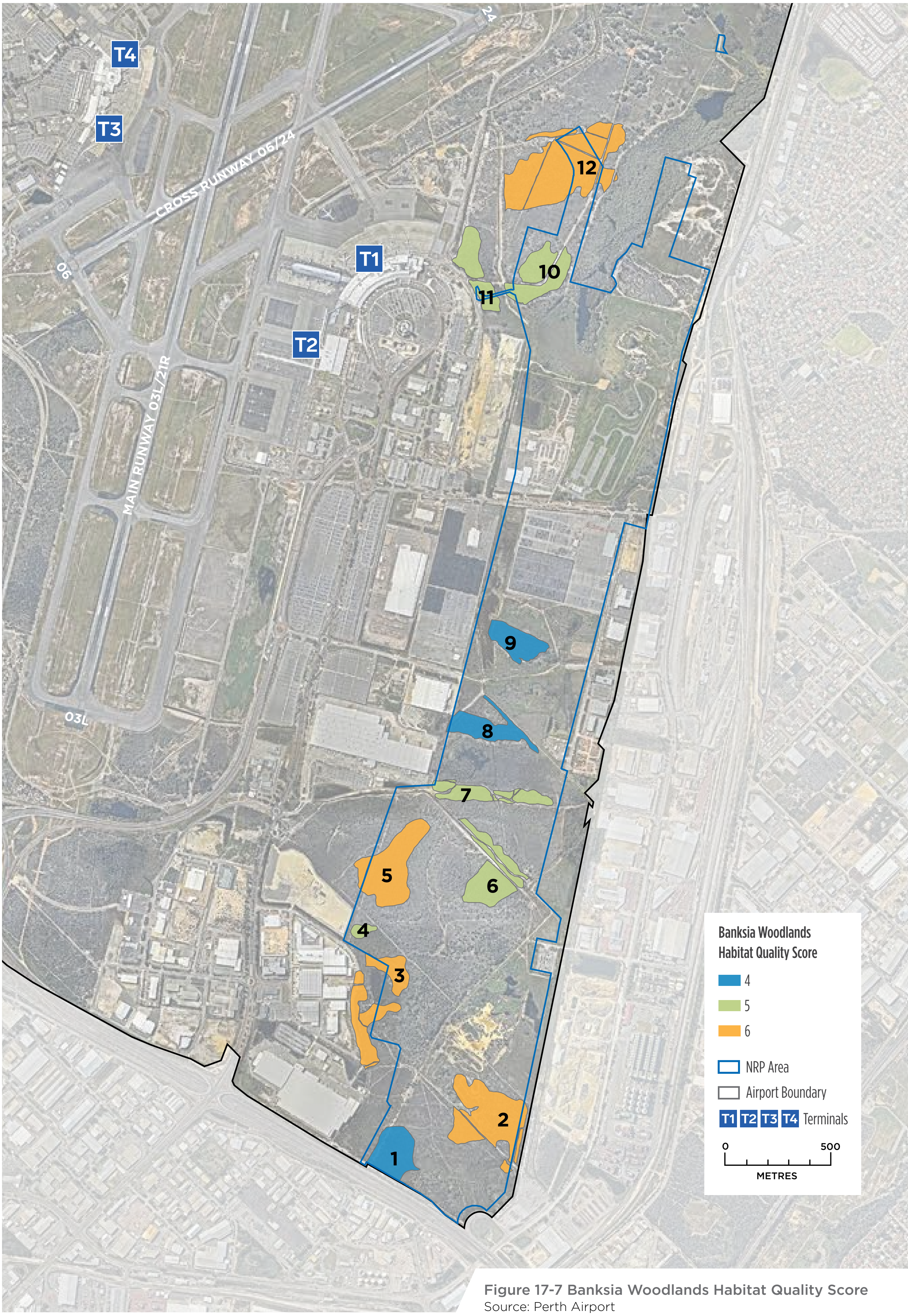


Figure 17-7 Banksia Woodlands Habitat Quality Score
Source: Perth Airport

Patch Number	Impact Area (hectares)	Habitat Quality Score (10)	Weighted Score (Area X HQS)	Overall Habit Quality Score
1	3.5	4	15	
2	7.9	6	43	
3	1.9	6	11	
4	0.5	5	3	
5	6.4	6	35	
6	4.8	5	24	
7	3.0	5	15	
8	3.2	4	14	
9	2.8	4	10	
10	4.3	5	21	
11	0.2	5	1	
12	3.1	6	18	
Total	**41.4**		**210**	
Average				4.98
Weighted Average Score				5.07
Overall Habitat Quality Score (to nearest whole number)				5

Table 17-6 Overall Banksia Woodlands Habitat Quality Score for NRP

17.9.3.3 Proposed Offset for Banksia Woodlands

The Offset Proposal for the residual impact of the clearing of 41.4 hectare of Banksia Woodlands TEC within the NRP project area is to restore cleared or degraded areas of the respective Floristic Community Type (FCT) in the Perth metropolitan area (the Restoration Offset). The proposed offset will be chosen to ensure that the sites identified:

- increase the area of Banksia Woodland that meets the diagnostic criteria for the TEC,
- improve the condition of remnants and corridors in the metropolitan area through removing fragmentation and threats to the remnants,
- restore TEC within close proximity to the impact area of clearing, and
- maximise 'like for like' offset outcomes (that is, providing offsets of the same FCTs and not less than the species richness of the impact sites).

The restoration offset site/s will be selected based on site characteristics with a preference given to land that:

- is close to Perth Airport,
- is located on soils and landforms most similar to the area to be cleared at Perth Airport (in order to provide confidence that the restored ecosystem will provide a more 'like for like' offset),
- increases the size and or connectivity of existing patch/es of the Banksia Woodland TEC,
- have as few threats to the success of the restoration as possible (e.g. significant or declared weeds, evidence of Phytophthora dieback etc.), and
- has secure tenure either within the existing conservation estate or is currently managed for the purposes of conservation

Perth Airport considers that it is highly likely it will be able to deliver sufficient offsets for the loss of 41.4 hectares of Banksia Woodlands TEC. FCT 23a is a relatively common vegetation type in the central Swan Coastal Plain; inhabiting primarily mid to upper slopes of sand dunes in the Bassendean sand unit. Examination of the current Swan Coastal Plain floristic quadrat dataset held by DBCA identifies (refer to Figure 17-8) 41 quadrats of 23a 'Central '*Banksia attenuata*' – '*Banksia menziesii*' woodlands' located within remnant vegetation patches within 30km of the Perth Airport.

This clearly indicates that suitable habitat occurs for this FCT in proximity to Perth Airport, with patches having a wide variety of habitat qualities.

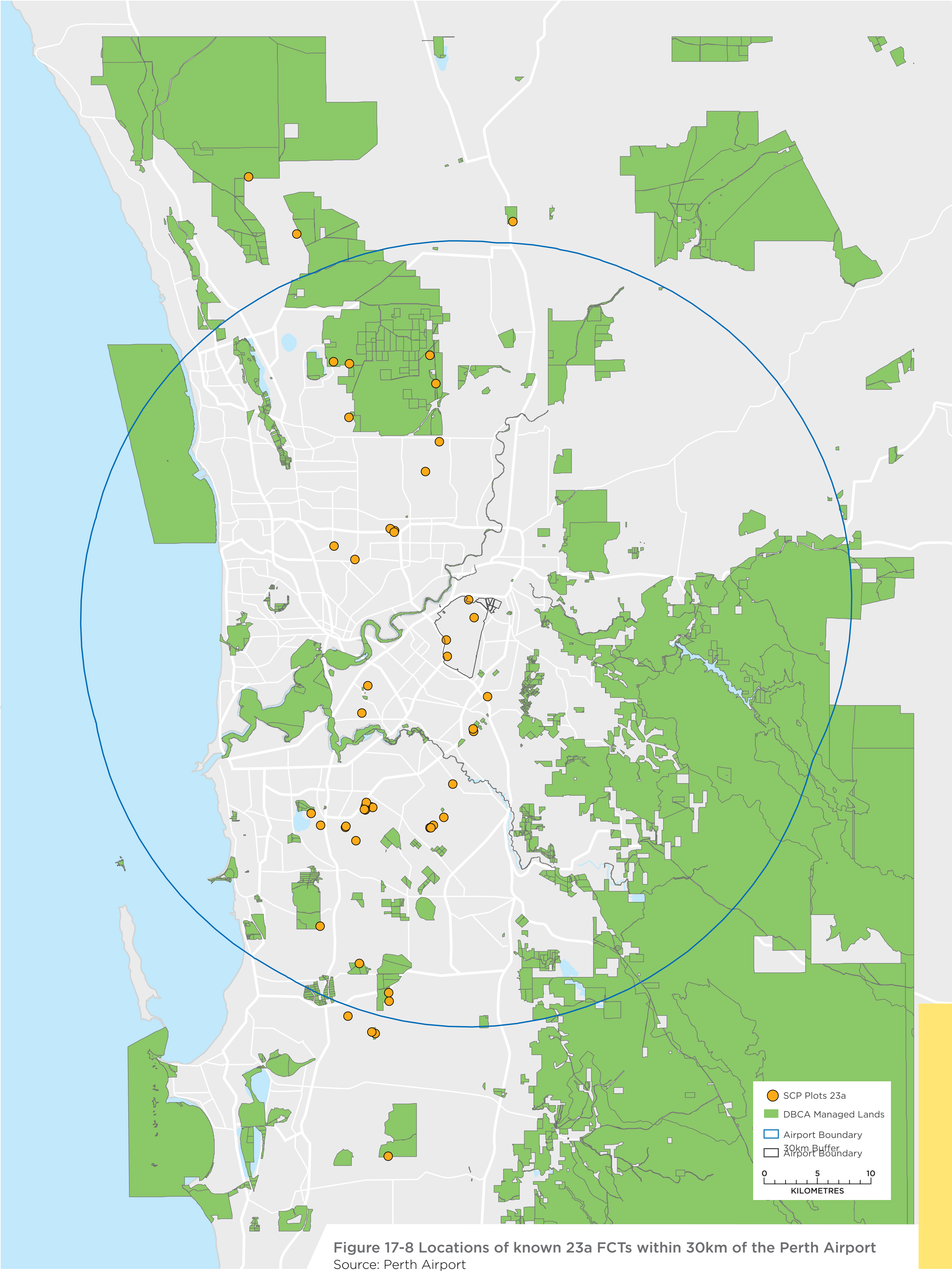


Figure 17-8 Locations of known 23a FCTs within 30km of the Perth Airport
Source: Perth Airport

17.9.4 Habitat Quality Score of the Offset Site for the Banksia Woodlands TEC

The Restoration Offset will target the creation of good or better condition vegetation (single patch of woodland) which is well connected and is larger than 20 hectares. This equates to a HQS of 6 out of 10. Table 17-7 outlines how the HQS methodloflogy (Section 17.11.1) has been applied to offset the Banksia Woodland TEC restoration offset.

Component (maximum score)	DoEE sub-components	Offset Site	Comment
Site Condition (50/100)	*Vegetation condition* (Keighery 1994) (100) • Pristine (100) • Excellent (80) • Very Good (60) • Good (40) • Degraded (25) • Completely Degraded (0)	40	The restoration activity will seek to create vegetation cover and quality to provide a functioning native system, recognising that the creation of Excellent or Pristine vegetation on a restoration site may ultimately be unachievable. Given appropriate actions and management the creation of Good or Very Good vegetation is considered achievable using current leading practice restoration methods.
	Species richness (10) • Average native species richness within the top half of recorded range for the TEC (10) • Average native species richness not within the top half of recorded range for the TEC (0)	10	Perth Airport will ensure that the restoration program will target the introduction/return of highly diverse vegetation during restoration activities. Species lists will be developed to reflect target Floristic Community Types and monitoring will inform adaptive management of the site that will direct ongoing maintenance and remedial actions as required.
	Presence of Threatened taxa (5) • Patch is critical habitat for and hosts Threatened taxa (10) • Patch is critical habitat for Threatened taxa (5) • Patch contains no critical habitat for Threatened Taxa (0)	0	N/A
	Contain State listed TEC/PEC (20) • Patch contains WA Floristic Community Type (FCT) listed as a State TEC (20) • Patch contains WA Floristic Community Type (FCT) listed as a State PEC (10)	10	The restoration activities will focus on returning those species belonging to FCT 23a, with full range of canopy, mid- and under-story species to be included in the species list.
	Presence Dieback (10) • Patch is dieback Free (10) • Patch is partly dieback free (5) Patch is dieback infested (0)	5	Being in the Perth metro region, adjacent sites is likely to be dieback infested
Total Site Condition	150/3	22	
Site Context (50/100)	*Connectivity (30)* • Patch is continuous with remnant native vegetation and forms a corridor that links different landscape units (30) • Patch is continuous with remnant native vegetation that forms a medium to large local remnant (20) • Patch is in close proximity to (within 1 km) of other medium to large remnants (10) • Patch is within 12 km*3 of other significant remnants and contributes to support of significant avifauna (i.e. known Black Cockatoo Breeding sites are located within 12km of the patch) (5) • Patch is not within 12 km*3 of other significant remnants and contributes to support of significant avifauna (i.e. known Black Cockatoo Breeding sites are located within 12km of the patch) (0)	20	Perth Airport will ensure that the restoration activity will enhance connectivity in the local bioregion through the selection of specific areas

Table 17-7 Habitat Quality Score of Offset Site for the Banksia Woodland TEC

Component (maximum score)	DoEE sub-components	Offset Site	Comment
	Patch size (50) • >20 hectares (50) • 10- 20 hectares (40) • 5 -10 hectares (30) • 2 - 5 hectares (20) • <2 hectares (10)	50	The area under consideration for restoration will be part of an area of native vegetation that will be in excess of 20 hectares.
	Site location and risk (10+10) • Patch located in an area where the TEC has been extensively cleared (10) • Patch located at the geographical edge of the recorded range (10)	10	The restoration area is located in an area where the TEC has been extensively cleared and will lead to an increase in the TEC in the area.
Site Context total	*100/2*	45	No comment required.
Quality total (out of 100)	*Site Condition total + Site Context total*	57	No comment required.
Quality (above /10)		5.7	No comment required.
	Rounded to nearest whole number	6	No comment required.

Table 17-7 Habitat Quality Score of Offset Site for the Banksia Woodland TEC (continued)

17.9.4.1 Banksia Woodlands TEC Offsets Guide

Table 17-8 summarises the inputs for the Offsets Guide for offset of 41.4 hectares of clearing of the Banksia Woodland TEC with restoration.

Based on these inputs, the Restoration Offset requires 75 hectares to address the loss of 41.4 hectares of Banksia Woodland TEC habitat for the NRP. When the offset site/s are finalised the habitat quality score of the offset site will be revised by applying the HQS method described in section 17.9.3.1. This may result in an increase or decrease in the offset area required. For example, if the offset site is in better condition, it will result in a higher offset area requirement. Conversely, if the offset site is a more connected patch of Banksia Woodlands TEC, the offset area may be lower.

Offset Calculator Attribute	Input	Explanation
Time Horizon		
Time over which loss is averted	20	It is expected that the final restoration offset site will be either part of an existing conservation estate or under an existing conservation covenant. A timeframe of 20 years (the maximum number of years that can be entered into the Offsets Guide) has therefore been selected.
Time until ecological benefit	20	Perth Airport recognises that development of a Banksia Woodland restored habitat will take 10 to 20 years to achieve. Habitat function and diversity will not be realised until mature trees dominate the woodland and the vegetation has achieved a state where nutrient cycles are in place and the vegetation has achieved a self-sustaining state.
Start area (hectares)	75	This is the area of restoration required by the Offsets Guide to satisfy 100 per cent of the offsets required.
Start quality (scale of 1-10)	1	The restoration offset site to be selected will be highly degraded/ cleared and adjacent to an existing patch of Banksia Woodland TEC within the Perth metropolitan area.
Future area and quality with and without offset (per cent)		
Risk of Loss (per cent) without offset	5	5 per cent has been allocated because it is intended to select a restoration offset site that is already within a conservation estate or under an existing conservation covenant. A score of 0 per cent has not been allocated because land can still be removed from the conservation estate through an Act of Parliament and a conservation covenant can be removed by amending a title deed. Given this, there still remains a risk that the site could in future be subject to developments that may not align with the Restoration Offset.

Table 17-8 Summary of Offsets Guide Inputs

Offset Calculator Attribute	Input	Explanation
Future quality without offset (scale 1-10)	1	Without an offset, it is unlikely that the quality of the selected restoration offset site will improve and the future quality of the site without an offset remains at 1.
Risk of loss (per cent) with offset	5	The tenure and level of protection over the final restoration offset site is unlikely to change as a result of this offset proposal. Perth Airport intends to select a site that is already part of a conservation estate or under a conservation covenant. Therefore, the risk of loss remains at 5 per cent.
Future quality with offset (scale 1-10)	7	It is expected that the Restoration Offset will increase the quality of the TEC habitat to 7.
Confidence in result (per cent)	75	Leading practice restoration methods will be employed and a site suitable for restoration will be selected to ensure that confidence in the outcome is high. It is expected that the Project will have a long duration that will be informed by a monitoring program and adaptive management process to ensure restoration processes allow the site to achieve the target HQS.
Net present value (adjusted hectares)	21.05	
Percentage of impact offset	101.68	

Table 17-8 Summary of Offsets Guide Inputs (Continued)

17.9.4.2 Consistency with Offsets Policy for Banksia Woodlands TEC Offset

Table 17-9 demonstrates how the Proposed Offset for the loss of Banksia Woodland TEC is consistent with the principles of the Offsets Policy and hence the offset requirements within the Conservation Advice for Banksia Woodland TEC.

Offsets Policy Requirement	Proposed offset
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of a protected matter.	The proposed offset will provide an increased area of the TEC within the Perth Metropolitan Area and will seek to increase the integrity, quality and ecological functioning of existing Patch/es.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	Restoration of Banksia Woodland TEC is a direct offset.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	The NRP Proposed Offset is considered appropriate and consistent with the DEE policy, as it takes into account the Banksia Woodlands TEC level of statutory protection, specific attributes of the protected matters, the ongoing viability of the protected matter, the permanent nature of the residual impacts to the species, and the time taken to yield a conservation gain for the species, as indicated by the Offsets Assessments Guide.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protect matter.	The NRP will result in the clearing of 41.4 hectares of the Banksia Woodland TEC that is currently exposed to significant threats from weeds and Phytophthora dieback. The NRP Proposed Offset includes restoration of 75 hectares of Banksia Woodland TEC that balances the remainder of the residual impact as defined through use of the Offsets Guide. The offset is of a size and scale proportionate to the residual impacts on the protected matter, as indicated by the Offsets Guide. The final offset site will be selected to ensure that threats from weeds will be less than that of the impact from the NRP and can be effectively managed through existing land management practices. The Restoration and Monitoring Plan for the Proposed Offset will target species richness values above those recorded during pre-clearing surveys of the impact site.

Table 17-9 Offsets Policy Requirements and Proposed Offset for Banksia Woodland TEC

Offsets Policy Requirement	Proposed offset
Suitable offsets must effectively account for and manage the risk of the offset not succeeding.	The NRP Proposed Offset will be located within existing conservation lands under appropriate management. The offset restoration project will be planned and implemented utilising the principles described in the Society for Ecological Restoration National Restoration Standards. The NRP Proposed Offset will be implemented under a Restoration and Monitoring Plan that will include: • Restoration objectives • Completion criteria • Implementation methods • Monitoring and reporting program • Contingency actions • Site maintenance/management program The Restoration and Monitoring Plan will be submitted to DEE for review and approval prior to implementation of the offset. Perth Airport will commit to an annual review for the ongoing implementation of the offset proposal until completion criteria are met or an alternative offset is provided (and approved by DEE).
Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programmes.	The NRP Proposed Offset is proposed solely to satisfy the requirements of the EPBC Act.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable.	**Efficient** The NRP Proposed Offset will directly offset the loss of 41.4 hectares of the TEC through the application of existing knowledge and technology. Species establishment will be achieved through accepted practices utilised in other restoration and rehabilitation programs in WA. The offset site will be chosen to ensure that an in situ natural landform and soil profile exists on the site that will reduce the requirement for expensive earthworks and the associated risks to project outcomes. **Effective** The NRP Proposed Offset will establish an area of Banksia Woodland within the Perth Metropolitan Area larger than being cleared at the Airport site. The offset will be situated to enhance the integrity, quality and extent of urban bushland and where possible improve ecological functions of the region. **Timely** The NRP Proposed Offset will be a long-term project that will not realise the full values of the target habitat for between 10 and 20 years. However, the establishment and associated management actions will gradually improve the ecological functioning of the site over time in terms of hydrological function, habitat for flora and fauna and reductions in weed presence. **Transparent** The NRP Proposed Offset will be managed under a Restoration and Monitoring Plan that will contain a monitoring and reporting requirement. The offset site will be located on existing conservation lands and as such will be subject to the oversight of the land manager. **Scientifically robust** The NRP Proposed Offset will be based on the Commonwealth endorsed Society for Ecological Restoration National Restoration Standards. The Restoration and Monitoring Plan will only be implemented following review and acceptance by the DEE and respective land manager. **Reasonable** Existing remnant bushland within the Perth Metropolitan Area of a suitable vegetation type to constitute a direct offset for the NRP is not readily available. Most are held in private property either highly degraded or too small to provide a secure long-term remnant without extensive management. The NRP proposed offset has been developed to directly replace lost habitat while enhancing the existing conservation estate through improvement in habitat condition and extent. The proposed offset for the NRP will increase the Banksia Woodland TEC area through the sound allocation of resources in a timely manner.
Suitable offsets must have transparent governance arrangements, including being able to be readily measured, monitoring, audited and enforced.	Implementation of the offset will be in accordance with a formal agreement with the DBCA and a Restoration and Monitoring Plan, approved by the DEE, and which is able to be monitored, audited and enforced.

Table 17-9 Offsets Policy Requirements and Proposed Offset for Banksia Woodland TEC (continued)

17.9.5 Offset for Black Cockatoos

This sub section describes the habitat quality score methodology for the three species of Black Cockatoo and how it has been applied at both impact and offset sites. This is followed by application of the Offsets Guide and how the proposed offset is consistent with EPBC offset policy.

17.9.5.1 Habitat Quality Score Methodology for Black Cockatoos

Application of the Offsets Guide developed by the DAWE for assessing Black Cockatoo foraging habitat requires the calculation of a score out of 10 as described in Section 17.10.1. The following system has been developed by Bamford Consulting Ecologists (BCE) to provide an objective scoring system that is practical and can be used by trained field zoologists with experience in the environments frequented by the species.

Calculating the total score (out of 10) requires the following steps:

- determining a score out of six for the vegetation composition, condition and structure (Table 17-11),
- determining a score out of three for context (Table 17-12),
- determining a score out of one for species density, and
- determining the total score out of 10 requires moderation for context and species density with respect to the vegetation composition that has a condition score of 0-2 to prevent it receiving an unrealistic score out of 10. In this instance, applying a score of 0 for context and species density scores would give a true reflection of its foraging value as the Black Cockatoos would only be present because of adjacent vegetation of high foraging quality. The approach to calculating a score out of 10 can be summarised as shown in Table 17-10.

Vegetation composition, condition and structure score	Context score	Species density score
3-6 (low/moderate to high value)- as per Table 17-11	Assessed as per Table 17-12	Assessed as per Species density score in section 17.12.1.3
0-2 (no to low value)- as per Table 17-11	0	0

Table 17-10 Habitat Quality Score Calculation

Calculation of scores are described in more detail below.

17.9.5.1.1 Vegetation composition, condition and structure score

The scoring system for vegetation composition and condition relative to the three Black Cockatoo species is provided in Table 17-11.

	Description of vegetation values relative to each species		
Score	Carnaby's Black Cockatoo	Baudin's Black Cockatoo	Forest Red-tailed Black Cockatoo
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers); Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No eucalypts or other potential sources of food. Examples: Water bodies (e.g. dams, rivers); Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No eucalypts or other potential sources of food. Examples: Water bodies (e.g. dams, rivers); Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	Negligible to low foraging value. Examples: Scattered specimens of known food plants but projected foliage cover of these is < 2 per cent. This could include urban areas with scattered foraging trees; Paddocks that are partly vegetated with melons or other known food-source weeds (e.g. Erodium spp.) that represent a short-term and/or seasonal food source; Blue Gum plantations (foraging by Carnaby's Black Cockatoos has been reported but appears to be unusual).	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1 per cent. This could include urban areas with scattered foraging trees.	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1 per cent. Could include urban areas with scattered foraging trees.

	Description of vegetation values relative to each species		
Score	Carnaby's Black Cockatoo	Baudin's Black Cockatoo	Forest Red-tailed Black Cockatoo
2	Low foraging value. Examples: Shrubland in which species of foraging value, such as shrubby banksias, have < 10 per cent projected foliage cover; Woodland with tree banksias 2-5 per cent projected foliage cover; Open eucalypt woodland/mallee of small-fruited species; Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. *Erodium* spp.) that represent a short-term and/or seasonal food source.	Low foraging value. Examples: Woodland with scattered specimens of known food plants (e.g. Marri and Jarrah) 1-5 per cent projected foliage cover; Urban areas with scattered foraging trees.	Low foraging value. Examples: Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah or Sheoak) 1-5 per cent projected foliage cover; Urban areas with scattered food plants such as Cape Lilac, *Eucalyptus caesia* and *E. erythrocorys.*
3	Low to Moderate foraging value. Examples: Shrubland in which species of foraging value, such as shrubby banksias, have 10-20 per cent projected foliage cover; Woodland with tree banksias 5-20 per cent projected foliage cover; Eucalypt Woodland/Mallee of small-fruited species; Eucalypt Woodland with Marri < 10 per cent projected foliage cover.	Low to Moderate foraging value. Examples: Eucalypt Woodland with known food plants (especially Marri) 5-20 per cent projected foliage cover; Parkland-cleared Eucalypt Woodland/ Forest with known food plants 10-40 per cent projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40 per cent projected foliage cover (establishing food sources with good long-term viability).	Low to Moderate foraging value. Examples: Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20 per cent projected foliage cover; Parkland-cleared Eucalypt Woodland/ Forest with known food plants 10-40 per cent projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40 per cent projected foliage cover (establishing food sources with good long-term viability).
4	Moderate foraging value. Examples: Woodland/forest with tree banksias 20-40 per cent projected foliage cover; Eucalypt Woodland/Forest with Marri 20-40 per cent projected foliage cover.	Moderate foraging value. Examples: Marri-Jarrah Woodland/Forest with 20-40 per cent projected foliage cover; Marri-Jarrah Forest with 40-60 per cent projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Eucalypt Woodland/Forest with diverse, healthy understorey and known food trees (especially Marri) 10-20 per cent projected foliage cover. Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits).	Moderate foraging value. Examples: Marri-Jarrah Woodland/Forest with 20-40 per cent projected foliage cover; Marri-Jarrah Forest with 40-60 per cent projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Sheoak Forest with 40-60 per cent projected foliage cover.
5	Moderate to High foraging value. Examples: Banksia Forest with 40-60 per cent projected foliage cover; Banksia Forest with > 60 per cent projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Pine plantations with trees more than 10 years old.	Moderate to High foraging value. Examples: Marri-Jarrah Forest with 40-60 per cent projected foliage cover; Marri-Jarrah Forest with > 60 per cent projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths.	Moderate to High foraging value. Examples: Marri-Jarrah Forest with 40-60 per cent projected foliage cover; Marri-Jarrah Forest with > 60 per cent projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Sheoak Forest with > 60 per cent projected foliage cover.
6	High foraging value. Example: Banksia Forest with > 60 per cent projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: Marri-Jarrah Forest with > 60 per cent projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: Marri-Jarrah Forest with > 60 per cent projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).

Table 17-11 Vegetation Composition, Condition and Structure Scoring
*Vegetation structural class terminology follows Keighery (1994).

17.9.5.1.2 Context scoring

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds, and Table 17-12, developed by BCE in conjunction with DEE, provides a guide to assigning site context scores (note that 'local area' is defined as within a 15 km radius of the centre point of the study site).

17.9.5.1.3 Species density score

Assignation of the species density score (0 or 1) is based upon the Black Cockatoo species being either abundant or not abundant and is species specific. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence.

17.9.5.2 Black Cockatoos Habitat Quality Score of the Impact Area

The residual impacts of the NRP to Black Cockatoos include:

- Loss of 232.7 hectares of Carnaby's Black Cockatoo foraging habitat; and
- Loss of 63.9 hectares of Baudin's and Forest Red-tailed Black Cockatoo foraging habitat.

There is a difference between the impacts to Carnaby's Black Cockatoos foraging habitat and that of Baudin's and Forest Red-tailed Black Cockatoos. Carnaby's can forage on a larger range of plant species than Baudin's and Forest Red-tailed Black Cockatoos. As such, impacts for Carnaby's Black Cockatoo have been considered separately to the other two Black Cockatoo species.

The HQS for Carnaby's Black Cockatoo is shown in Table 17-13 and Figure 17-9. The HQS for Baudin's and Forest Red-tailed Black Cockatoos is shown in Table 17-14 and Figure 17-10.

Site Context Score	Percentage of the existing native vegetation within the 'local' area that the study site represents.	
	'Local' breeding known/likely	'Local' breeding unlikely
3	> 5 per cent	> 10 per cent
2	1 - 5 per cent	5 - 10 per cent
1	0.1 - 1 per cent	0.1 - 5 per cent
0	< 0.1 per cent	< 0.1 per cent

Table 17-12 Site Context Scoring

<table>
<tr><th>Foraging score based on vegetation characteristics (out of 6)</th><th>Area (hectares)</th><th>Site Context (0 to 3)</th><th>Density / Presence (0 to 1)</th><th>Score Including Context and Density</th></tr>
<tr><td>1 – Negligible to low</td><td>170.0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>2 – Low</td><td>12.0</td><td>0</td><td>0</td><td>2</td></tr>
<tr><td>3 – Low to moderate</td><td>4.8</td><td rowspan="4">3</td><td rowspan="4">1</td><td>7</td></tr>
<tr><td>4 – Moderate</td><td>16.5</td><td>8</td></tr>
<tr><td>5 – Moderate to high</td><td>27.7</td><td>9</td></tr>
<tr><td>6 – High</td><td>1.74</td><td>10</td></tr>
<tr><td>Total</td><td>232.7</td><td></td><td></td><td></td></tr>
<tr><td>Weighted Average Score</td><td></td><td></td><td></td><td>3</td></tr>
</table>

Table 17-13 Carnaby's Black Cockatoo HQS of the NRP Impact Site

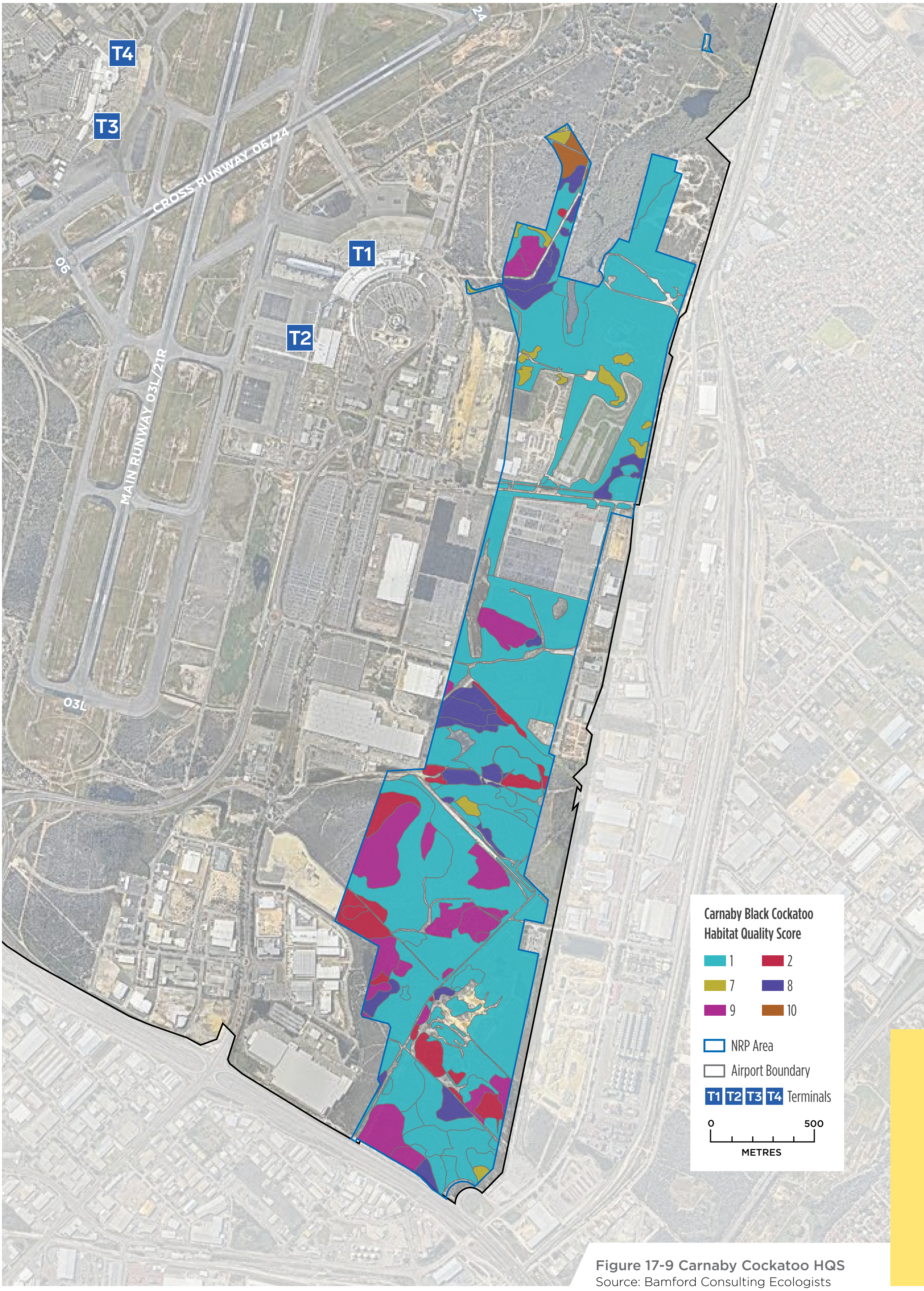


Figure 17-9 Carnaby Cockatoo HQS
Source: Bamford Consulting Ecologists

17.9.5.3 Habitat Quality Score of the Black Cockatoos Offset Site

Offsets for residual impacts to Black Cockatoos will comprise a Restoration Offset (Banksia Woodlands offset discussed in section 17.11.3) with an assumed HQS of 10 (Refer Table 17-15) and a Land Purchase Offset that consists of existing habitat.

Existing habitat will be purchased and managed for conservation purposes and added to the conservation estate to address the remainder of the residual impacts not addressed by the Restoration Offset. This land purchase offset has been assigned an estimated HQS of 7 at this stage to aid in the Offsets Guide calculations. At the time of selecting the property to be implemented, in consultation with DEE and DBCA, the methodology outlined in Section 17.12.1 will be applied to confirm the HQS and the Offsets Guide calculations amended accordingly.

17.9.5.4 Black Cockatoos Offsets Guide

Table 17-16 summarises the inputs and outputs for the Offsets Guide for the three species of Black Cockatoo for impact to foraging habitat. It should be noted that:

- 75 hectares of restoration and 127 hectares of land purchase offset are required to address the impact of the loss of 232.7 hectares of Carnaby's Black Cockatoo habitat.
- The 127 hectares of land purchase offset will also offset the loss of 63.8 hectares of Baudin's and Forest Red-tailed Black Cockatoos

Foraging score based on vegetation characteristics (out of 6)	Area (hectares)	Context (0 to 3)	Density / Presence (0 to 1)	Score Including Context and Density
1 – Negligible to low	31.0	0	0	1
2 – Low	10.0	0	0	2
3 – Low to moderate	10.7	3	1	7
4 – Moderate	8.4			8
5 – Moderate to high	3.6			9
6 – High	0			0
Total	**63.8**			
Weighted Average Score				4

Table 17-14 Baudin's and Forest Red-tailed Black Cockatoo HQS of the NRP Impact Site

Component (score range)	Offset Site Score	Comment
Condition Score (0-6)	6	A score of 6 is given as Perth Airport is confident that at least 60 per cent cover of foliage within Banksia Woodland can be achieved within the given timeframe.
Site Context Score (0-3)	3	A score of 3 is given as the percentage of native vegetation containing Black Cockatoo breeding habitat within a 15km radius is greater than 10 per cent.
Species Density (1)	1	Perth Airport is confident that Black Cockatoos will be regularly sighted in the restoration areas within the given timeframe.
HQS	**10**	

Table 17-15 Restoration Offset HQS
Scores taken from Bamford Consulting Ecologists, 2018.

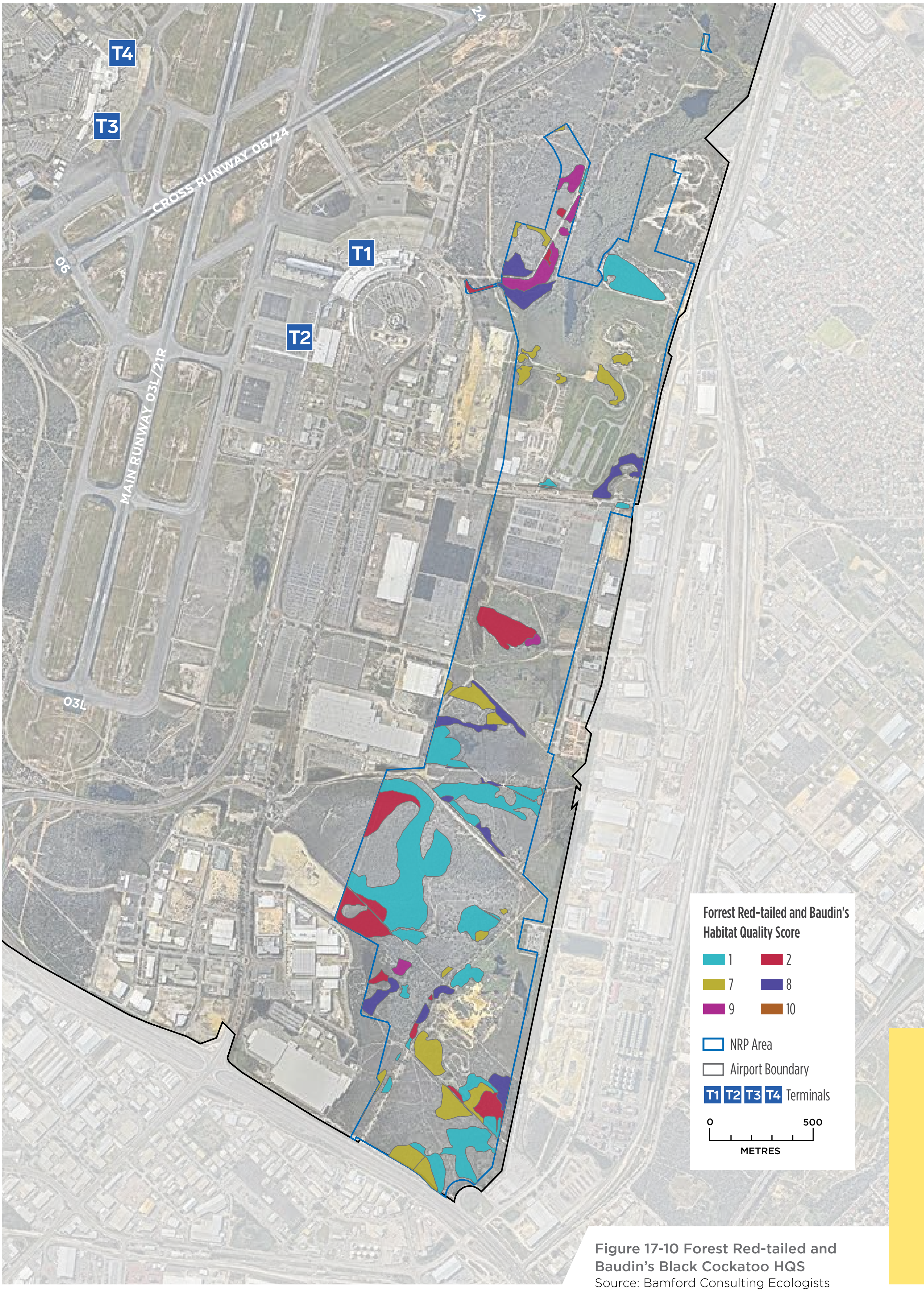


Figure 17-10 Forest Red-tailed and Baudin's Black Cockatoo HQS
Source: Bamford Consulting Ecologists

Offset Calculator Attribute	Input for Restoration Portion of Offset	Input for Land Purchase Portion of Offset	Explanation
Time Horizon			
Time over which loss is averted (years)	20	20	It is expected that the final restoration offset site will be either part of an existing conservation estate or under an existing conservation covenant. It is also expected that the land purchase offset will become part of an existing conservation estate. A timeframe of 20 years (the maximum number of years that can be entered into the Offsets Guide) has therefore been selected.
Time until ecological benefit (years)	20	1	Perth Airport recognises that development of a Banksia Woodland restored habitat may take up to 20 years achieve. Habitat function and diversity will not be realised until mature trees dominate the woodland and the vegetation has achieved a state where nutrient cycles are in place and the vegetation has achieved a self-sustaining state. The Land Purchase Offset will already be providing ecological benefit.
Start area (hectares) Carnaby's Black Cockatoo	75	127	This is the area of restoration required by the Offsets Guide to satisfy 100 per cent of the offsets required.
Start area (hectares) Baudin's Black Cockatoo	0	127	This is the area of restoration required by the Offsets Guide to satisfy 100 per cent of the offsets required.
Start area (hectares) Forest Red-tailed Black Cockatoo	0	127	This is the area of restoration required by the Offsets Guide to satisfy 100 per cent of the offsets required.
Start quality (scale of 1-10)	1	7	The restoration offset site to be selected will be highly degraded/ cleared and adjacent to an existing patch of Banksia Woodland TEC within the Perth metropolitan area. An assumed starting score of 7 is allocated to land purchase offsets. This will be revised once land parcels are identified.
Future area and quality with and without offset (per cent)			
Risk of Loss (per cent) without offset	5	30	5 per cent has been allocated because it is intended to select a restoration offset site that is already within a conservation estate or under an existing conservation covenant. A score of 0 per cent has not been allocated because land can still be removed from the conservation estate through an Act of Parliament and a conservation covenant can be removed by amending a title deed. Given this, there still remains a risk that the site could in future be subject to developments that may not align with the Restoration Offset. Land purchase offsets will be freehold land where ther are developmental pressures such as mining, agriculture or urban/rural expansion. Hence the attribution of 30 per cent risk of loss.
Future quality without offset (scale 1-10)	1	6	Without an offset, it is unlikely that the quality of the selected restoration offset site will improve and the future quality of the site without an offset remains at 1. Land purchased site is expected to decrease in quality due to lack of management and hence a score of 6
Risk of loss (per cent) with offset	5	5	The tenure and level of protection over the final restoration offset site is unlikely to change as a result of this offset proposal. Perth Airport intends to select a site that is already part of a conservation estate or under a conservation covenant. Therefore, the risk of loss remains at 5 per cent. Land purchased would become part of the conservation estate and risk of loss remains at 5 per cent.

Offset Calculator Attribute	Input for Restoration Portion of Offset	Input for Land Purchase Portion of Offset	Explanation
Future quality with offset (scale 1-10)	10	8	It is expected that the Restoration Offset will increase the quality of the TEC habitat to 10.It is expected that Land Purchase Offset will have an increase quality to 8 due to being managed.
Confidence in result (per cent)	75	90	Leading practice restoration methods will be employed to ensure that confidence in the outcome is as high as possible. In populating the offsets calculator, a confidence level of 75 per cent was used to provide a conservative view of the Restoration Project. However, it is expected that the Project will have a 20 year duration that will be informed by a monitoring program and adaptive management process to ensure restoration processes allow the site to achieve the target HQS. Land purchase offsets will already have the values and will be improved by management. Hence a confidence level of 90 per cent.
Net present value (adjusted hectares)- Carnaby's Black Cockatoo	70.72	32.21	
Percentage of impact offset - Carnaby's Black Cockatoo	54.34	46.28	Total 110.62 per cent meets 100 per cent minimum criteria
Net present value (adjusted hectares)- Baudin's Black Cockatoo	n/a	33.82	
Percentage of impact offset -Baudin's Black Cockatoo	n/a	132.52	Total 132.52 per cent meets 100 per cent minimum criteria
Net present value (adjusted hectares)- Forest Red-tailed Black Cockatoo	n/a	37.93	
Percentage of impact offset - Forest Red-tailed Black- Cockatoo	n/a	148.65	Total 148.65 per cent meets 100 per cent minimum criteria

Table 17-16 Summary of Offsets Guide Inputs for Carnaby's, Baudin's and Forest Red-tailed Black Cockatoos

17.9.5.5 Conistency with Offsets Policy for Black Cockatoo Offsets

Table 17-17 demonstrates how the NRP Offset Proposal for the three Black Cockatoo species is consistent with the principles of the Offsets Policy and hence the offset requirements within the Conservation Advice for the Black Cockatoos.

Offsets Policy Requirement	Proposed offset
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of a protected matter.	The NRP Proposed Offset for all Black Cockatoo species will secure a conservation area of 127 hectares of foraging habitat vegetated land with a nominal Habitat Quality Score of 7. These areas of foraging habitat are currently not secure for conservation purposes but will be added to the conservation estate and managed by the Department of Biodiversity, Conservation and Attractions. The NRP Proposed Offset also includes 75 hectares of restoration of Banksia Woodland TEC as foraging habitat.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	Restoration of Banksia Woodland TEC and purchase of land that is quality foraging habitat are direct offsets.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	The NRP Proposed Offset is considered appropriate and consistent with the DEE policy, as it takes into account the Black Cockatoos' level of statutory protection, specific attributes of the protected matters, the ongoing viability of the protected matter, the permanent nature of the residual impacts to the species, and the time taken to yield a conservation gain for the species, as indicated by the Offsets Assessments Guide.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protect matter.	The NRP will result in the clearing of 232.7 hectares of Carnaby's Black Cockatoo habitat, and 63.9 hectares of Baudin's and Forest Red-tailed Black Cockatoo habitat. The NRP Proposed Offset will secure a conservation area of 127 hectares of foraging habitat vegetated land and includes restoration of 75 hectares of Banksia Woodland TEC that balances the remainder of the residual impact as defined through use of the Offsets Assessments Guide. The offset is therefore of a size and scale proportionate to the residual impacts on the protected matter.
Suitable offsets must effectively account for and manage the risk of the offset not succeeding.	The NRP Proposed Offset will be located within existing conservation lands under appropriate management, and on land purchased for inclusion into the conservation estate. The offset restoration project will be planned and implemented utilising the principles described in the Society for Ecological Restoration National Restoration Standards. The NRP Proposed Offset will be implemented under a Restoration and Monitoring Plan that will include: • Restoration objectives • Completion criteria • Implementation methods • Monitoring and reporting program • Contingency actions • Site maintenance/management program • The Restoration and Monitoring Plan will be submitted to DEE for review and approval prior to implementation of the offset.
Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programmes.	The NRP Proposed Offset is proposed solely to satisfy the requirements of the EPBC Act.

Offsets Policy Requirement	Proposed offset
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable.	**Efficient** The NRP Proposed Offset will directly offset the loss of 232.7 hectares of Carnaby's Black Cockatoo habitat, and 63.9 hectares of Baudin's and Forest Red-tailed Black Cockatoo habitat, through the proposed measures including restoration of 75 hectares of Banksia Woodland TEC and securing a conservation area of 127 hectares of quality Black Cockatoo foraging habitat. Species establishment will be achieved through accepted practices utilised in other restoration and rehabilitation programs in WA. The offset site will be chosen to ensure it has an in situ natural landform and soil profile that closely replicates or matches foraging habitat for Black Cockatoo. **Effective** The NRP Proposed Offset will establish an area of quality Black Cockatoo foraging habitat larger than being cleared for the NRP. The offset will be situated to enhance the integrity, quality and extent of urban bushland in order to improve ecological functions of the region. The offset site will also be chosen to have a size, shape and location to ensure that the restored habitat will be subject to a reduced level of ecological threat compared to NRP area. **Timely** The NRP Proposed Offset will be a long term project that will not realise the full values of the target habitat for between 10 and 20 years. However the establishment and associated management actions will gradually improve the ecological functioning of the site over time in terms of hydrological function, habitat for flora and fauna and reductions in weed loading. **Transparent** The NRP Proposed Offset will be managed under a Restoration and Monitoring Plan that will contain a monitoring and reporting requirement. The offset site will be located on existing conservation lands and as such will be overseen by the land manager. **Scientifically robust** The NRP Proposed Offset will be based on the Commonwealth endorsed Society for Ecological Restoration National Restoration Standards. The Restoration and Monitoring Plan will only be implemented following review and acceptance by the DEE and respective land manager. **Reasonable** The proposed offset for the NRP will maintain or improve the viability of Black Cockatoos in the local region through the sound allocation of resources in a timely manner.
Suitable offsets must have transparent governance arrangements, including being able to be readily measured, monitoring, audited and enforced.	Implementation of the offset in accordance with a documented agreement with the land manager and a Restoration and Monitoring Plan approved by the DEE is considered readily measurable, able to be monitored, audited and enforced.

Table 17-17 Offsets Policy Requirements and Proposed Offset for Black Cockatoo Habitat

17.9.6 Offset for *Macarthuria keigheryi* and *Conospermum undualtum*

17.9.6.1 Offset objectives for *M.keigheryi* and *C.undulatum*

The offset objectives for these two species have been developed to optimise the benefits for the species in a scientifically robust and transparent manner in consultation with DBCA and Woodman Environmetnal Consulting.

Objective 1: Preserve the genetic diversity of the plant material of *M.keigheryi and C.undualatum*

In order to achieve this objective, Perth Airport is proposing a twofold approach to mitigate the potential loss of genetic diversity due to the impacts to the species of the NRP. This involves:

- collaboration with the Threatened Species Seed Centre to collect and store seed from the poulations to be impacted, including the provision of funding, and
- collaboration with the Botanic Gardens and Parks Authority at Kings Park for the collection of propagative material from populations to be impacted, and propagation to be funded to preserve genetic material in a secure nursery.

Objective 2: Establish new populations of *M.keigheryi* and *C.undulatum* within existing conservation estate or other suitable habitat sites utilising salvaged genetic material.

In order to achieve this objective, Perth Airport proposes to undertake the following:

- collaboration with DBCA to plant seedlings raised from seeds and propagative genetic material collected from the Perth Airport estate in areas containing existing populations within the conservation estate (security of tenure), and
- collaboration with DBCA to investigate the use of topsoils salvaged from impacted populations for use in assisting establishment of new populations within areas of appropriate topography, soil and hydrological conditions.

Objective 3: Increase the scientific knowledge of the genetics and ecology of the taxa to inform future recovery efforts.

In order to achieve this objective, Perth Airport proposes to undertake the following:

- create and implement a survey plan to conduct additional targeted surveys for *M.keigheryi* in previously unsurveyed potential habitat, with particular focus on areas that may have been burnt in recent years,
- create a survey plan to conduct additional targeted surveys for *C. undulatum* in previously unsurveyed potential habitat, and
- fund genetic assessment of extant popluations to further understand the genetic fitness of the taxon and to resolve outstanding questions on taxonomy.

A translocation, research and monitoring plan will be developed for each species outlining how the above objectives will be met.

17.9.6.2 *M.keigheryi* and *C.undualatum* Offsets Guide

Table 17-18 summarises the offset guide inputs for *M.keigheryi* and *C.undualatum* for the translocation component.

Offset Calculator Attribute	Input for Translocation and Propagation Program	Explanation
Quatum of Impact (*M.keigheryi*)	855	Number of individual impacted
Quatum of Impact (*C.undualatum*)	199	Number of individual impacted
Time Horizon	20	It is expected that the final translocation offset site will be either part of an existing conservation estate or under an existing conservation covenant. A timeframe of 20 years (the maximum number of years that can be entered into the Offsets Guide) has therefore been selected.
Start value	0	The translocation offset site to be selected in areas with suitable habitat.
Future value without offset	0	Without an offset, it is unlikely that the number of plants will increase
Future value with offset (*M.keigheryi*)	1160	Translocation will increase the number of plants
Future value with offset (*C.undualatum*)	250	Translocation will increase the number of plants
Confidence in result (per cent)	75	Leading practice translocation methods will be employed to ensure that confidence in the outcome is as high as possible. In populating the offsets calculator, a confidence level of 75 per cent was used to provide a conservative view of the translocation project. However, it is expected that the project will be informed by a monitoring program and adaptive management process to ensure translocation processes allow the site to achieve the target future value

Offset Calculator Attribute	Input for Translocation and Propagation Program	Explanation
Percentage of impact offset (*C.undualatum)*	92.36	Total 92.36 per cent meets 90 per cent minimum criteria
Percentage of impact offset (*M.keigheryi*))	90.31	Total 90.31 per cent meets 90 per cent minimum criteria

Table 17-18 Offsets Guide input

17.9.6.3 Consistency with Offsets Policy

Table 17-19 demonstrates how the NRP Offset Proposal for the two threatened flora species, as outlined in Section 17.9.6, is consistent with the principles of the Offsets Policy.

Offsets Policy Requirement	Proposed offset
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of a protected matter.	The proposed offset will increase the integrity, and genetic diversity of existing populations and establish new populations.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	Increase in habitat area and establishing new populations through translocation is a direct offset.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	The Proposed Offset is considered appropriate and consistent with the DEE policy, as it takes into account the taxon's level of statutory protection, specific attributes of the protected matter, the ongoing viability of the protected matter, the permanent nature of the residual impacts to the species, and the time taken to yield a conservation gain for the species, as indicated by the Offsets Assessments Guide.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter.	The NRP will result in the clearing of 855 plants of *M. keigheryi* and 199 plants of *C.undualatum*. The Proposed Offset includes seed collection, propagation, establishment of new populations and funding for scientific research that balances the remainder of the residual impact as defined through use of the Offsets Guide. The offset is of a size and scale proportionate to the residual impacts on the protected matter, as indicated by the Offsets Guide. The final offset site will be selected to ensure that threats from weeds will be less than that of the impact from the NRP and can be effectively managed through existing land management practices. The Translocation, Research and Monitoring Plan for the Proposed Offset will be consistent with requirements of the Interim Recovery Plan for the taxon and target population size values above those recorded during pre-clearing surveys of the impact site.
Suitable offsets must effectively account for and manage the risk of the offset not succeeding.	The Proposed Offset will be located within existing conservation lands under appropriate management, or on land that will be purchased and transferred to the conservation estate. The offset restoration project will be planned and implemented utilising the principles described in the Society for Ecological Restoration National Restoration Standards. The Proposed Offset will be implemented under a Translocation, Research and Monitoring Plan that will be consistent with the requirements of the Interim Recovery Plan for the taxon and include: • Translocation and research objectives • Completion criteria for plant establishment and population viability • Implementation methods • Monitoring and reporting program • Contingency actions • Site maintenance/management program The Translocation, Research and Monitoring Plan will be submitted to DEE for review and approval prior to implementation of the offset. The Proposed Offset will include genetic material will be maintained at the Threatened species seed centre and Kings Park if necessary to ensure no loss of genetic material and capacity for ongoing recovery efforts.

Offsets Policy Requirement	Proposed offset
Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programmes.	The Proposed Offset is proposed solely to satisfy the requirements of the EPBC Act.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable.	**Efficient** The Proposed Offset will directly offset the loss of 855 plants of *M. keigheryi* and 199 *C.undualatum* through the application of existing knowledge and technology. Population establishment will be achieved through accepted practices utilised in other translocation programs in WA. The offset site will be chosen to ensure it has an in situ natural landform and soil profile that closely replicates or matches that required for the taxon. **Effective** The Proposed Offset will preserve the genetic material of plants to be cleared and establish an area of habitat and population size within the Perth Metropolitan Area larger than being cleared at the Airport site. The offset will be situated to enhance the integrity, quality and extent of urban bushland and where possible improve ecological functions of the region. **Timely** The Proposed Offset will be a long-term project. Establishment of the taxon may be achieved earlier than 10 years, however the long term survival and functioning of the population/s will be reliant on the habitat and as such the outcome timeframes are linked. Moreover, the establishment and associated management actions will gradually improve the ecological functioning of the site over time in terms of hydrological function, habitat for flora and fauna and reductions in weed presence. **Transparent** The Proposed Offset will be managed under a Translocation, Research and Monitoring Plan that will contain a monitoring and reporting requirement. The offset site will be located on existing conservation lands and as such will be overseen by the land manager **Scientifically robust** The Proposed Offset will be based on the Commonwealth endorsed Society for Ecological Restoration National Restoration Standards. The Translocation, Research and Monitoring Plan will only be implemented following review and acceptance by the DEE and respective land manager. The recovery plan will only be implemented following review and acceptance by the DBCA and respective land manager. **Reasonable** Existing remnant bushland within the Perth metropolitan area of a suitable vegetation type to constitute habitat for the taxon and a direct offset for the project is not readily available. Most are held in private property either highly degraded or too small to provide a secure long-term remnant without extensive management. The Proposed Offset has been developed to preserve genetic material that would otherwise be lost and directly replace lost habitat while enhancing the existing conservation estate through improvement in habitat condition and extent. The proposed offset will increase local population numbers and increase the area of habitat through the sound allocation of resources in a timely manner.
Suitable offsets must have transparent governance arrangements, including being able to be readily measured, monitoring, audited and enforced.	Implementation of the offset will be in accordance with a formal agreement with the DBCA and a Translocation, Research and Monitoring Plan, approved by the DEE, and which is able to be monitored, audited and enforced.

Table 17-19 Consistency with offset policy requirements

17.10 Conclusion

Perth Airport has developed frameworks to identify, assess and manage environmental and heritage values on the estate. The Perth Airport environment and heritage management frameworks provide guidance and set out expectations on the level of mitigation undertaken, or offset required, to adequately manage construction and operational impacts from the NRP.

A summary of impacts which have been assessed to pose medium and high levels of risk from the NRP will guide construction contractors during the development of a construction environmental management plan (CEMP). Perth Airport will work closely with the construction contractor to develop an effective CEMP for the NRP. An operational environmental management plan (OEMP) will be developed following construction to mitigate against environmental and heritage impacts from the operation of the NRP and current Perth Airport operating procedures will be updated where required.

Perth Airport will implement reporting and incident management processes to ensure ongoing compliance with legislative requirements and approval conditions.

The proposed offset has been prepared in consultation with DEE and DBCA to optimise benfits for the matters impacted with residual significant impact. It has been designed to scientifically robust, transparent and consistent with the EPBC offset policy.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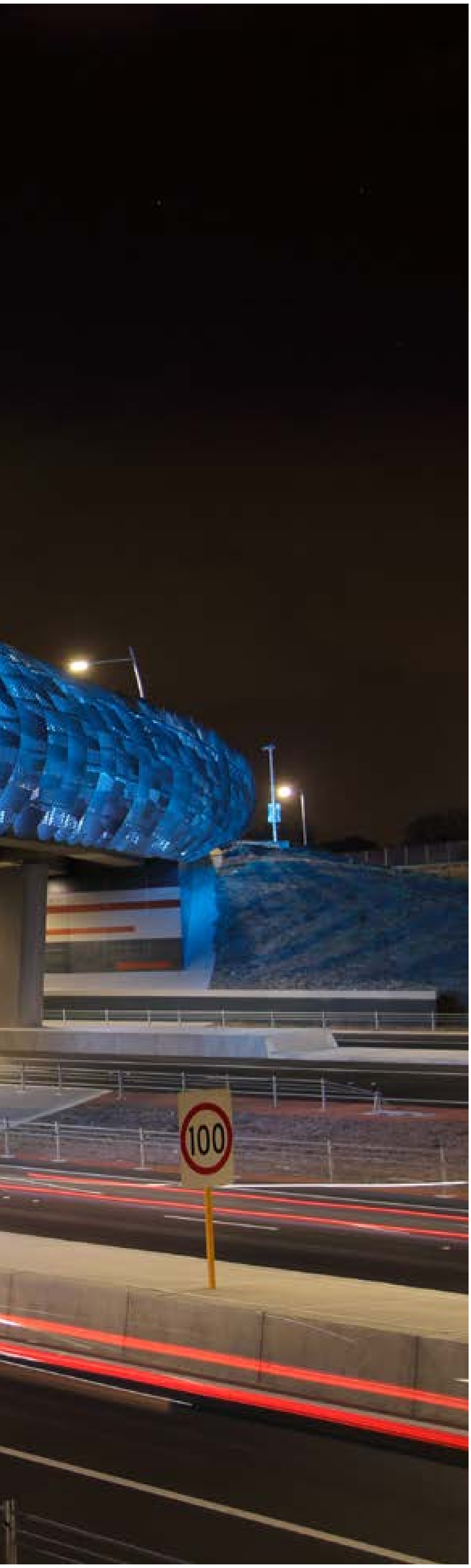


18 Ground Transport

This section describes the impacts on the ground transport network from the construction and operation of the New Runway Project (NRP).

Detail is also provided on the following areas:

- What is the impact on the internal and external road network during construction of the new runway?
- How can the impacts of construction on the road network be mitigated?
- What are the changes to the road network required to accommodate the operation of the new runway?
- Will the operation of the runway impact the external road network?

18.1 Introduction

This section describes the impacts of changes to the ground transport network resulting from the construction and operation of the NRP.

Section 91 (ga) of the *Airports Act 1996* (Airports Act) requires that a Major Development Plan (MDP) address the likely effect that a proposed development will have on traffic flows.

The NRP will have impacts on the ground transport network, including:

- permanent closure of Grogan Road and therefore a change of access in Airport Central for local traffic to the east of the estate as shown in Figure 18-1,
- temporary traffic volume increase on surrounding major roads due to construction traffic, and
- the construction of the runway would permit an increase to the peak period traffic at the airport due to the increased hourly runway capacity.

A study was undertaken to examine the existing road network, identify potential impacts of the NRP and propose suitable mitigation.

Additional information on construction of the new runway and associated infrastructure can be found in Section 6.

18.2 Key Findings

Key findings from investigations into ground transport include:

- The vehicle traffic associated with flights will increase during the peak periods as more flights are able to be accommodated by the NRP, as well as through the future growth of flights to meet the travel demand. The impact of the growth in vehicle traffic attributed to the NRP in comparison to the natural increase in traffic volumes is found to be minimal.
- The NRP will require the closure of Grogan Road, resulting in a change of access in Airport Central for local traffic to the east of the estate. Up to 64 per cent of the traffic using Grogan Road during peak periods is non-airport traffic using the road as a short cut to reduce travel distance and avoid congestion on the major road network. By 2045 there will be a moderate adverse impact on the traffic volumes on Abernethy Road caused by the closure of Grogan Road, however, this is primarily caused by the non-airport traffic. The level of this impact is only in the morning peak period and is mainly caused by the diversion of local traffic not destined for the airport.
- Initial planning considered Grogan Road being replaced by a tunnel constructed beneath the new runway. Modelling identified that the performance of the road network is similar with or without the tunnel constructed, and the cost benefit for construction of a tunnel to serve the low volume of terminal related traffic that would use it could not be justified.
- The impacts of construction traffic will be temporary and will be managed so that they do not adversely impact the internal or external road networks.
- The importation of fill for bulk earthworks will be the highest impact activity of the NRP construction to the surrounding road network. A conservative program of 16 months for bulk earthworks results in an average of 12 vehicles per hour delivering materials to the site. Construction vehicle access can be provided at six locations off Horrie Miller Drive and Abernethy Road, reducing the impact on the traffic network when compared to that which would occur if a single point of access was used.
- There will be an estimated 100 staff vehicles and 100 general deliveries a day at peak construction stage. As the typical construction hours are expected to be 7.00am to 7.00pm, contractor staff traffic movements will generally occur outside of the road network peak times.
- A traffic management plan will be prepared and agreed prior to construction works commencing.
- Debris removal facilities, such as a wash down facility or rumble strips for vehicles leaving the site, will be implemented to ensure the public road network is kept free from construction materials. All trucks carrying loose material will have their loads covered to ensure dust and debris is contained within the truck.

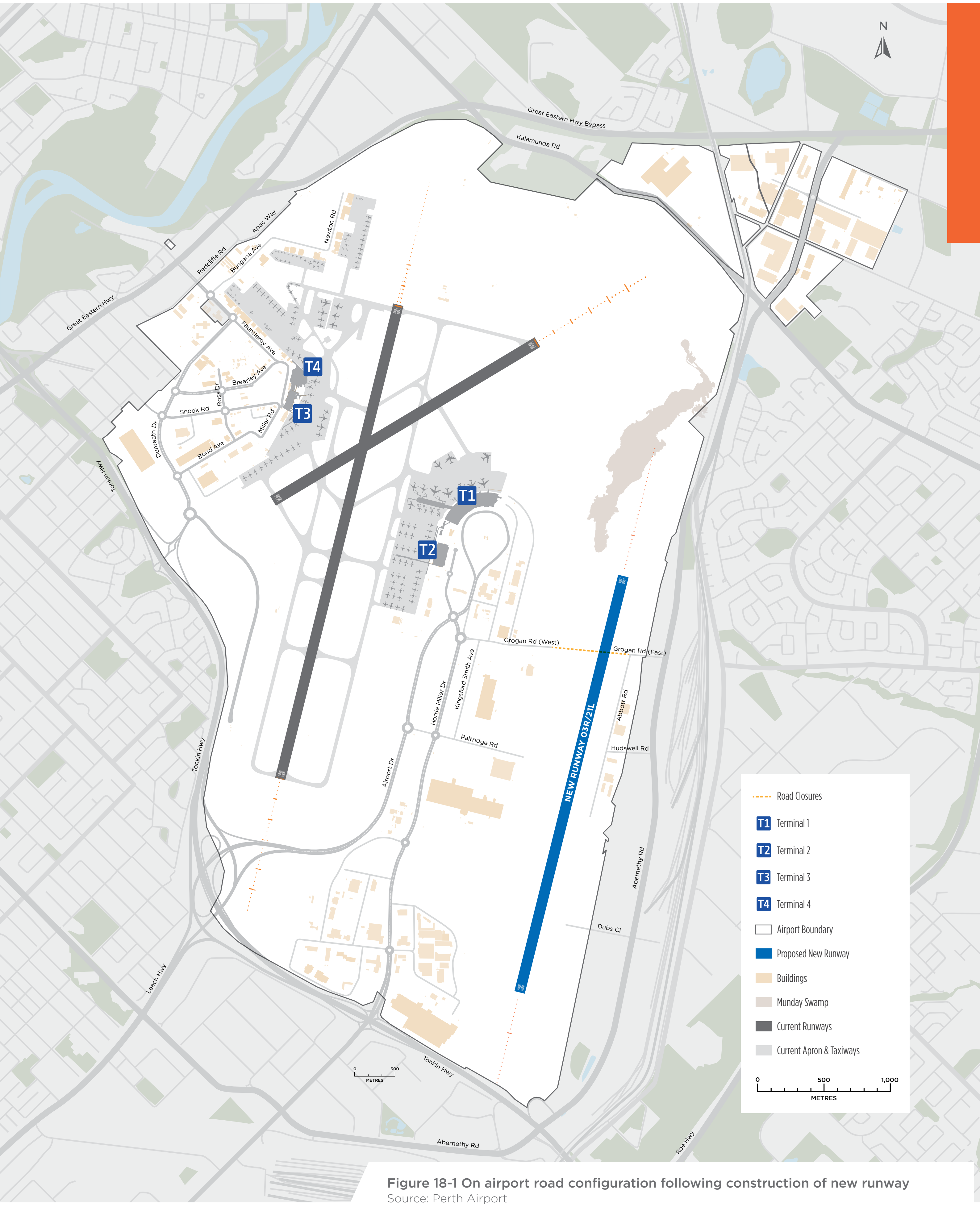


Figure 18-1 On airport road configuration following construction of new runway
Source: Perth Airport

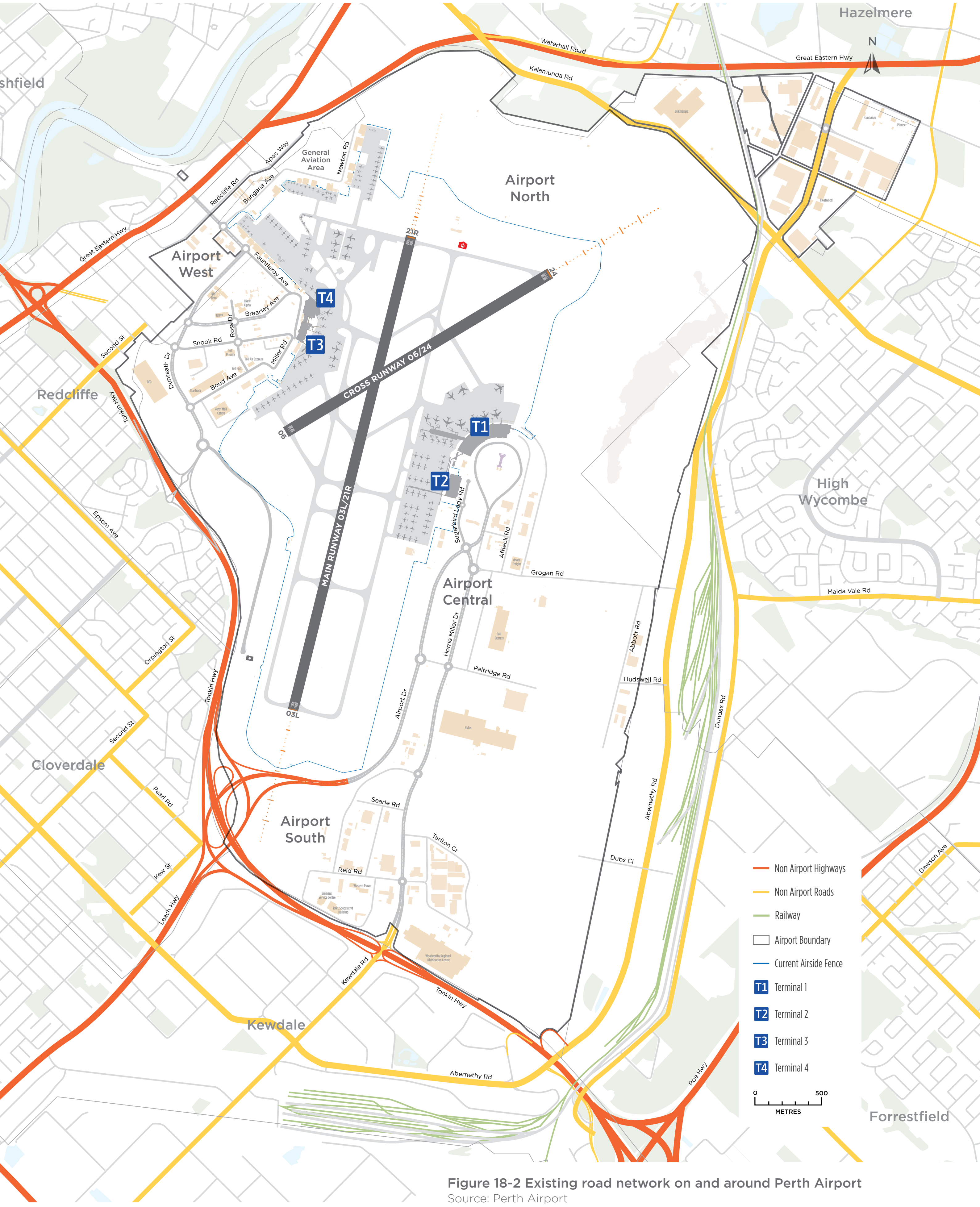


Figure 18-2 Existing road network on and around Perth Airport
Source: Perth Airport

18.3 Existing Condition

18.3.1 Perth Airport Ground Transport Plan

Perth Airport's Ground Transport Plan is articulated in the Master Plan 2014, covering a five-year period and includes the NRP. The development and implementation of the Ground Transport Plan is based on a core principle of seeking to provide multiple options and streamline the efficiency and customer experience for people coming from and going to the airport.

As stated in the Master Plan 2014, "Ground transport planning is a critical component for the efficient operation of Perth Airport. The journey to and from the airport often creates the first and last impression for people visiting Western Australia."

The Ground Transport Plan is based on integrated planning and adopting a collaborative approach with the State and Local governments in ensuring that the road, rail, shared path and public transport network and services are developed and operated to provide a suitable level of service.

The key factors informing the Ground Transport Plan and access to Perth Airport are:

- the modes of transport used and how they will change over time,
- meeting the demands of forecast passenger numbers,
- the consolidation of all commercial air services into Airport Central,
- the anticipated level of commercial development and associated employment on the airport estate,
- the growth in traffic on the roads surrounding Perth Airport that is generated by city activities unrelated to the airport,
- integration of the Forrestfield Airport-Link project into the transport and built form planning,
- the preference to reduce the confluence of passenger vehicle and freight vehicle traffic,
- integration of the airport's ground transport network into the wider local and state wide networks, and
- providing a safe, secure and sustainable solution.

Perth Airport is responsible for the planning, construction and management of internal roads within the airport estate, in conjunction with the following key government stakeholders:

- the State Government Department of Transport, which sets policy and strategic direction for transport throughout Western Australia,
- the State Government Department of Planning, Lands and Heritage which develops planning policies related to land use and the transport network,
- the Public Transport Authority which manages and operates public transport, including passenger rail and bus services, within Perth and the regions,
- Main Roads Western Australia (Main Roads), which is responsible for planning, construction and management of the major State roads to the airport,
- Local governments, which are responsible for the planning, construction and management of local and regional roads adjacent to and connecting to Perth Airport,
- the Commonwealth Minister of Infrastructure and Transport who is responsible for the approval of the Ground Transport Plan as part of the master plan, as well as the approval of any subsequent major developments on the estate.

Perth Airport is surrounded by several major arterial roads that provide transport links within Perth and to the regional areas. As shown in Figure 18-2, Perth Airport is bounded by Great Eastern Highway to the north and Tonkin Highway to the west, with Roe Highway running just outside Perth Airport's eastern boundary. Leach Highway connects to Tonkin Highway and provides access from Perth Airport to Fremantle. Orrong, Abernethy and Kewdale roads provide key arterial links between the highways and surrounding suburbs.

Perth Airport works with State and Local governments to ensure that the changing demands of Perth Airport operations are reflected in their strategic network modelling and planning. Perth Airport also ensures that developments on the estate consider the State and Local infrastructure capacity.

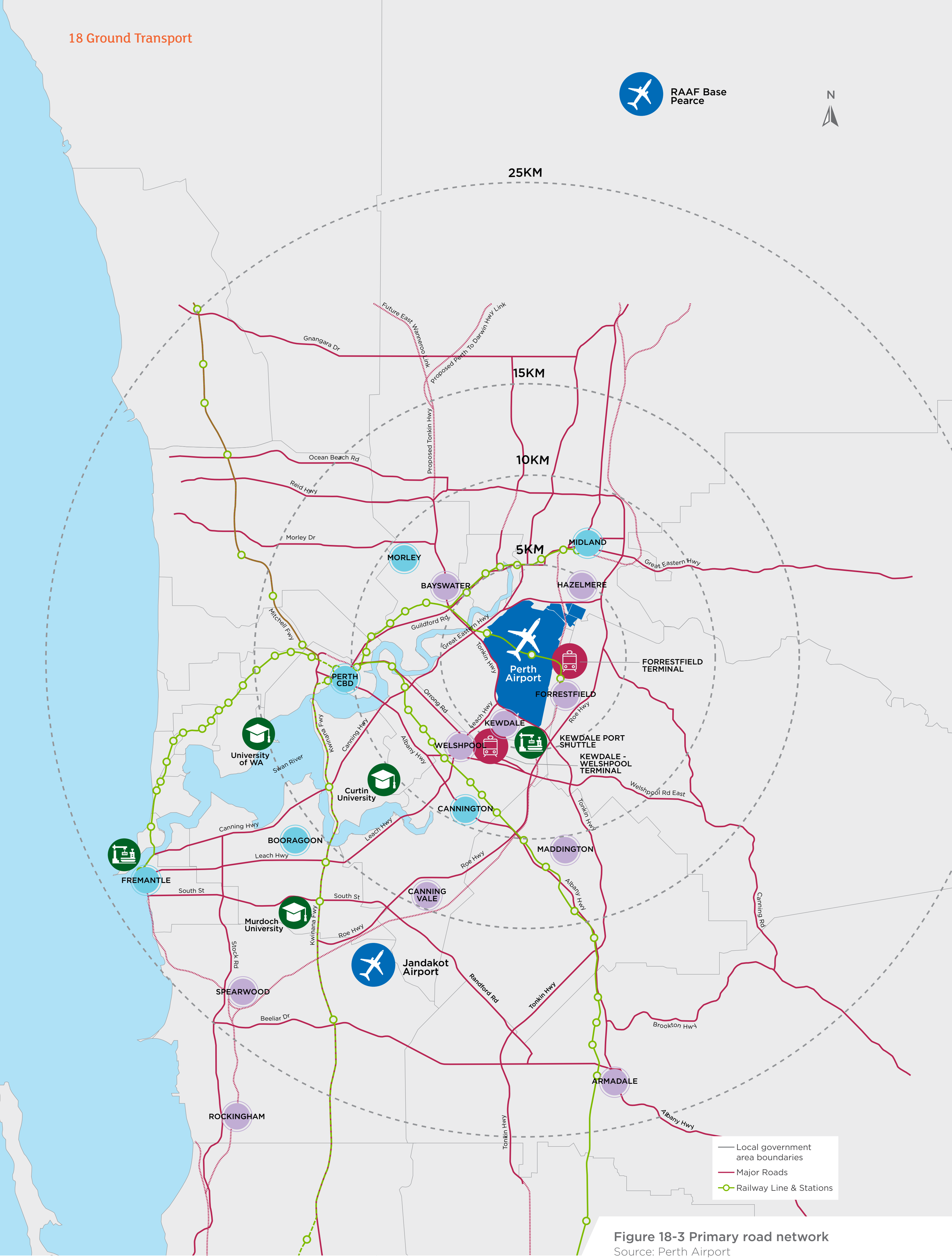


Figure 18-3 Primary road network
Source: Perth Airport

18.3.2 Existing Road Network

The road network in Western Australia is categorised by a hierarchy that represents the role that the road is intended to perform. The hierarchy is determined by a range of criteria, including location, degree of connectivity, predominant road use, indicative traffic volume, and recommended operating speed. The State Government, through Main Roads, is responsible for 'Primary Distributor' roads and local governments manage all other roads.

The road hierarchy relevant to Perth Airport is:

- Primary Distributor: Tonkin Highway, Great Eastern Highway, Great Eastern Highway Bypass and Roe Highway, roads that provide for major traffic movement and carry large volumes of generally fast moving traffic,
- Distributor A: urban area roads in built up areas that carry traffic between industrial, commercial and residential areas and generally connect to Primary Distributor roads,
- Distributor B: similar to Distributor A roads, but with reduced capacity due to flow restrictions (often older roads with a traffic demand in excess of that originally intended),
- Local Distributor: roads that link Distributor roads (A and B) to access roads, and
- Access Roads: provide access to properties with amenity, safety and aesthetic aspects having priority over the vehicle movement function.

Figure 18-3 shows the Primary Distributor road network surrounding the Airport.

Perth Airport is well served by the metropolitan primary main-road network, connecting the airport with the Perth CBD and the major metropolitan areas. The primary roads surrounding the airport, (being Tonkin Highway, Great Eastern Highway and Roe Highway) are managed by Main Roads. Lower-order roads (Distributor A, Distributor B, Local Distributor and Access roads) feeding into the primary road network are managed by the three local-government authorities (Cities of Belmont, Swan and Kalamunda) that border the estate, as shown in Figure 18-4.

The main access to the passenger terminals within Airport Central – Terminal 1 (T1) and Terminal 2 (T2), is through the fully-grade separated Tonkin Highway, Leach Highway and Airport Drive intersection, as shown in Figure 18-5. Airport Drive is the designated primary access to Airport Central and all road signs direct traffic for T1 and T2 onto this route. It has been designed and land safeguarded to allow it to be upgraded to provide a three-lane dual carriageway access to the airport terminals.

The secondary access point into Airport Central is the Tonkin Highway, Horrie Miller Drive and Kewdale Road intersection. This intersection was upgraded as part of the Gateway WA works to a grade separated 'single point' intersection, controlled by a single set of traffic signals providing access to Airport South and Kewdale Industrial areas, as shown in Figure 18-6. Traffic for T1 and T2 is not directed along this route as it is intended primarily for commercial vehicle access.

Traffic between the Perth CBD and the airport is directed onto the Great Eastern and Tonkin highways; while traffic from the east on the primary road network is directed to use the Roe, Reid and Tonkin highways as shown in Figure 18-7.

Grogan Road is primarily used by local traffic either accessing T1 and T2, businesses on the estate, or as a through route to access the primary road network south and west of the estate. Grogan Road historically connected to the local road network before Abernethy Road was constructed; the road was closed in 1987 following the construction of T1, preventing its use for through traffic until it was reopened in 2005.

The primary road network within and surrounding the estate also forms part of the Metropolitan Freight network for over-size Restricted Access Vehicles (RAV) as shown in Figure 18-8. There are RAV 4 (27.5 metre B-Double, comprising a towing vehicle and two semi-trailers) and RAV 6 (36.5 metre Double Road Train 87.5 tonnes) routes on the estate and RAV 7 (36.5 metre Double Road Train 107.5 tonnes) on Horrie Miller Drive, Tonkin Highway and Abernethy Road providing heavy vehicle access to the estate.

There is a turning restriction at the intersection of Abernethy Road and Grogan Road for all RAV vehicles, with right turns not being permitted either from Abernethy Road into Grogan Road or from Grogan Road into Abernethy Road.

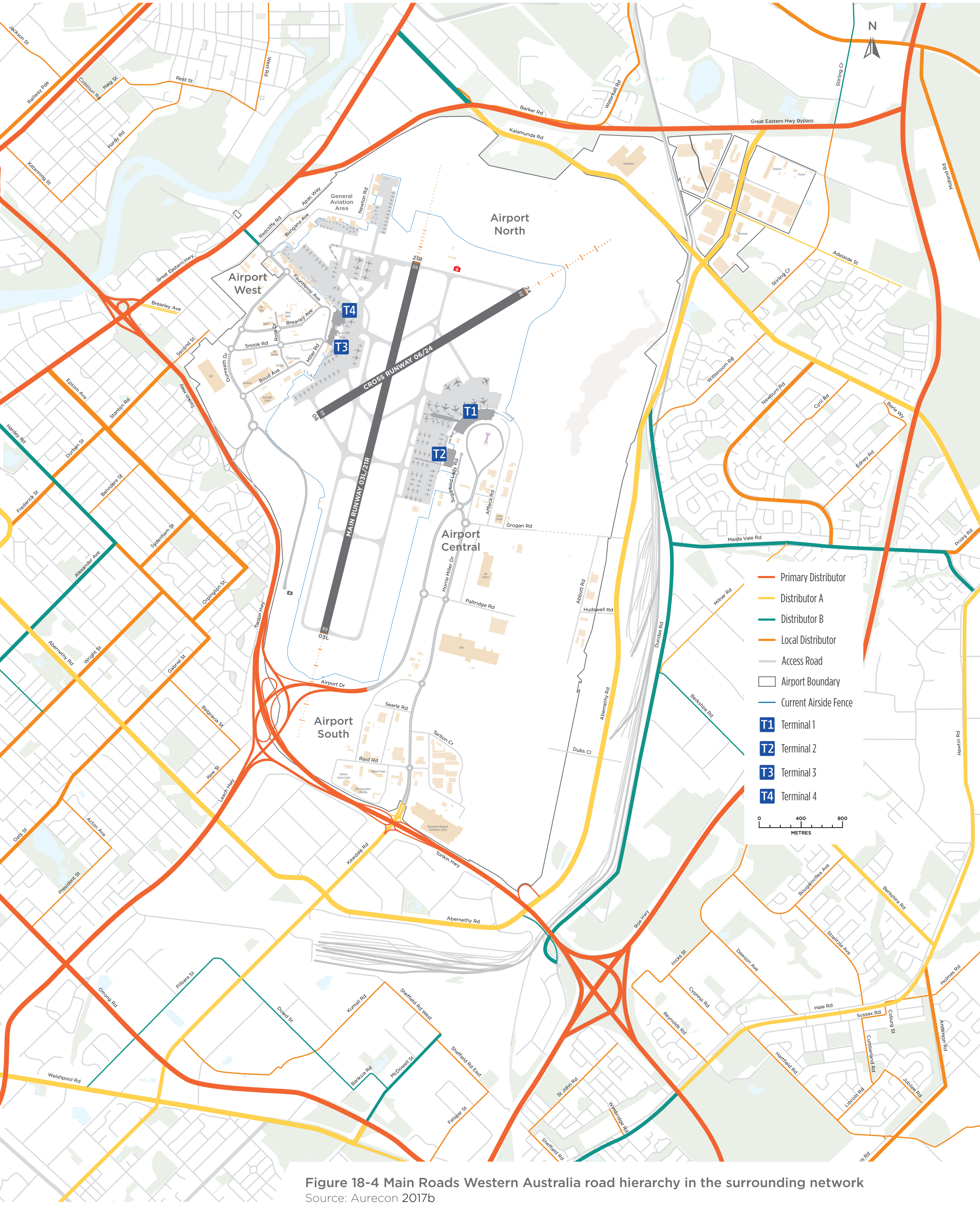


Figure 18-4 Main Roads Western Australia road hierarchy in the surrounding network
Source: Aurecon 2017b

Figure 18-5 Tonkin Highway, Airport Drive and Leach Highway intersection
Source: Gateway WA

Figure 18-6 Tonkin Highway, Horrie Miller Drive and Kewdale Road intersection
Source: Gateway WA

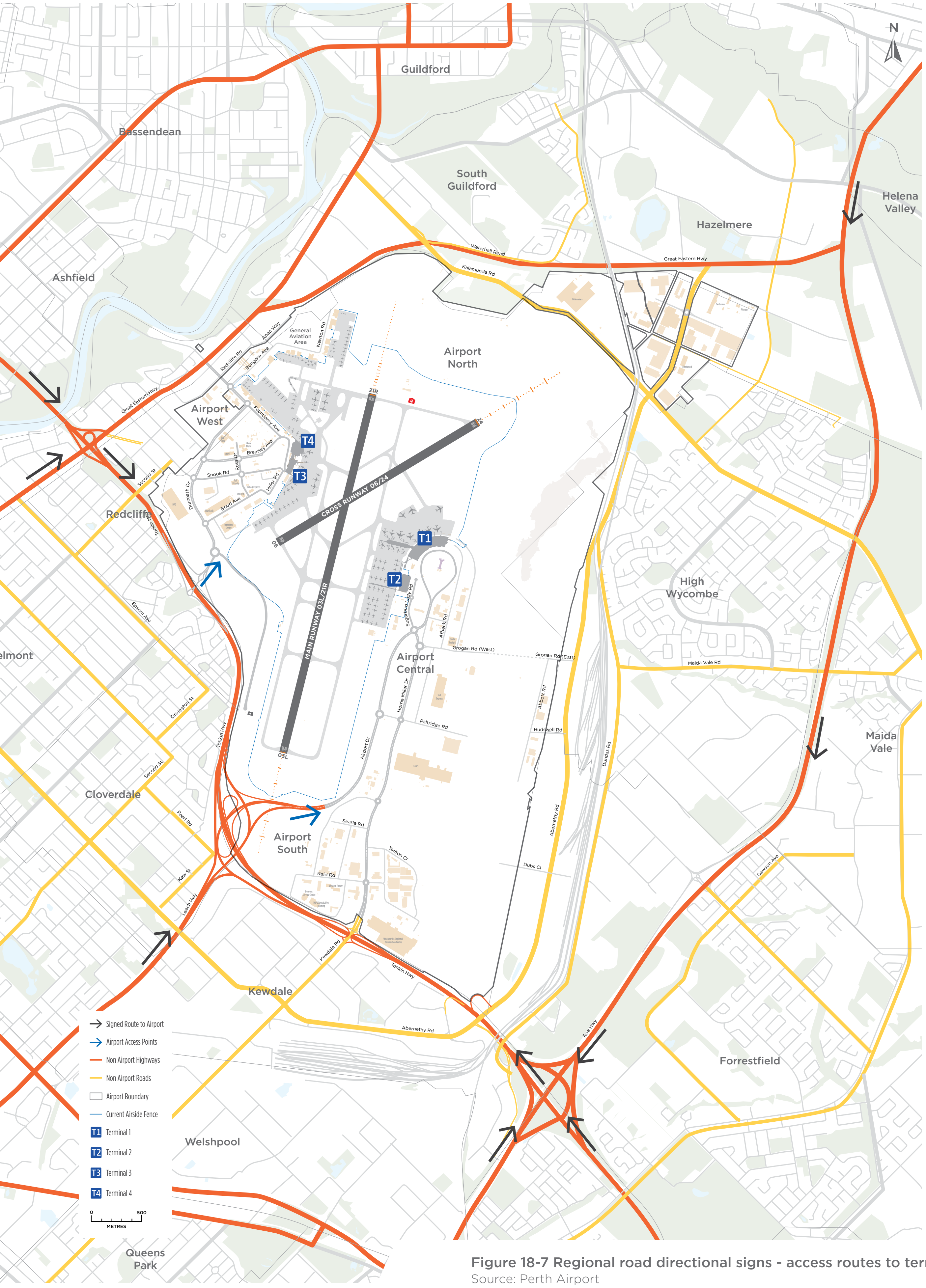


Figure 18-7 Regional road directional signs - access routes to terminals
Source: Perth Airport

Figure 18-8 Restricted-access vehicles network on the road network surrounding the New Runway Project
Source: Aurecon 2017b / Main Roads Western Australia

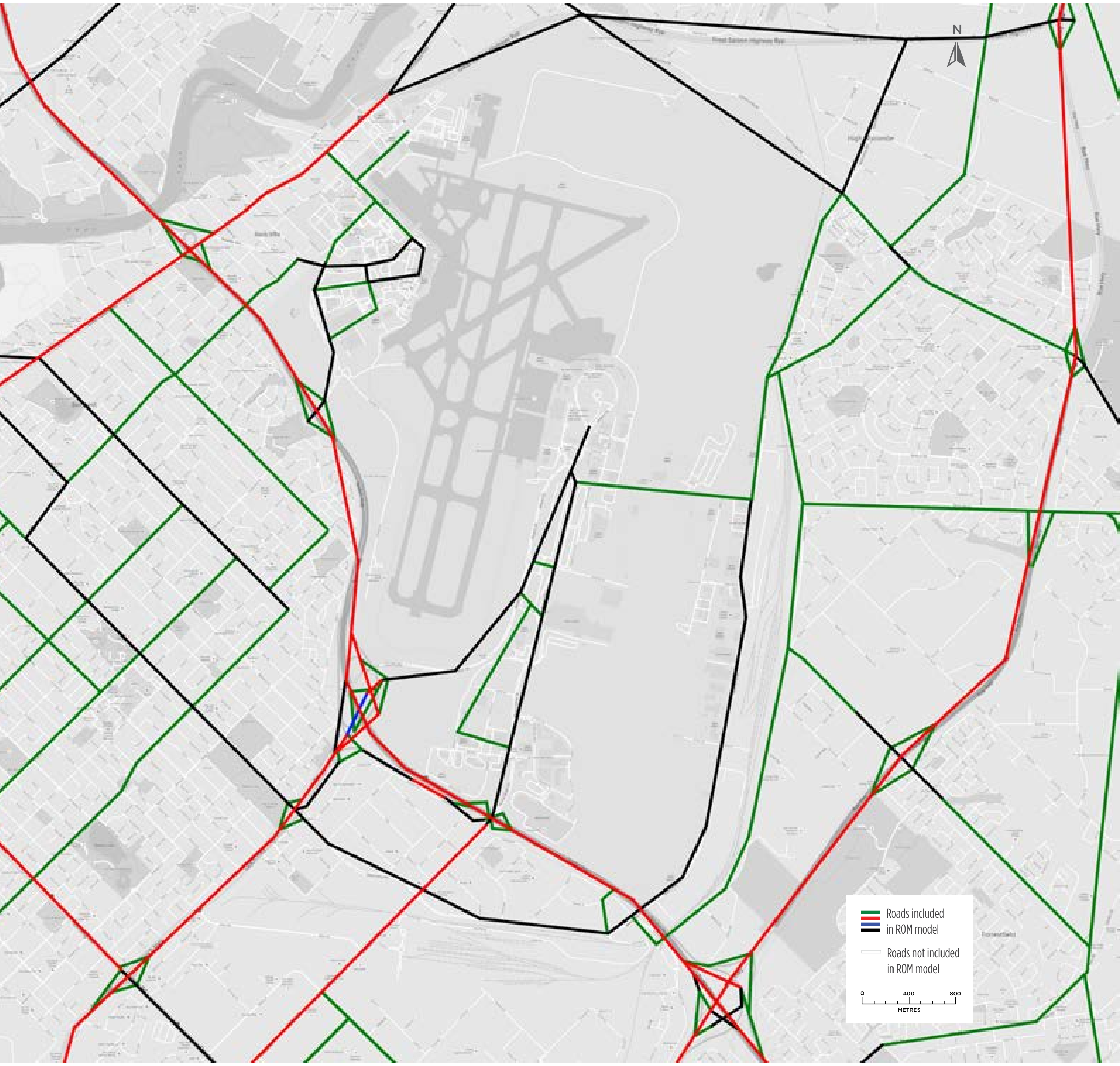


Figure 18-9 Extract from Main Roads regional operations model
Source: Main Roads Western Australia

18.4 Methodology

18.4.1 Development of Traffic Model

To determine the impacts of the NRP, a traffic model was built using the AIMSUN traffic modelling software and considered both day of opening (2025) and 20 years from the day of opening (2045). The following impacts were considered:

- closure of Grogan Road on the road network surrounding the airport, and
- traffic flow with and without the NRP.

The entire Perth metropolitan primary road network has been modelled by Main Roads, and is referred to as the Regional Operations Model (ROM). This model is used to forecast traffic volumes on the Main Roads network, with current models forecasting traffic up to 2031. A model to 2051 is currently under development. The ROM model uses forecast traffic volumes and includes allowances for known road improvements, land development and also changes to flows of traffic. This includes changes such as those that would result from the consolidation of all commercial air services to Airport Central, when Qantas relocates by the end of 2025 (subject to commercial agreement being reached).

To determine the impacts of the NRP, the traffic volumes generated by the 2031 ROM model have been extrapolated using Main Roads traffic network growth figures to determine traffic volumes up to 2045.

The ROM model covers the entire Perth metropolitan area; is at a large scale; contains only the major roads shown in dark blue, red and green in Figure 18-9, and utilises trip generation from land uses for large parcels of land. Therefore, to determine the impact of the NRP on the local road network surrounding the airport, a more detailed model was required.

For local roads, a traffic model of the existing local road network and land uses was developed, using the AIMSUN traffic-modelling software programme. This was calibrated against the ROM model and then the results from the model validated against measured traffic count, traffic signal and journey-time data to reflect the current performance of the local road network.

There are currently no appropriate model-validation guidelines for Western Australia. Therefore, to calibrate and validate the AIMSUN model, the New Zealand Transport Agency Model Development Guidelines (NZTA) were used.

The NRP model is referred to as the AIMSUN model followed by the relevant assessment year.

Table 18-1 shows the validation results for the morning peak and Table 18-2 summarises the overall modelling results. These results show that the AIMSUN model achieved very good correlation throughout the day with the actual measured data, indicating an acceptable level of accuracy.

	Criteria	Modelled R^2 Value
R^2 value for modelled versus observed volumes for all individual links	>0.95	0.99
Line of best fit	Y=0.9x-1.1x	0.99x

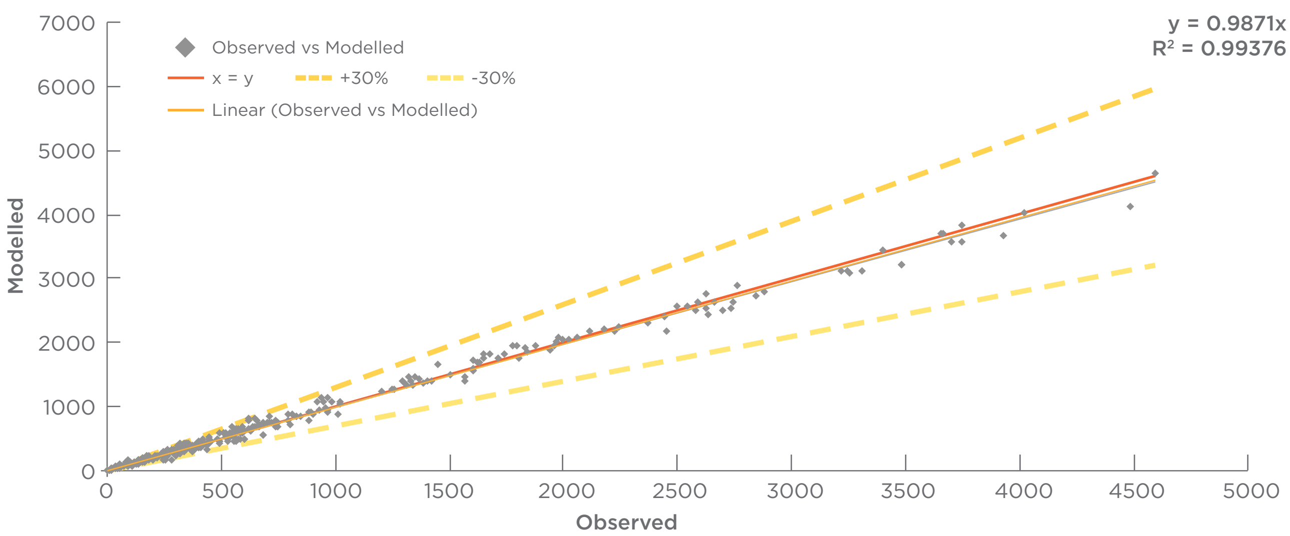


Table 18-1 AM peak hour period link count calibration results XY scatter plots
Source: Aurecon 2017b

As a further check, the NZTA Model Development Guidelines also require that the travel times for general traffic passing through the model be compared with actual performance. The criteria states that the modelled travel times should be within one minute of the observed time if less than six-minutes travel and otherwise within 15 per cent. Table 18-3 shows that the modelled travel times all lie well within the criteria.

The AIMSUN traffic network model, developed from the Main Roads ROM model, is shown in Figure 18-10.

The 2031 Main Roads ROM model allows for planned changes in land use and predicted road network improvements. The following known upgrades and changes to the current traffic network are included in the Main Roads ROM model and have been included in AIMSUN 2025 model.

External upgrades:

- three lanes bi-directional on Roe Highway between Tonkin Highway and Welshpool Road,
- three lanes bi-directional on Great Eastern Highway between Tonkin Highway and Great Eastern Highway Bypass,
- upgraded Roe Highway and Kalamunda Road Interchange,
- Redcliffe and Forrestfield rail stations for the Forrestfield-Airport Link,
- two lanes bi-directional on Kalamunda Road between Great Eastern Highway Bypass and Abernethy Road,
- removal of the Brearley Avenue link to Great Eastern Highway (closed for the new Redcliffe rail station), and
- upgrade of Fauntleroy Avenue / Great Eastern Highway intersection

Airport upgrades:

- grade separation at the Airport Drive and Sugarbird Lady Road roundabout.

Additionally, the traffic generated by re-development of the area around the new Redcliffe Station as identified in the City of Belmont's DA6 Vision Plan and the development of the area around the new Forrestfield Station, as identified in the City of Kalamunda's draft Forrestfield North structure plan has been included in the AIMSUN 2025 and 2045 models.

To ensure that the regional road network functions with an acceptable level of service after 2031, additional road upgrades will be required. While these upgrades are planned, they are not all currently in the Main Roads forward works programme. To achieve a level of service considered to be acceptable when comparing with the current standards, the AIMSUN 2045 model has also included the following additional road upgrades.

External upgrades:

- upgraded Roe and Tonkin Highway interchange,
- upgraded Roe Highway and Great Eastern Highway Bypass interchange,
- upgraded Great Eastern Highway and Kalamunda Road Interchange,
- upgraded Abernethy Road between Kalamunda Road and Great Eastern Highway Bypass,
- upgraded Roe Highway between Tonkin Highway and Great Eastern Highway Bypass,
- grade separation along Great Eastern Highway between Great Eastern Highway Bypass and Tonkin Highway off-ramp,

Period	Modelled Peak Hour Link Count Calibration		Modelled Peak Hour Turn Count Calibration	
	R2 (>0.95)	Best Fit (0.9x to 1.1x)	R2 (>0.95)	Best Fit (0.9x to 1.1x)
AM Peak	0.99	0.99x	0.99	0.99x
PM Peak	0.99	0.99x	0.99	0.99x
Airport Peak	0.99	0.99x	0.99	0.98x

Table 18-2 Summary model validation results
Source: Aurecon 2017b

Period	Direction	Survey Travel Time	Modelled Travel Time	Difference
AM Peak	Northbound	0:04:51	0:05:16	0:00:25
	Southbound	0:04:49	0:05:04	0:00:15
PM Peak	Northbound	0:04:52	0:05:14	0:00:22
	Southbound	0:04:54	0:05:05	0:00:11
Airport Peak	Northbound	0:04:52	0:05:12	0:00:20
	Southbound	0:04:54	0:05:01	0:00:07

Table 18-3 Travel time validation results
(NZTA Criteria: within one minute)
Source: Aurecon 2017b

- grade separation along Great Eastern Highway Bypass between Kalamunda Road and Roe Highway,
- upgraded Tonkin Highway,
- additional lane for Tonkin Highway northbound between Dunreath Drive on-ramp and Great Eastern Highway off-ramp, and
- upgraded intersection of Tonkin Highway and Horrie Miller Drive.

Perth Airport will continue to work with Main Roads and the Cities of Belmont, Swan and Kalamunda to ensure that roads are upgraded in a timely manner.

Airport upgrades:

- an additional lane at the northern approach of Sugarbird Lady Road to the Horrie Miller Drive and Airport Drive roundabout,
- grade separation at the Airport Drive and Paltridge Road intersection,
- additional lane on the western and southern approach and the eastern exit of the Airport Drive and Sugarbird Lady Road roundabout,
- additional short lane on the Grogan Road approach at the Horrie Miller Drive and Grogan Road roundabout,
- additional short lane on the southern approach to Horrie Miller Drive and Paltridge Road intersection,
- change of the Fauntleroy Avenue, Kleinig Road and Bungana Avenue roundabout to an un-signalised intersection, and
- property developments within the Airport Precinct zones in accordance with the Airport Master Plan.

The 2025 and 2045 AIMSUN models include future traffic-generation figures for the airport, which have been calculated based on the predicted passenger growth forecasts and using the travel-mode shares detailed in Figure 18-11.

Figure 18-10 AIMSUN traffic model boundary
Source: Aurecon 2017b

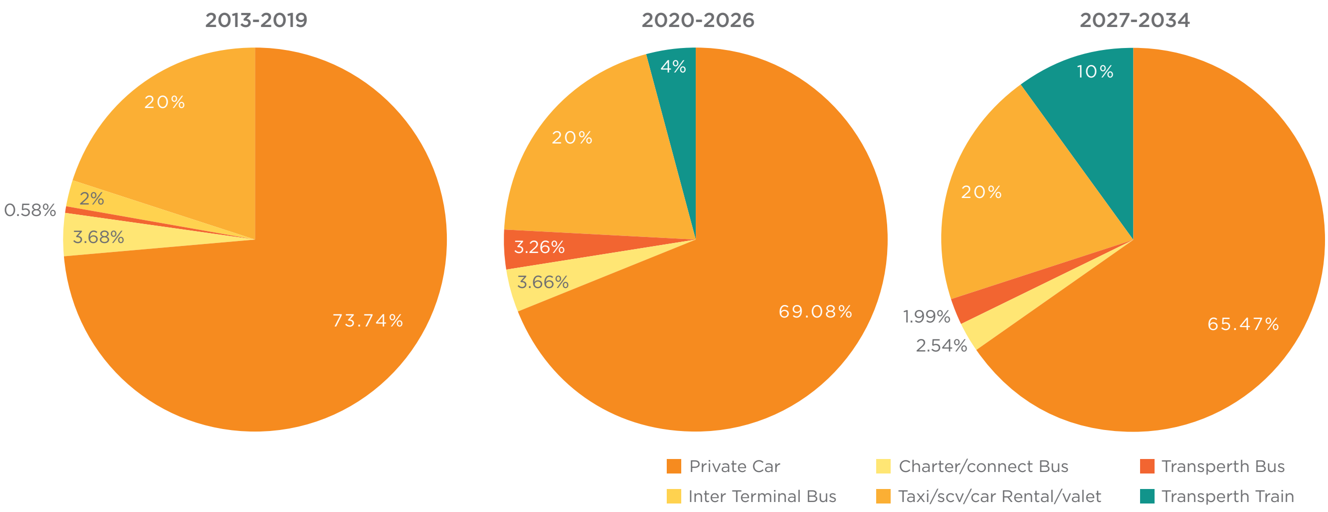


Figure 18-11 Projected passenger travel modes
Source: Perth Airport Master Plan 2014

	2016 Base	2025 (without new runway)	2045 (without new runway)
Vehicle hours travelled	**3,307**	5,768	10,019
Vehicle kilometres travelled	**201,481**	283,859	392,947
Total number of vehicles	**30,044**	46,379	59,800
Mean speed kilometres per hour	**60.9**	49.2	39.2

Table 18-4 Existing road network, morning peak-period modelled network statistics
Source: Aurecon 2017b

	2016 Base	2025 (without new runway)	2045 (without new runway)
Vehicle hours travelled	**3,571**	7,564	11,469
Vehicle kilometres travelled	**217,405**	311,526	449,757
Total number of vehicles	**32,527**	49,251	66,458
Mean speed kilometres per hour	**60.9**	41.2	39.2

Table 18-5 Existing road network, afternoon peak period modelled network statistics
Source: Aurecon 2017b

	2016 Base	2025 (without new runway)	2045 (without new runway)
Vehicle hours travelled	**2,789**	4,697	7,047
Vehicle kilometres travelled	**175,609**	264,930	372,052
Total number of vehicles	**26,313**	42,080	56,876
Mean speed kilometres per hour	**63.0**	56.4	52.8

Table 18-6 Existing road network, airport peak period modelled network statistics
Source: Aurecon 2017b

Land development on the estate has also been included in the AIMSUN models, assuming full build out by 2045 of the precincts identified in the Master Plan 2014. The changing land uses on the estate resulting from the relocation of the businesses impacted by the construction of the new runway, the New Domestic Terminal and associated aprons and taxiways to accommodate the consolidation of the Qantas Group have also been factored into the traffic-generation figures for the 2025 and 2045 models. These will primarily be the freight and logistics companies that are some of the main users of Grogan Road.

18.5 Impact Assessment

18.5.1 External Roads

To determine the impacts of the NRP on the road network, an assessment of "without" and "with" the NRP was undertaken. The difference between these two scenarios therefore demonstrates the impacts of building the NRP.

The peak-vehicle traffic-generation for the airport occurs mid-afternoon (2.00 pm to 3.00 pm), outside the busiest times for the metropolitan road network, which experiences the traditional morning (7.15 am to 8.15 am) and afternoon (4.30 pm to 5.30 pm) peak commuter traffic flows. To ensure that all peaks were reflected in the traffic modelling, the road network performance was analysed for the morning and afternoon network peaks and the mid-afternoon airport traffic peak.

Peaks are identified in the section as:

- AM Peak – 7:15 am to 8:15 am
- PM Peak – 4:30 pm to 5:30pm
- Airport Peak – 2:00 pm to 3:00 pm

18.5.1.1 Modelled Network Performance without NRP

Following the calibration and validation of the AIMSUN model, the existing road network with the upgrades detailed in Section 18.4.1 was modelled for 2025 (date of opening of the new runway) and for 2045 (after 20 years of operation).

The outputs from the modelling show that if the existing external road network around the estate is upgraded in line with the improvements, then the network will perform as shown in the tables of the AIMSUN outputs in Table 18-4 to Table 18-6.

Level of Service	Description	Delay (seconds)	
		Signalised	Un-signalised
A	Free flow of traffic at or above posted speed.	Less than 10	Less than 10
B	Reasonably free flow, speed maintained.	10 to 20	10 to 20
C	Stable flow, road close to capacity.	20 to 35	20 to 35
D	Approaching unstable flow, slight speed decrease, road at practical capacity.	35 to 55	35 to 50
E	Unstable flow, road at capacity, speed varies, congestion occurs.	55 to 80	50 to 70
F	Breakdown flow, travel time cannot be predicted.	Greater than 80	Greater than 70

Table 18-7 Level of service criteria
Source: TRB(US) Highway Capacity Manual

Intersection	Level of Service								
	2016			2025			2045		
	AM Peak	Airport Peak	PM Peak	AM Peak	Airport Peak	PM Peak	AM Peak	Airport Peak	PM Peak
Airport Drive and Tonkin Highway	A	A	A	A	A	A	A	A	B
Horrie Miller Drive and Tonkin Highway	C	C	C	B	C	B	C	C	C
Roe Highway and Tonkin Highway (North)	A	A	A	A	A	B	A	A	A
Roe Highway and Tonkin Highway (South)	C	C	C	C	C	C	A	A	A
Abernethy Road and Kewdale Road	D	C	D	C	D	D	D	D	D

Table 18-8 Existing road network modelled intersection level of service
Source: Aurecon 2017b

Where:

- vehicle hours travelled (VHT) is the total travel for all vehicles and is a primary indicator of delay or improved network conditions,
- vehicle kilometres travelled (VKT) is the total distance travelled and indicates if network changes are changing route choice,
- total vehicles is a check to see how many vehicles are being loaded in to and processed by the model, and
- average (mean) speed is another useful indicator of the overall performance and delay of all model areas.

The 2016 model results are presented to demonstrate the performance of the existing road network to allow comparison with current conditions.

Table 18-4 to Table 18-6 shows that during the airport peak periods and with planned and proposed upgrades (i.e. the optimum road network) vehicles are slowing from a mean 63.0 kilometres per hour to 52.8 kilometres per hour, showing some congestion on the road network. Also, if any of the modelled upgrades are not constructed before 2045, then congestion would increase. This would show up in the model results, with less traffic able to pass through the network, and result in reduced vehicle numbers and speeds at peak times.

Overall analysis of the modelled AIMSUN outputs indicates that the reducing mean speed over time shows congestion is increasing, as the vehicles are moving slower and taking longer to travel through the model. This is most evident in the morning and afternoon peak periods where vehicles are slowing from a mean 60.9 kilometres per hour to 39.2 kilometres per hour.

Therefore, to identify the degree of congestion and whether vehicles are slowing because the entire network is at capacity, or if it is specific sections or intersections are causing delays, a detailed assessment of each intersection was carried out.

The AIMSUN traffic model also predicts the delays experienced at each of the intersections and thereby attributes a level of service to indicate the comparative performance, based on the level of service criteria detailed in Table 18-7.

Generally, roads at the airport operate at a range of level of service A to D. For planning purposes, Perth Airport would consider that additional road upgrades are undertaken when level of service reaches a level of service D. Level of service D would see a delay to vehicles of between 35 and 55 seconds at a signalised intersection or a delay of between 35 to 50 seconds at an un-signalised intersection.

Analysis of the individual road intersections in the AIMSUN model shows that most of the intersections are operating at level of service A to C with just the Abernethy Road and Kewdale Road intersection operating at level of service D. This is relatively consistent across the three peak periods and up until 2045. The results are shown in Table 18-8.

This analysis shows that the reduced overall performance, as shown in Table 18-4 to Table 18-6 is as a result of increased traffic across the entire network.

As part of the Gateway WA development agreement between Perth Airport and the State Government, a mechanism relating to the level of congestion was agreed for upgrading Airport Drive and Tonkin Highway as the main access route to Airport Central. This will be activated as congestion and delays impact traffic flows to the terminals.

Perth Airport will continue to work with the State and Local governments regarding the external road network to ensure that upgrades and developments are undertaken at the appropriate time to manage congestion. However as can be seen from the data, congestion is most evident outside the airport peak periods and aligns with commuter traffic patterns.

18.5.1.2 Modelled Network Performance with the NRP

Early planning for the new runway identified the need to maintain an eastern access to Airport Central. This was via a tunnel under the new runway aligned with Grogan Road.

During concept design of the NRP, the alignment of the tunnel moved further south, to achieve the necessary clearances and approach and exit gradients, making the route less attractive to the traffic accessing the terminals, being over 3.1 kilometres longer than the current route along Grogan Road. The associated infrastructure and management requirements for the tunnel also increased significantly.

An assessment of the need for the eastern access and therefore the requirement for a tunnel at a cost of over $240 million was undertaken.

To assess the impact of constructing the runway and the closure of Grogan Road, two scenarios were tested:

1. closure of Grogan Road as a through route, with displaced traffic using Tonkin Highway to access the estate, or using Kalamunda Road or Tonkin Highway to travel past the airport as shown in Figure 18-12
2. closure of Grogan Road and a new tunnel connection between Horrie Miller Drive and Abbott Road constructed as shown in Figure 18-13.

Observations and results of the 2016 traffic flow model show that not all traffic using Grogan Road is accessing the terminals. A significant number of vehicles are using it to either access destinations elsewhere within the estate (for example businesses off Horrie Miller Drive), or as through traffic to access other off-estate destinations. The direction and percentage of external traffic using Grogan Road changes during the day, reflecting the changing priorities of commuters, as detailed in Table 18-9. It is anticipated that non-airport traffic using airport roads would further increase as the external network becomes congested, as traffic will seek alternative routes to avoid delays.

Figure 18-12 Option 1 Layout – removal of Grogan Road connection
Source: Aurecon 2017b

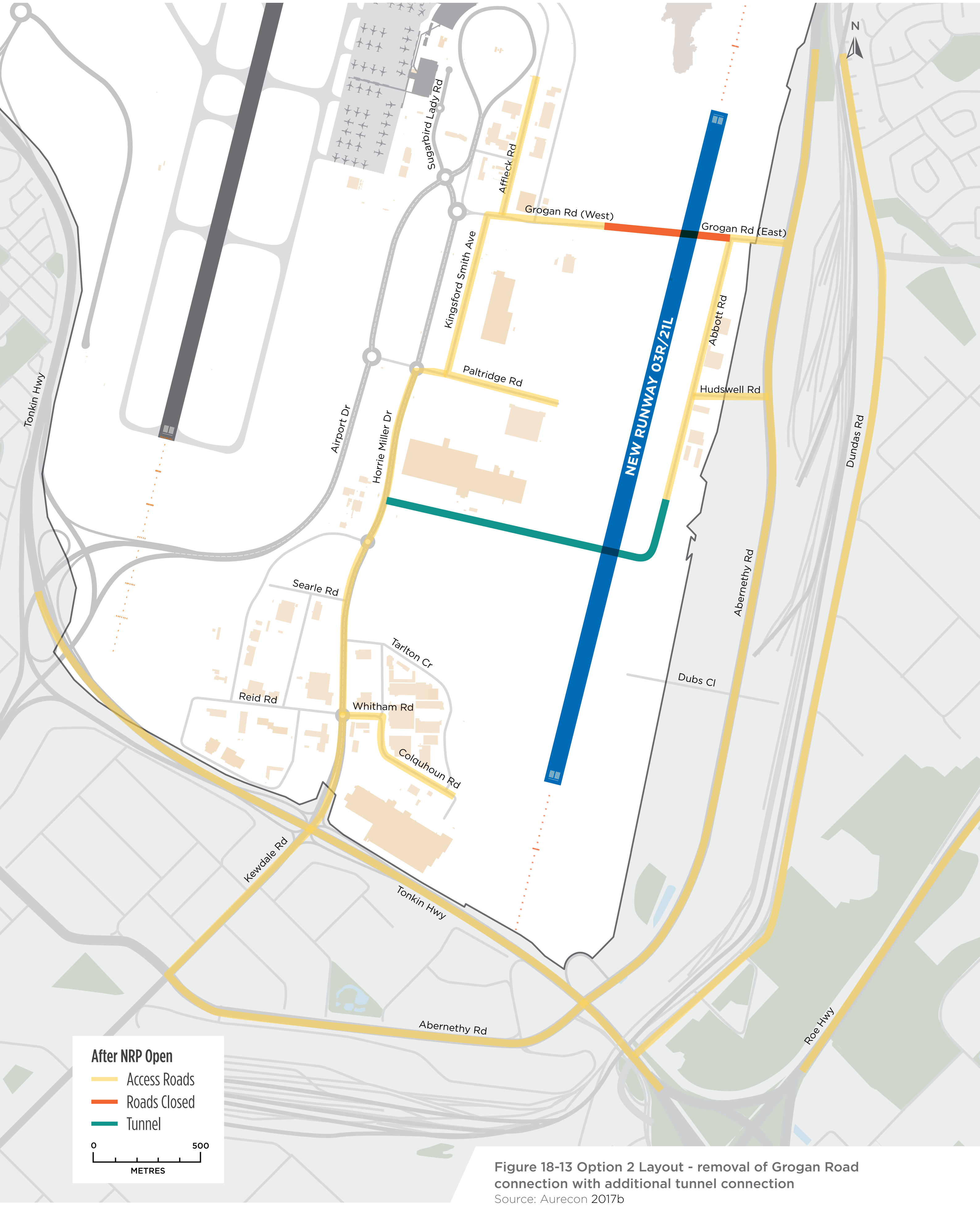


Figure 18-13 Option 2 Layout - removal of Grogan Road connection with additional tunnel connection

Source: Aurecon 2017b

The closure of Grogan Road for the NRP will require the local traffic that would have used the airport road network to use the regional road network to access both the airport terminals and destinations to the south and east of the airport.

The AIMSUN traffic model distributes the traffic that would have been travelling on Grogan Road onto the surrounding road network. The relocation of the businesses in the area to facilitate the construction of the new runway, new terminals and associated aprons and taxiways have also been factored in to the traffic modelling.

2025 Network Performance – Option 1 (Grogan Road Closed)

Option 1 was modelled and compared against the base traffic model, 2025 with no runway, as shown in Table 18-4 to Table 18-6.

The results of the network with option 1 in 2025 (day of opening) show that the impact of the re-routed traffic on the external road network is minimal, as the performance figures and modelled traffic volumes both with and without the runway constructed are similar and lie within acceptable ranges. This is highlighted in the afternoon peak period, where there is just a 0.8 km/h decrease in the mean speed of vehicles, with others showing a small improvement in network performance.

When assessing the capacity of road links, Austroads Guide to Traffic Management (Part 3) indicates that in a typical urban environment a single traffic lane can accommodate a minimum of 900 vehicles per hour and up to 1400 vehicles per hour, while freeways can accommodate in excess of 1800 vehicles per hour. The modelling shows that all roads would operate within these guidelines.

Table 18-10 to Table 18-21 show the overall performance of the road network over the peak periods, followed by the predicted hourly volumes on the major roads.

Time	Westbound	Eastbound
	2016 (Grogan Road) per cent	
AM Peak	44	64
PM Peak	34	41
Airport Peak	11	16

Table 18-9 Percentage of through traffic using Grogan Road
Source: Aurecon 2017b

Morning Peak (2025 Option 1 - Grogan Road closed)

	2025	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	5,768	5,867
Vehicle kilometres travelled (VKT)	283,859	289,487
Total number of vehicles	46,379	46,577
Mean speed (kilometres per hour)	49.2	49.3

Table 18-10 2025 morning peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)			Number of Traffic Lanes
		2016 Base	Without Runway	With Runway	
Horrie Miller Drive (south of Grogan Road)	Northbound	436	604	411	2
	Southbound	532	702	457	2
Airport Drive (south of Sugarbird Lady Road)	Northbound	603	1,239	1,448	2
	Southbound	432	889	835	2
Grogan Road (east of Horrie Miller Drive)	Eastbound	220	367	-	1
	Westbound	637	715	-	1
Horrie Miller Drive (north of Tonkin Highway)	Northbound	681	1,115	1,345	2
	Southbound	329	594	699	2
Airport Drive (north of Tonkin Highway)	Northbound	923	1,606	1,579	2
	Southbound	728	1,128	906	2
Roe Highway	Northbound	2,187	3,054	3,126	3
	Southbound	2,620	3,885	3,961	3
Tonkin Highway	Eastbound	2,182	2,557	2,680	3
	Westbound	4,102	5,053	5,117	3
Abernethy Road	Northbound	574	859	1,047	2
	Southbound	588	791	1,045	2

Table 18-11 2025 morning peak-period modelled link volume
Source: Aurecon 2017b

Afternoon Peak (2025 Option 1 - Grogan Road closed)

	2025	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	7,564	7,862
Vehicle kilometres travelled (VKT)	311,526	317,344
Total number of vehicles	49,251	49,697
Mean speed (kilometres per hour)	41.2	40.4

Table 18-12 2025 afternoon peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)			Number of Traffic Lanes
		2016 Base	Without Runway	With Runway	
Horrie Miller Drive (south of Grogan Road)	Northbound	622	466	689	2
	Southbound	440	675	963	2
Airport Drive (south of Sugarbird Lady Road)	Northbound	961	2,122	2,129	2
	Southbound	586	1,356	1,462	2
Grogan Road (east of Horrie Miller Drive)	Eastbound	640	846	-	1
	Westbound	335	428	-	1
Horrie Miller Drive (north of Tonkin Highway)	Northbound	246	500	672	2
	Southbound	768	1,199	1,614	2
Airport Drive (north of Tonkin Highway)	Northbound	1,364	2,158	2,139	2
	Southbound	988	1,809	1,920	2
Roe Highway	Northbound	2,918	3,694	3,751	3
	Southbound	2,037	3,333	3,519	3
Tonkin Highway	Eastbound	3,852	4,746	5,506	3
	Westbound	2,561	3,255	3,299	3
Abernethy Road	Northbound	501	787	1,047	2
	Southbound	383	618	719	2

Table 18-13 2025 afternoon peak-period modelled link volume
Source: Aurecon 2017b

Airport Peak (2025 Option 1 - Grogan Road closed)

	2025	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	4,697	4,761
Vehicle kilometres travelled (VKT)	264,930	270,508
Total number of vehicles	42,080	42,049
Mean speed (kilometres per hour)	56.4	56.8

Table 18-14 2025 airport peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)			Number of Traffic Lanes
		2016 Base	Without Runway	With Runway	
Horrie Miller Drive (south of Grogan Rd)	Northbound	438	535	634	2
	Southbound	408	669	1,190	2
Airport Drive (south of Sugarbird Lady Rd)	Northbound	724	1,479	1,707	2
	Southbound	756	1,730	1,743	2
Grogan Road (east of Horrie Miller Dr)	Eastbound	448	727	-	1
	Westbound	299	494	-	1
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	472	757	988	2
	Southbound	868	1,614	2,140	2
Airport Drive (north of Tonkin Hwy)	Northbound	910	1,599	1,750	2
	Southbound	966	1,910	1,976	2
Roe Highway	Northbound	1,584	2,620	3,020	3
	Southbound	1,587	2,887	3,016	3
Tonkin Highway	Eastbound	3,213	3,863	4,287	3
	Westbound	2,663	3,581	3,619	3
Abernethy Road	Northbound	564	587	663	2
	Southbound	482	771	810	2

Table 18-15 2025 airport peak-period modelled link volume
Source: Aurecon 2017b

2045 Modelled Network Performance – Option 1 (Grogan Road Closed)

The 2045 modelling results show that while the network is closer to capacity even without the new runway, and has been extensively upgraded to avoid excessive congestion, the re-routed traffic does not significantly impact the performance of the model. Traffic volumes and speeds are similar for each of the three time periods, with hourly volumes within the upgraded road capacities. Table 18-16 to Table 18-21 show the overall performance of the road network over the peak periods, followed by the predicted hourly volumes on the major roads in 2045.

Again, the modelling shows that all roads would operate broadly within the Austroads Guide to Traffic Management (Part 3) guidelines.

Morning Peak (2045 Option 1 - Grogan Road closed)

	2045	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	10,019	10,245
Vehicle kilometres travelled (VKT)	392,947	397,830
Total number of vehicles	59,800	60,163
Mean speed (kilometres per hour)	39.2	38.8

Table 18-16 2045 morning peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)			Number of Traffic Lanes
		2016 Base	Without Runway	With Runway	
Horrie Miller Drive (south of Grogan Rd)	Northbound	436	785	707	2
	Southbound	532	756	543	2
Airport Drive (south of Sugarbird Lady Rd)	Northbound	603	3,039	2,839	3
	Southbound	432	1,965	2,047	3
Grogan Road (east of Horrie Miller Dr)	Eastbound	220	664	-	1
	Westbound	637	816	-	1
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	681	1,496	1,637	2
	Southbound	329	755	872	2
Airport Drive (north of Tonkin Hwy)	Northbound	923	3,304	2,912	3
	Southbound	728	2,331	2,119	3
Roe Highway	Northbound	2,187	5,117	4,534	3
	Southbound	2,620	6,109	5,409	3
Tonkin Highway	Eastbound	2,182	3,526	3,478	4
	Westbound	4,102	6,134	6,016	4
Abernethy Road	Northbound	574	850	667	2
	Southbound	588	937	1,322	2

Table 18-17 2045 morning peak-period modelled link volume
Source: Aurecon 2017b

Afternoon Peak (2045 Option 1 - Grogan Road closed)

	2045	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	11,469	11,946
Vehicle kilometres travelled (VKT)	449,757	442,141
Total number of vehicles	66,458	64,455
Mean speed (kilometres per hour)	39.2	37.0

Table 18-18 2045 afternoon peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)			Number of Traffic Lanes
		2016 Base	Without Runway	With Runway	
Horrie Miller Drive (south of Grogan Rd)	Northbound	622	803	1,470	2
	Southbound	440	585	1,031	2
Airport Drive (south of Sugarbird Lady Rd)	Northbound	961	2,854	2,695	3
	Southbound	586	2,796	2,493	3
Grogan Road (east of Horrie Miller Dr)	Eastbound	640	761	-	1
	Westbound	335	715	-	1
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	246	1,794	2,347	2
	Southbound	768	1,264	1,788	2
Airport Drive (north of Tonkin Hwy)	Northbound	1,364	2,409	2,311	3
	Southbound	988	2,932	2,916	3
Roe Highway	Northbound	2,918	6,187	6,101	3
	Southbound	2,037	4,492	5,007	3
Tonkin Highway	Eastbound	3,852	5,453	5,288	4
	Westbound	2,561	3,983	4,393	4
Abernethy Road	Northbound	501	836	809	2
	Southbound	383	785	760	2

Table 18-19 2045 afternoon peak-period modelled link volume
Source: Aurecon 2017b

Airport Peak (2045 Option 1 - Grogan Road closed)

	2045	
	Without Runway	With Runway
Vehicle hours travelled (VHT)	7,047	7,243
Vehicle kilometres travelled (VKT)	372,015	383,715
Total number of vehicles	56,876	57,267
Mean speed (kilometres per hour)	52.8	53.0

Table 18-20 2045 airport peak-period modelled network statistics
Source: Aurecon 2017b

		Volume (per hour)			
Road Name	Direction	2016 Base	Without Runway	With Runway	Number of Traffic Lanes
Horrie Miller Drive (south of Grogan Road)	Northbound	438	713	1,192	2
	Southbound	408	586	944	2
Airport Dr (south of Sugarbird Lady Road)	Northbound	724	2,455	2,957	3
	Southbound	756	2,500	2,737	3
Grogan Road (east of Horrie Miller Drive)	Eastbound	448	667	-	1
	Westbound	299	768	-	1
Horrie Miller Drive (north of Tonkin Highway)	Northbound	472	1,666	2,075	2
	Southbound	868	1,753	2,060	2
Airport Drive (north of Tonkin Highway)	Northbound	910	2,373	2,632	3
	Southbound	966	2,349	2,792	3
Roe Highway	Northbound	1,584	3,254	3,770	3
	Southbound	1,587	2,786	3,462	3
Tonkin Highway	Eastbound	3,213	4,553	4,999	4
	Westbound	2,663	3,469	4,114	4
Abernethy Road	Northbound	564	754	658	2
	Southbound	482	749	818	2

Table 18-21 2045 airport peak-period modelled link volume
Source: Aurecon 2017b

Horrie Miller Drive / Tonkin Highway		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2016	Existing	B	C	C
2025	Without new runway	B	C	B
	With new runway and Grogan Road closed (Option 1)	C	C	B
2045	Without new runway	C	C	C
	With new runway and Grogan Road closed (Option 1)	C	C	D

Table 18-22 Horrie Miller Drive and Tonkin Highway modelled intersection level of service
Source: Aurecon 2017b

2025 and 2045 Modelled Intersection Performance – Option 1 (Grogan Road Closed)

Although congestion on the external road network has not increased with the closing of Grogan Road, the performance of individual intersections in the network, as shown in Figure 18-23 to Table 18-25, were also considered.

As with the overall network performance, the comparative intersection performance shows minimal impact in 2025 when the new runway opens, with all intersections on the network performing at an acceptable level of service, with only the Roe Highway and Tonkin Highway (southbound) intersection showing some degree of delay in the PM peak. Analysis of the model indicates that this is a consequence of the cumulative effect that development in the area and the construction of the runway has on the road network.

For the AIMSUN 2045 traffic model, it is assumed that due to the expected growth of all traffic on Roe and Tonkin highways (including airport traffic which makes up less than 25 per cent) the State Government would have upgraded the intersection to full freeway to freeway prior to 2045.

This results in the overall network performance being similar for each busy period modelled both with and without the runway constructed. The intersection of Abernethy Road and Kewdale Road starts to experience a minor increase in congestion in the AM and PM peaks, but the modelled results show that the changes to traffic flows caused by the closure of Grogan Road do not have a material effect on the performance of the major road network surrounding the airport and that the capacity of the road network is not significantly impacted.

Roe Highway / Tonkin Highway (North)		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2016	Existing	A	A	A
2025	Without new runway	A	A	B
	With new runway and Grogan Road closed (Option 1)	B	A	B
2045	Without new runway	A	A	A
	With new runway and Grogan Road closed (Option 1)	A	A	A

Table 18-23 Roe Highway and Tonkin Highway (north) modelled intersection level of service
Source: Aurecon 2017b

Roe Highway / Tonkin Highway (South)		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2016	Existing	C	C	C
2025	Without new runway	C	C	C
	With new runway and Grogan Road closed (Option 1)	C	D	E
2045	Without new runway	A	A	A
	With new runway and Grogan Road closed (Option 1)	A	A	A

Table 18-24 Roe Highway and Tonkin Highway (south) modelled intersection level of service
Source: Aurecon 2017b

Abernethy Road / Kewdale Road		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2016	Existing	D	C	D
2025	Without new runway	C	D	D
	With new runway and Grogan Road closed (Option 1)	D	D	D
2045	Without new runway	D	D	D
	With new runway and Grogan Road closed (Option 1)	D	E	E

Table 18-25 Abernethy Road and Kewdale Road modelled intersection level of service
Source: Aurecon 2017b

Network Performance – Option 2 (Runway Tunnel Constructed)

Following analysis of the performance of the external road network with the runway constructed, a similar analysis was carried out for Option 2, with the construction of a two-lane tunnel (one lane in each direction) underneath the new runway, with the comparison of results for 2025 and 2045 as shown in Table 18-26 to Table 18-37.

These results show that the difference in the performance of the external road network between the two options is not significant, and that the construction of a tunnel beneath the runway is not warranted. This is, in part, due to the additional route distance travelled to the Terminals due to the requirement to connect to tunnel at the intersection of Horrie Miller Drive and Anderson Place. Additionally, much of the on airport transport demand to businesses south of Grogan Road will be removed, as these businesses will be relocated as the area is transitioned to direct aviation related uses.

Morning Peak (2025 Option 2 – Runway Tunnel Constructed)

	2025	
	Option 1 With Runway	Option 2 With Runway and Tunnel
Vehicle hours travelled (VHT)	5,867	5,782
Vehicle kilometres travelled (VKT)	289,487	287,562
Total number of vehicles	46,577	46,667
Mean speed (kilometres per hour)	49.3	49.7

Table 18-26 2025 morning peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)	
		With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Rd)	Northbound	411	483
	Southbound	457	473
Airport Drive (south of Sugarbird Lady Rd)	Northbound	1,448	1,373
	Southbound	835	825
Grogan Road (east of Horrie Miller Dr)	Eastbound	-	-
	Westbound	-	-
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	1,345	1,200
	Southbound	699	672
Airport Drive (north of Tonkin Hwy)	Northbound	1,579	1,569
	Southbound	906	1,049
Airport Tunnel	Eastbound	-	317
	Westbound	-	588
Roe Highway	Northbound	3,126	3,072
	Southbound	3,961	3,521
Tonkin Highway	Eastbound	2,680	2,641
	Westbound	5,117	4,923
Abernethy Road	Northbound	1,047	834
	Southbound	1,045	764

Table 18-27 2025 morning peak-period modelled link volume
Source: Aurecon 2017b

Afternoon Peak (2025 Option 2 – Runway Tunnel Constructed)

	2025	
	With Runway	With Runway and Tunnel
Vehicle hours travelled (VHT)	7,862	7,513
Vehicle kilometres travelled (VKT)	317,344	318,828
Total number of vehicles	49,697	49,808
Mean speed (kilometres per hour)	40.4	42.4

Table 18-28 2025 afternoon peak period modelled network statistics
Source: Aurecon 2017b

		Volume (per hour)	
Road Name	Direction	With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Rd)	Northbound	-	-
	Southbound	963	961
Airport Drive (south of Sugarbird Lady Rd)	Northbound	2,129	2,075
	Southbound	1,462	1,458
Grogan Road (east of Horrie Miller Dr)	Eastbound	-	-
	Westbound	-	-
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	672	760
	Southbound	1,614	1,486
Airport Drive (north of Tonkin Hwy)	Northbound	2,139	2,082
	Southbound	1,920	1,821
Airport Tunnel	Eastbound	-	526
	Westbound	-	304
Roe Highway	Northbound	3,751	3,781
	Southbound	3,519	3,607
Tonkin Highway	Eastbound	5,506	5,189
	Westbound	3,299	3,492
Abernethy Road	Northbound	1,047	789
	Southbound	719	595

Table 18-29 2025 afternoon peak period modelled link volume
Source: Aurecon 2017b

Airport Peak (2025 Option 2 – Runway Tunnel Constructed)

	2025	
	With Runway	With Runway and Tunnel
Vehicle hours travelled (VHT)	4,761	4,757
Vehicle kilometres travelled (VKT)	270,508	269,783
Total number of vehicles	42,049	42,111
Mean speed (kilometres per hour)	56.8	56.7

Table 18-30 2025 airport peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)	
		With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Rd)	Northbound	634	801
	Southbound	1,190	1,131
Airport Drive (south of Sugarbird Lady Rd)	Northbound	1,707	1,533
	Southbound	1,743	1,811
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	988	939
	Southbound	2,140	1,836
Airport Drive (north of Tonkin Hwy)	Northbound	1,750	1,583
	Southbound	1,976	2,002
Airport Tunnel	Eastbound	-	513
	Westbound	-	506
Roe Highway	Northbound	3,020	2,818
	Southbound	3,016	2,853
Tonkin Highway	Eastbound	4,287	4,047
	Westbound	3,619	3,508
Abernethy Road	Northbound	663	506
	Southbound	810	708

Table 18-31 2025 airport peak-period modelled link volume
Source: Aurecon 2017b

Morning Peak (2045 Option 2 – Runway Tunnel Constructed)

	2045	
	With Runway	With Runway and Tunnel
Vehicle hours travelled (VHT)	10,245	10,208
Vehicle kilometres travelled (VKT)	397,830	392,090
Total number of vehicles	60,163	59,131
Mean speed (kilometres per hour)	38.8	38.4

Table 18-32 2045 morning peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)	
		With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Rd)	Northbound	707	792
	Southbound	543	533
Airport Drive (south of Sugarbird Lady Rd)	Northbound	2,839	2,886
	Southbound	2,047	2,057
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	1,637	1,564
	Southbound	872	730
Airport Drive (north of Tonkin Hwy)	Northbound	2,912	3,101
	Southbound	2,119	2,457
Airport Tunnel	Eastbound	-	444
	Westbound	-	726
Roe Highway	Northbound	4,534	5,012
	Southbound	5,409	5,926
Tonkin Highway	Eastbound	3,478	3,894
	Westbound	6,016	6,090
Abernethy Road	Northbound	667	763
	Southbound	1,322	1,070

Table 18-33 2045 morning peak-period modelled link volume
Source: Aurecon 2017b

Afternoon Peak (2045 Option 2 – Runway Tunnel Constructed)

	2045	
	With Runway	With Runway and Tunnel
Vehicle hours travelled (VHT)	11,946	11,581
Vehicle kilometres travelled (VKT)	442,141	456,435
Total number of vehicles	64,455	66,744
Mean speed (kilometres per hour)	37.0	39.4

Table 18-34 2045 afternoon peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)	
		With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Rd)	Northbound	1,470	1,546
	Southbound	1,031	823
Airport Drive (south of Sugarbird Lady Rd)	Northbound	2,695	1,825
	Southbound	2,493	2,777
Horrie Miller Drive (north of Tonkin Hwy)	Northbound	2,347	2,071
	Southbound	1,788	1,287
Airport Drive (north of Tonkin Hwy)	Northbound	2,311	1,397
	Southbound	2,916	2,961
Airport Tunnel	Eastbound	-	721
	Westbound	-	315
Roe Highway	Northbound	6,101	6,367
	Southbound	5,007	4,643
Tonkin Highway	Eastbound	5,288	4,912
	Westbound	4,393	4,562
Abernethy Road	Northbound	809	756
	Southbound	760	799

Table 18-35 2045 afternoon peak-period modelled link volume
Source: Aurecon 2017b

Airport Peak (2045 Option 2 – Runway Tunnel Constructed)

	2045	
	With Runway	With Runway and Tunnel
Vehicle hours travelled (VHT)	7,243	7,262
Vehicle kilometres travelled (VKT)	383,715	381,226
Total number of vehicles	57,267	57,318
Mean speed (kilometres per hour)	53.0	52.5

Table 18-36 2045 airport peak-period modelled network statistics
Source: Aurecon 2017b

Road Name	Direction	Volume (per hour)	
		With Runway	With Runway and Tunnel
Horrie Miller Drive (south of Grogan Road)	Northbound	1,192	1,199
	Southbound	944	894
Airport Dr (south of Sugarbird Lady Road)	Northbound	2,957	2,904
	Southbound	2,737	2,719
Grogan Road (east of Horrie Miller Drive)	Eastbound	-	-
	Westbound	-	-
Horrie Miller Drive (north of Tonkin Highway)	Northbound	2,075	2,021
	Southbound	2,060	1,664
Airport Drive (north of Tonkin Highway)	Northbound	2,632	2,618
	Southbound	2,792	2,804
Airport Tunnel	Eastbound	-	458
	Westbound	-	315
Roe Highway	Northbound	3,770	3,536
	Southbound	3,462	3,258
Tonkin Highway	Eastbound	4,999	4,780
	Westbound	4,114	3,917
Abernethy Road	Northbound	658	584
	Southbound	818	715

Table 18-37 2045 airport peak-period modelled link volume
Source: Aurecon 2017b

2025 and 2045 Modelled Intersection Performance – Option 2 (Runway Tunnel Constructed)

The performance of individual intersections in the network for the two options was also assessed, with the results as shown in Table 18-38 to Table 18-41.

Again, these results show that the difference in the performance of the external road network between the two options is not significant, with the only increase in delay between Option 1 and Option 2 being evident at the Roe Highway and Tonkin Highway (South), with the model showing up to an additional 20 second delay in 2025. To alleviate this small impact, planned upgrades may need to be considered sooner.

Therefore, the modelling shows that the construction of a tunnel beneath the runway is not warranted.

Horrie Miller Drive / Tonkin Highway		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2025	With Runway (Option 1)	C	C	B
	With Runway and Tunnel (Option 2)	B	C	B
2045	With Runway (Option 1)	C	C	D
	With Runway and Tunnel (Option 2)	C	C	D

Table 18-38 Horrie Miller Drive and Tonkin Highway modelled intersection level of service
Source: Aurecon 2017b

Roe Highway / Tonkin Highway (North)		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2025	With Runway (Option 1)	B	A	B
	With Runway and Tunnel (Option 2)	B	A	B
2045	With Runway (Option 1)	A	A	A
	With Runway and Tunnel (Option 2)	A	A	A

Table 18-39 Roe Highway and Tonkin Highway (north) modelled intersection level of service
Source: Aurecon 2017b

Roe Highway / Tonkin Highway (South)		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2025	With Runway (Option 1)	C	D	E
	With Runway and Tunnel (Option 2)	C	D	D
2045	With Runway (Option 1)	A	A	A
	With Runway and Tunnel (Option 2)	A	A	A

Table 18-40 Roe Highway and Tonkin Highway (south) modelled intersection level of service
Source: Aurecon 2017b

Abernethy Road / Kewdale Road		AM Peak (7.15 am – 8.15 am)	Airport Peak (2.00 pm – 3.00 pm)	PM Peak (4.30 pm – 5.30 pm)
2025	With Runway (Option 1)	D	D	D
	With Runway and Tunnel (Option 2)	D	D	D
2045	With Runway (Option 1)	D	E	E
	With Runway and Tunnel (Option 2)	D	E	E

Table 18-41 Abernethy Road and Kewdale Road modelled intersection level of service
Source: Aurecon 2017b

18.5.2 Internal Roads

Airport Drive, currently the primary traffic route to T1 and T2 (and ultimately to all terminals following consolidation of Qantas) is constructed as a dual carriageway with two lanes in each direction and designed to be widened to three lanes as traffic volumes increase. Major intersections on Airport Drive are currently roundabout controlled, as this facilitates turning movements and ensures the free flow of traffic to the terminals. The increased traffic volumes in the precinct following consolidation will require the upgrade of these intersections, with the ultimate configuration requiring grade separation.

Horrie Miller Drive is also a dual carriageway with two lanes in each direction and roundabouts at intersections. With the construction of Airport Drive, it now functions as the main access for Airport South and as the route for the Long-Term car park shuttle buses. The long-term plan along Horrie Miller Drive includes the conversion of the current at-grade car parks to multi storey car parking, potentially with integrated commercial development (Figure 18-14) and the increased use of Horrie Miller Drive as a transit spine to the terminals and the Airport Central rail station.

When modelling the impact of the closure of Grogan Road, the AIMSUN traffic model distributes the traffic from Grogan Road that is accessing the terminals and other locations on the estate onto the other internal airport roads. A number of the existing businesses that currently use Grogan Road for access will be displaced by the construction of the new runway or the new domestic terminal and associated aprons and taxiways. The traffic from these has been removed from the AIMSUM models. The internal airport roads included in the traffic model are shown in Figure 18-15.

18.5.2.1 Modelled Performance without NRP

As the vehicle traffic grows, the level of service on the internal airport roads reduces, however, progressive road upgrades within the estate will ensure an acceptable level of service is maintained as shown in Table 18-42.

The road upgrades included in the traffic model allow for the anticipated grade separation of the Airport Drive and Sugarbird Lady Road roundabout in 2025 to coincide with the relocation of Qantas into the precinct and the opening of a new domestic terminal.

While the actual timing of construction and final configuration of the upgrades will be subject to demand and future preferred methods of access to the airport, to ensure that the internal road network continues to provide an acceptable level of service for airport traffic, the following upgrades and changes to the current traffic network are included in the AIMSUN 2045 local traffic model:

- three lanes bi-directional on Airport Drive between Tonkin Highway and Sugarbird Lady Road, and
- grade separation of the Airport Drive and Paltridge Road intersection.

The intersection of Horrie Miller Drive and Grogan Road starts to experience delays in the AM peak due to queuing from the Airport Drive / Sugarbird Lady Road roundabout. While this is within the currently acceptable levels of service, it indicates that an assessment of additional turning lanes or further grade separation may be required to restore performance in the future.

Intersection	Level of Service								
	2016 (existing)			2025 without new runway			2045 without new runway		
	AM	PM	Airport	AM	PM	Airport	AM	PM	Airport
Horrie Miller Drive, Airport Drive and Sugarbird Lady Road	A	B	B	A	B	B	A	A	A
Horrie Miller Drive and Grogan Road	A	B	A	A	B	B	D	B	A
Horrie Miller Drive and Anderson Place	A	A	A	A	A	A	A	A	A

Table 18-42 Existing on Airport road network modelled intersection level of service
Source: Aurecon 2017b

18.5.2.2 Modelled Performance of Airport Road Network with Runway Constructed

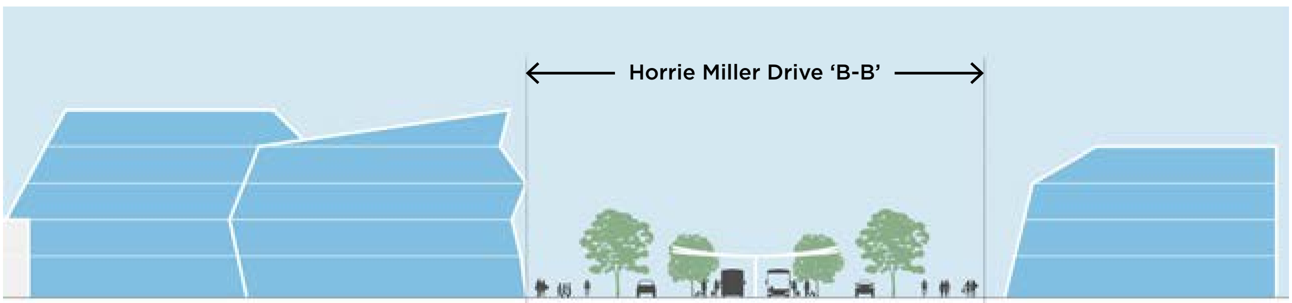


Figure 18-14 Horrie Miller Drive with potential retail or office development concept
Source: Perth Airport

Figure 18-15 Internal airport road network
Source: Perth Airport

The modelling results, detailed in Table 18-43 to Table 18-46, show that, by removing Grogan Road as an alternative route into the Airport, the on airport road intersections perform more efficiently as there are fewer interruptions to the flow of traffic to and from the terminals (although the level of service of the Airport Drive / Sugarbird Lady Road / Grogan Road intersection is reduced). This is mitigated in part, as the removal of the Grogan Road connection ensures that the traffic on the estate is for airport-related access only. The growth in vehicle numbers as passenger numbers increase will be accommodated by upgrading the intersections as detailed in this section, to ensure that the road capacity is adequate for the volumes and types of traffic using them and that an acceptable level of service is maintained.

Horrie Miller Drive, Airport Drive and Sugarbird Lady Drive		AM Peak (7.15 am – 8.15 am)	PM Peak (4.30 pm – 5.30 pm)	Airport Peak (2.00 pm – 3.00 pm)
2016	Existing	A	B	B
2025	Without new runway	A	B	B
2025	With new runway and Grogan Road closed (Option 1)	A	A	A
2045	With new runway and Grogan Road closed (Option 1)	A	A	D

Table 18-43 Horrie Miller Drive and Airport Drive and Sugarbird Lady Drive modelled intersection level of service
Source: Aurecon 2017b

Horrie Miller Drive and Grogan Road		AM Peak (7.15 am – 8.15 am)	PM Peak (4.30 pm – 5.30 pm)	Airport Peak (2.00 pm – 3.00 pm)
2016	Existing	A	B	A
2025	Without new runway	A	B	B
2025	With new runway and Grogan Road closed (Option 1)	A	A	A
2045	With new runway and Grogan Road closed (Option 1)	A	A	D

Table 18-44 Horrie Miller Drive and Grogan Road modelled intersection level of service
Source: Aurecon 2017b

Horrie Miller Drive and Anderson Place		AM Peak (7.15 am – 8.15 am)	PM Peak (4.30 pm – 5.30 pm)	Airport Peak (2.00 pm – 3.00 pm)
2016	Existing	A	A	A
2025	Without new runway	A	A	A
	With new runway and Grogan Road closed (Option 1)	A	A	A
2045	With new runway and Grogan Road closed (Option 1)	A	A	A

Table 18-45 Horrie Miller Drive and Anderson Place Modelled Intersection Level of Service
Source: Aurecon 2017b

Horrie Miller Drive and Paltridge Road		AM Peak (7.15 am – 8.15 am)	PM Peak (4.30 pm – 5.30 pm)	Airport Peak (2.00 pm – 3.00 pm)
2016	Existing	A	A	A
2025	Without new runway	A	B	A
	With new runway and Grogan Road closed (Option 1)	A	B	B
2045	With new runway and Grogan Road closed (Option 1)	A	B	B

Table 18-46 Horrie Miller Drive and Paltridge Road modelled intersection level of service
Source: Aurecon 2017b

18.5.3 Peak Traffic Impacts

As a result of the construction of the NRP and the capacity for additional flights, the peak period will see the potential for vehicle traffic to increase. The increases in the airport peak traffic will likely occur outside the external-road network peaks which are associated with commuter traffic.

The modelling has been carried out growing the passenger numbers across the whole day, including at peak times. This is the worst-case impact that the traffic will have on the network, as in practice, more growth will occur during the off-peak times.

The current and future internal road network has been planned to cater for the growth in passenger numbers annually and in the peak periods. The predicted vehicle traffic on both Airport Drive and Horrie Miller Drive, as shown in Table 18-47, are within planned capacity.

The way that passengers access the airport will change over time, as shown in the mode shares detailed in Figure 18-11. Increased use of public transport, ride share and pick-up and drop-off will impact the volume of vehicles on the internal roads, with less vehicles per passenger expected in the future, as demonstrated in Table 18-47.

18.5.4 Construction Traffic

Construction of the NRP is anticipated to take up to four years and require the placement of approximately 1.5 million cubic metres of material, much of it brought onto the estate from off airport. Due to the extent of the project works, it is anticipated that several site access points will be needed as shown in Figure 18-16 .

It is anticipated that whenever possible, materials will be transported using B-Double trucks (RAV Network 3 and 4), as these can use the surrounding road network and will reduce the total number of vehicle movements required to undertake the task when compared to a standard truck-and-trailer vehicle.

An assessment of the identified access points for their suitability for use by B-Double vehicles was carried out. It found that:

- Paltridge Road is already approved for use by B-Double vehicles. The road is designed to accommodate these vehicles as shown in Figure 18-17.
- Grogan Road east and west, as shown in Figure 18-18 and Figure 18-19, can be utilised by B-Doubles with explicit written approval from Perth Airport, with the roads already being used by other vehicles of this size, with this approval. The section of Grogan Road east between Abernethy Road and the estate boundary requires written approval from the City of Kalamunda to allow it to be used. Both roads are designed to accommodate B-Double vehicles.
- Turning restrictions prevent southbound traffic on Abernethy Road turning right into Grogan Road east, and from Grogan Road east turning right southbound onto Abernethy Road. However, neither movement is required for the construction traffic.
- The intersection of Tarlton Crescent and Horrie Miller Drive, as shown in Figure 18-20, will need to be modified to provide a temporary right-turn lane to allow traffic travelling north on Horrie Miller Drive to access Tarlton Crescent.
- Dubs Close and Hudswell Road, as shown in Figure 18-21 and Figure 18-22, will require approval from Main Roads and the City of Kalamunda to permit B-Double access, although Hudswell Road has previously been endorsed for B-Double use. Again, they are both able to accommodate B-Double vehicles without requiring modification.

As already identified, heavy truck movements at the intersection of Grogan Road east and Abernethy Road are currently restricted, with right turns from Abernethy Road into Grogan Road and from Grogan Road into Abernethy Road not being permitted. It is proposed that, in addition to the restrictions to truck movements in place at the Grogan Road intersection, the B-Double truck movements at the Dubs Close intersection with Abernethy Road are restricted to only permit left in and left out at the intersection due to the reduced road width.

Prior to construction, Perth Airport will work with relevant local governments and Main Roads to gain approval for an appropriate traffic management plan. While the actual work programme including the timing of the closure of Grogan Road, the haul routes and vehicle access points used will be determined by the contractor. It will be a requirement of the construction contract that a traffic impact assessment be carried out and an agreed methodology and haul programme form part of the Construction Management Plan.

	Passengers (annual in Airport Central)	Airport Drive (vehicles per day)	Horrie Miller Drive (vehicles per day)	Total Traffic Volume (vehicles per day)
2016	7.1 million	32,310	17,310	49,620
2025	16.7 million	40,700	27,290	67,990
2045	29.1 million	62,360	35,470	97,830

Table 18-47 Predicted on-airport traffic volumes in Airport Central
Source: Aurecon 2017b

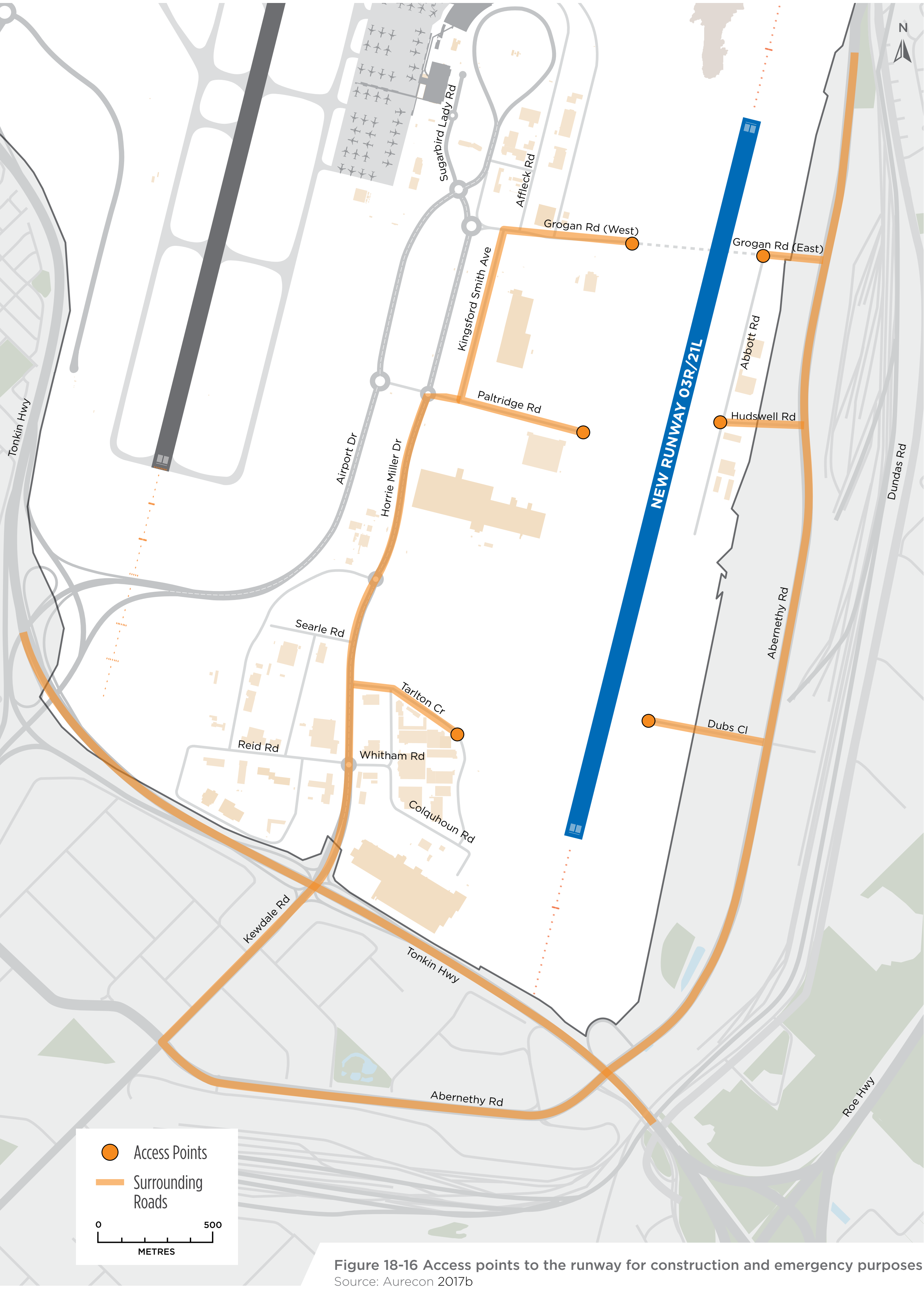


Figure 18-16 Access points to the runway for construction and emergency purposes
Source: Aurecon 2017b

Figure 18-17 B-Double turning movements right in and left out of Paltridge Road
Source: Aurecon 2017b

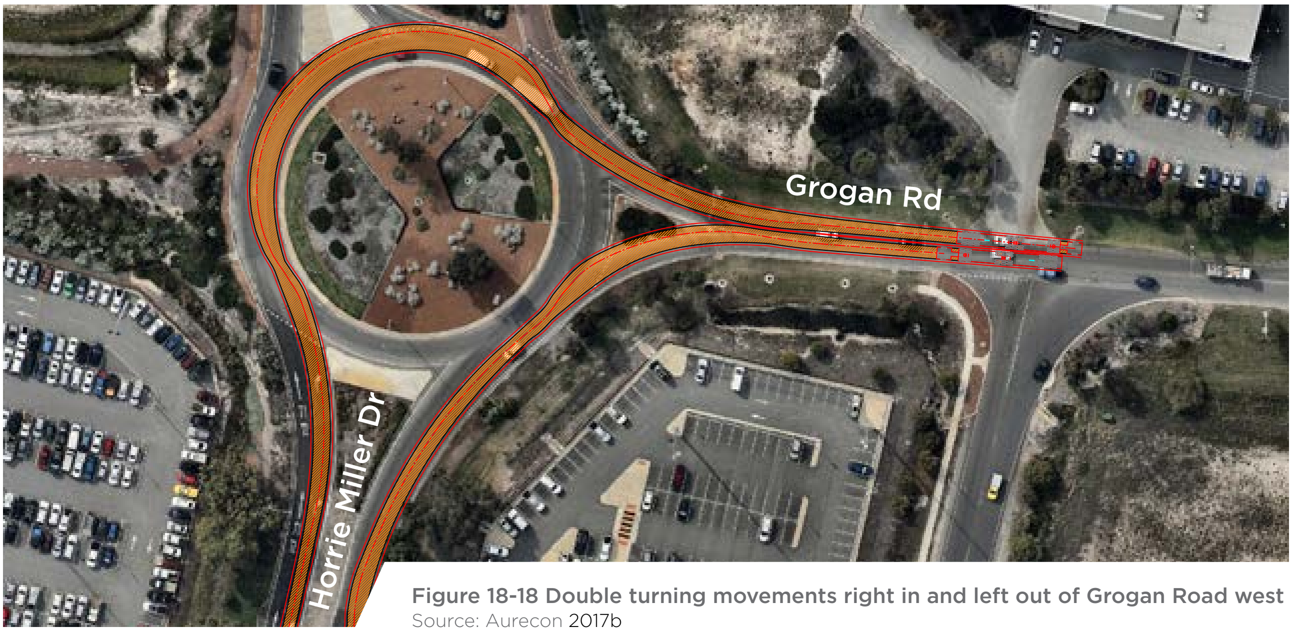


Figure 18-18 Double turning movements right in and left out of Grogan Road west
Source: Aurecon 2017b

Figure 18-19 B-Double turning movements left in and left out of Grogan Road east
Source: Aurecon 2017b

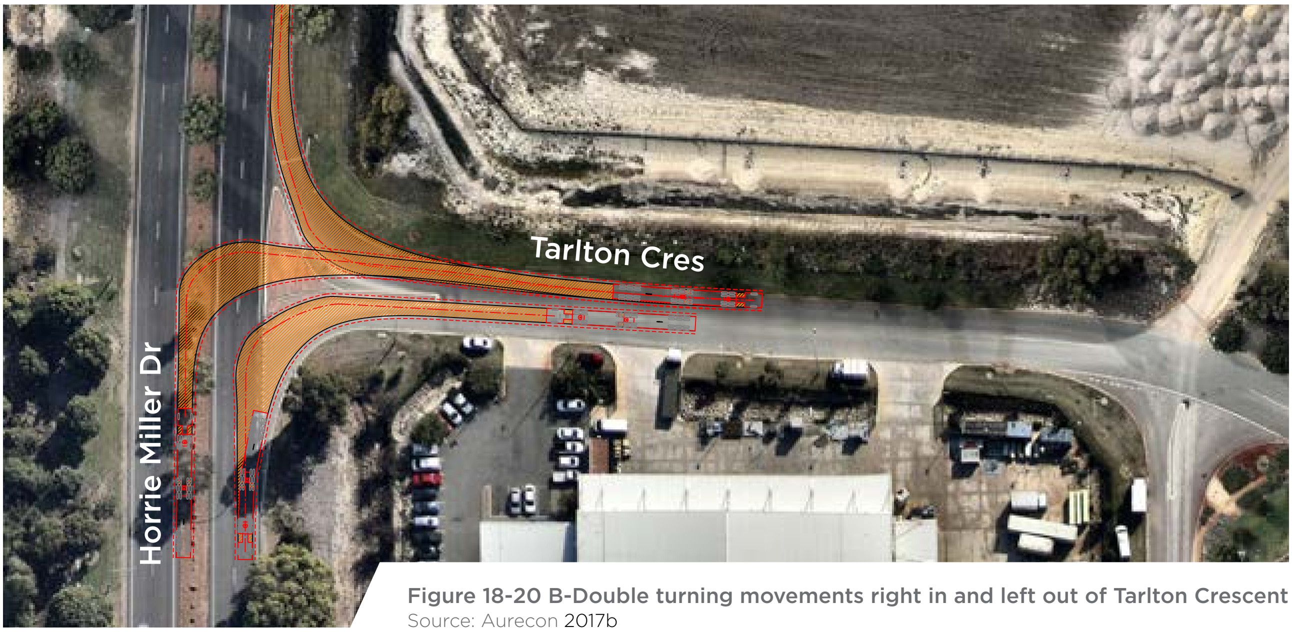


Figure 18-20 B-Double turning movements right in and left out of Tarlton Crescent
Source: Aurecon 2017b

Figure 18-21 B-Double turning movements left in and left out of Dubs Close
Source: Aurecon 2017b

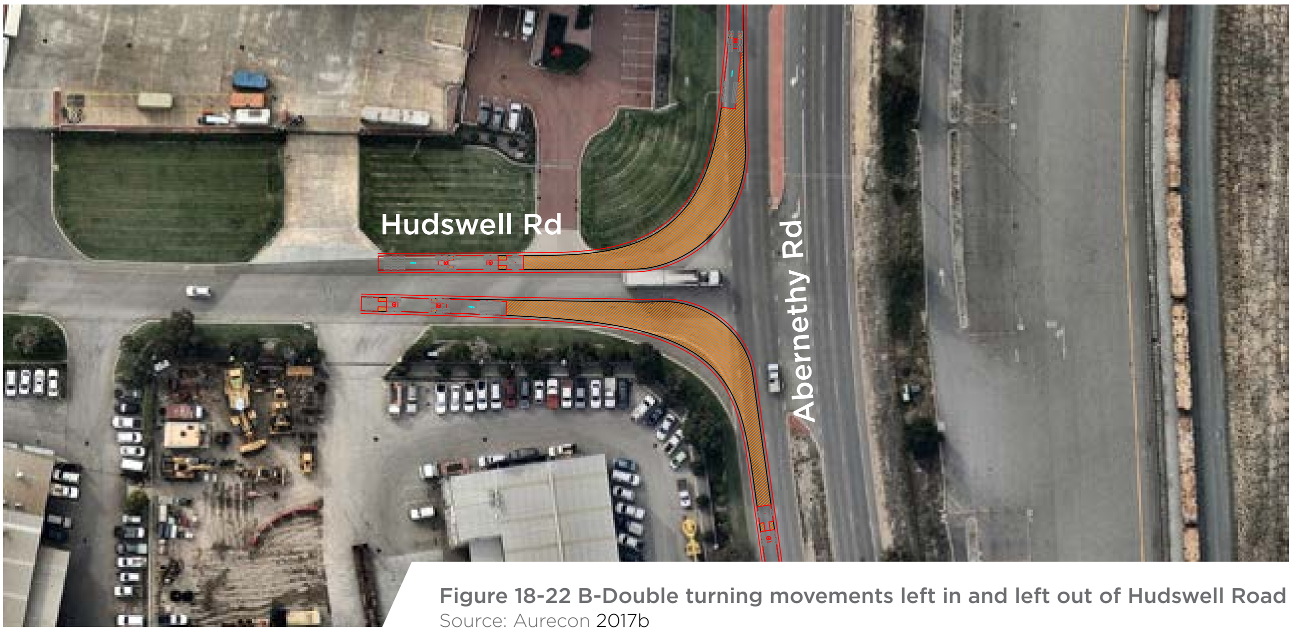


Figure 18-22 B-Double turning movements left in and left out of Hudswell Road
Source: Aurecon 2017b

The importation of fill for bulk earthworks will be the highest-impact activity of the project on the surrounding road network. A conservative construction program of 16 months for the bulk earthworks results in an average of 12 vehicles per hour delivering materials to the site. This is not a significant number of additional vehicles on the road network, and can be absorbed by the surrounding roads. The placing of the pavement materials will progressively follow the placement of fill and is anticipated to take a further eight months to complete (24 months total), however, the rate of importation of these materials is anticipated to be much slower and require fewer vehicle movements per day.

In practice, the contractors could seek a more aggressive programme and shorten this component of the construction works, to be as short as six months. This could see an average of 400 vehicles per day and up to 50 vehicles during the peak hours. These vehicles would likely be evenly distributed across Horrie Miller Drive and Abernethy Road. The current daily traffic on Horrie Miller Drive is approximately 16,500 vehicles per day with 13,000 vehicles a day on Abernethy Road.

The traffic volume on Horrie Miller Drive is 1,250 vehicles in the peak hour, while Abernethy Road has approximately 1,040 vehicles in the peak hour. Adding 25 vehicles to the peak-hour volumes on each of these roads would increase traffic by less than 2.5 per cent. Given that both Horrie Miller Drive and Abernethy Road already have high proportions of heavy vehicles and were experiencing higher traffic volumes prior to the completion of the Gateway WA project, the introduction of these volumes of construction traffic will not significantly impact the network.

The construction project will likely operate a 12-hour day, resulting in staff-traffic movements outside of the network peak times. These staff-traffic movements would add approximately 200 daily vehicle movements, to the road network; again, volumes that can be accommodated on Horrie Miller Drive and Abernethy Road.

There are also likely to be trucks delivering other materials during the peak hour and general deliveries associated with the construction from smaller vehicles, which may result in approximately 100 additional vehicle movements a day.

Internal haul roads will be provided during the construction to allow for construction traffic movements reducing the impact of the traffic on the road network. These will avoid unrestricted access to the Dampier Bunbury Natural Gas Pipeline corridor and any additional crossing points required will be constructed in accordance with Gas Pipeline requirements.

Overall, the construction traffic will not significantly change the percentage of heavy vehicles using the external road network as they already comprise a high proportion of the traffic, as demonstrated in Table 18-48.

18.5.5 Airport Car Parking

The construction of the NRP will not impact on the access to the long-term car parks, which will continue to be centred around Horrie Miller Drive, accessed from Airport Drive and the internal airport road network. Horrie Miller Drive will continue to be used as the main transit route between the terminal and the long-term car parks.

Short-Term parking will continue to be provided in the area immediately adjacent to the terminals, accessed from Airport Drive. Additional car parking will be provided to meet demand as passenger numbers grow, with existing "at grade" car parks converted to multi storey and additional at grade car parks constructed further from the Terminals. Perth Airport will continue to review car parking fees and charges in line with market rates in order to provide value for its customers.

Changes to the way that passengers access the airport will occur, with the increase in the use of public transport, ride share and automated vehicles. These changes will be accommodated within the existing areas allocated for ground transport and have been included in the AIMSUN model.

	Abernethy Road		Horrie Miller Drive		Tonkin Hwy	
	Cars	Trucks	Cars	Trucks	Cars	Trucks
Existing Traffic						
	10,000	3,250	14,500	3,000	60,000	10,000
Additional Construction Vehicles						
Peak Hour	25	25	25	25	38	50
Daily	100	200	100	200	150	400
Percentage Additional	**1.0**	**6.1**	**0.7**	**6.7**	**0.3**	**4.0**
Total Over Construction Period	10,000	20,000	10,000	20,000	15,000	40,000

Table 18-48 Impact of construction traffic on road network
Source: Aurecon 2017b

18.5.6 Pedestrians and Cyclists

There is no dedicated pedestrian or cycle infrastructure on Grogan Road. Pedestrians and cyclists will continue to use the new facilities constructed as part of the Gateway WA and Roe Highway projects into the estate, using the shared paths on Tonkin Highway, Dunreath Drive, Horrie Miller Drive and Airport Drive to access the terminals, as shown in Figure 18-23. Construction of the NRP and associated airside security fences will prevent cyclists and pedestrians from accessing the terminals from Abernethy Road.

Figure 18-23 Perth bicycle network
Source: Western Australian Department of Transport

18.5.7 Public Transport

Public transport to T1 and T2 is currently provided by the bus route 380 limited-stop service from the City, which accesses Airport Central along Tonkin Highway and Airport Drive as shown in Figure 18-24. Other bus routes serving adjoining suburbs run past the airport on Abernethy Road and Kalamunda Road. The bus service to T3 and T4 is provided by the separate routes 40 and 935.

Grogan Road is not used by any public transport service and the construction the NRP will not impact the provision of public transport to, or around the airport.

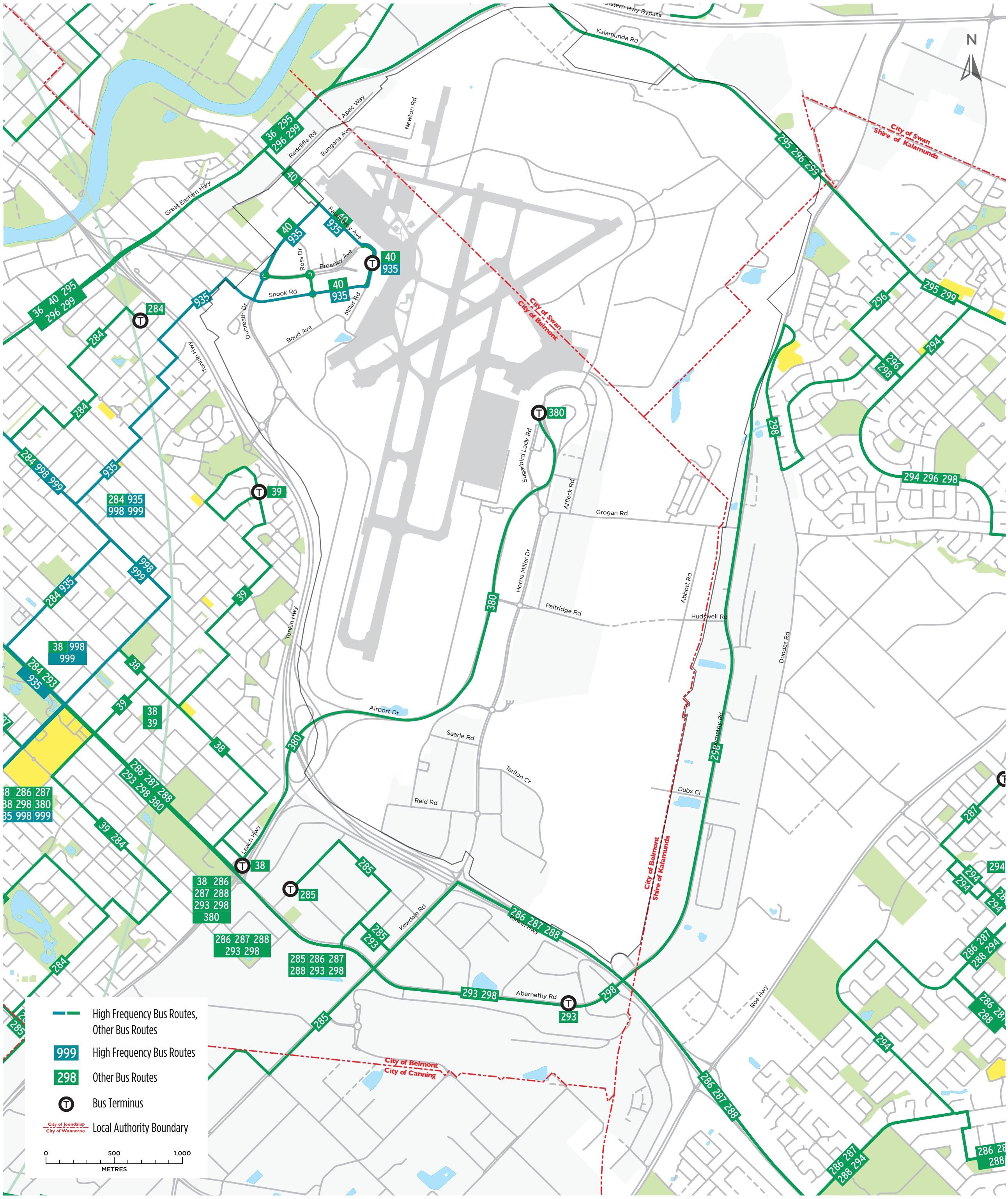


Figure 18-24 Bus routes on and around the Airport

Source: Transperth

18.5.7.1 Rail

The State Government has commenced construction of the Forrestfield-Airport Link (FAL), as shown in Figure 18-25, which is due to be operational by the end of 2020. The project comprises two tunnels bored beneath the existing runways and the footprint of the new runway and includes an underground station serving Airport Central adjacent to the Air Traffic Control Tower.

The station and tunnels have been designed to accommodate the loading from the construction and operation of the runway, terminals and associated airport infrastructure, including the NRP. This has been achieved through identifying the surface loadings attributable to each area of the airport, ensuring that the tunnel infrastructure is designed and placed at sufficient depth to distribute these loads, and ensuring that any infrastructure is located understanding its potential to impact airport operations. The construction methodology used to achieve the necessary ground and pavement material compaction has also been considered and factored into these loadings.

The overall project will also include the construction of bus interchanges at the Forrestfield and Redcliffe stations, with local bus routes amended to provide better linkages to each station. The Airport Central station, however will function solely to serve the Airport and will not include feeder bus services. The final feeder bus routes have not yet been confirmed, but when the railway service starts it will replace the 380 bus service from the City.

Opportunities for additional public transport, including an alternative bus service into Airport Central feeding from the Armadale rail line, are being investigated.

Some of the new bus routes will likely access Forrestfield Station along Abernethy Road, however the road has sufficient capacity to accommodate this traffic without being impacted by the traffic diverted due to the NRP.

As shown in Figure 18-26, the FAL rail tunnels will be built at the northern end of the NRP and not directly beneath the active runway pavement.

Figure 18-25 Forrestfield – Airport Link
Source: Public Transport Authority

18.6 Conclusion

The traffic assessment considered options for the year of opening for the new runway (2025) and after 20 years of operation of the runway (2045). These scenarios included planned and suggested changes and upgrades to the road network and the impact of the closure of Grogan Road on network operation, and whether replacement of the route with a tunnel beneath the runway is required.

Overall, the model results demonstrated that the removal of Grogan Road to construct the new runway would result in a minor impact on the major road network surrounding the airport, and that these roads have sufficient capacity to accommodate this traffic. The modelling showed that a comparison of the impact on traffic flows if a tunnel is built beneath the new runway demonstrated that construction of a tunnel is not justified. Perth Airport will continue to work with Main Roads WA to investigate the feasibility of alternative options to maintain road network connectivity, including an at grade solution.

By 2025, the model predicted some queues on Roe Highway and Tonkin Highway. The delays are the result of the right-turn movements from Roe Highway (north) and Tonkin Highway off-ramp (east), and indicate that full grade separation of the intersection will be required at some stage after this time.

Construction of the new runway will see additional heavy vehicles on the surrounding network. Access at six locations off Horrie Miller Drive and Abernethy Road for B-Double trucks will be provided to reduce the impact on external roads. A construction traffic-management plan will be prepared and agreed with Main Roads and the City of Kalamunda prior to works commencing to ensure that any impacts are mitigated and understood.

The NRP will not impact the local public-transport network, pedestrian or cycling routes, while the Forrestfield Airport Link project, which will result in the rail tunnels running adjacent to the NRP, has been designed to accommodate the construction and operation of the NRP.

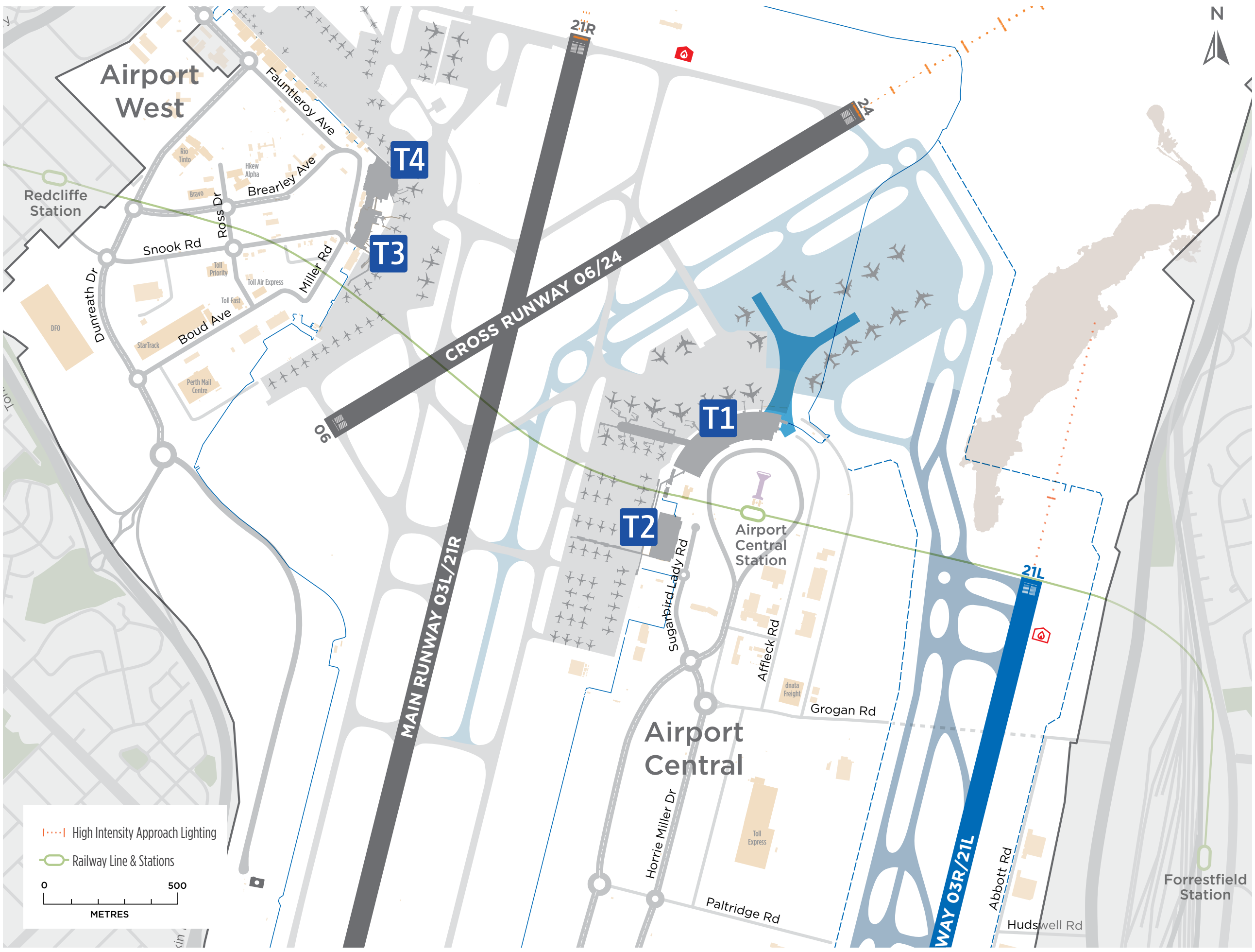
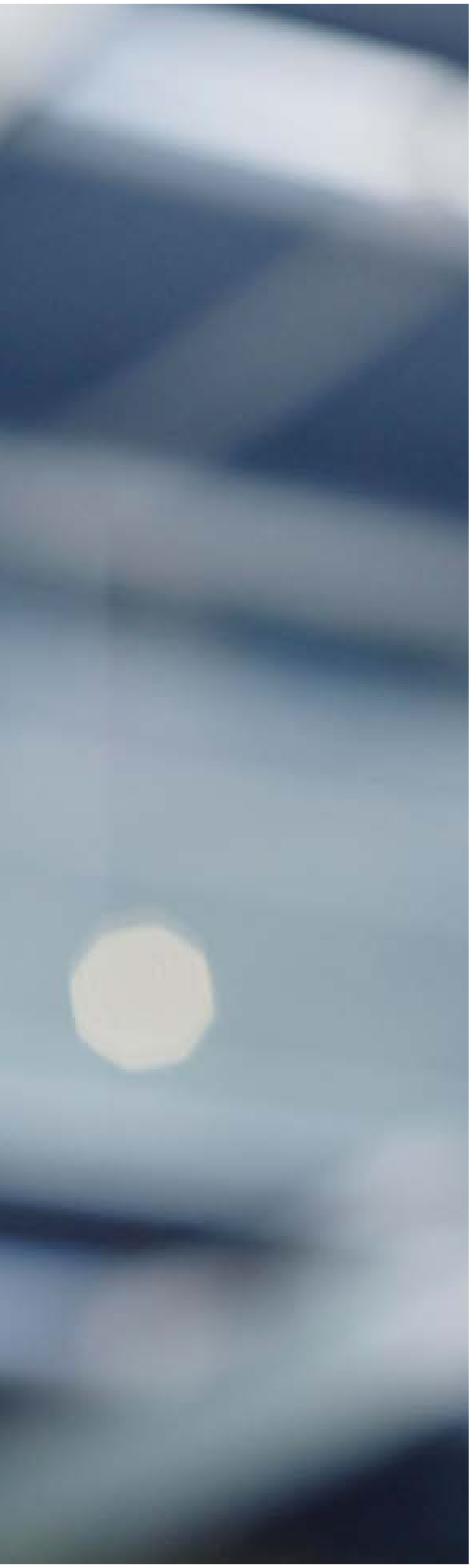


Figure 18-26 Forrestfield – Airport Link rail alignment

Source: Perth Airport



Appendices

Glossary of Terms

03L/21R
Existing main runway designation

03R/21L
New runway designation

06/24
Existing cross runway designation

Airshed
A geographical area within which the air frequently is confined or channeled, with all parts of the area thus being subject to similar conditions of air pollution.

Airside
The movement area of an airport, adjacent terrain and building or portions thereof, access to which is controlled.

Approaches
The course to be followed by an aircraft in approaching for a landing or in joining a traffic pattern.

Apron
A defined area on a land aerodrome intended to accommodate aircraft for loading and unloading passengers, mail or cargo, fuelling, parking or maintenance.

Average Return Interval (ARI)
A measure of the rarity of a rainfall event. e.g. 1 in 50 year, 1 in 100 year etc. It is defined as the average, or expected, value of the periods between exceedances of a given total rainfall accumulated over a given duration. Periods between exceedances are random.

Baseline
A specific value or values that can serve as a comparison or control a basic standard or level; guideline.

Bio-accumulative
The accumulation within living organisms of toxic substances occurring in the environment.

Bund
An embankment of earth or a wall constructed of brick, stone or concrete to form the perimeter of a compound that will prevent lateral movement of the material contained within the embankment or wall.

Corridor
A restricted path along which an aircraft must travel to avoid hostile action, other air traffic, etc.

Declared Rare Flora
The flora protected under the *Wildlife Conservation Act 1950* (State) due to it being rare, in danger of extinction, or otherwise in need of special protection

Detention Storage
An area that will temporarily store water until the downstream drainage network has capacity to drain the stored water

Dewatering
Removal or draining groundwater or surface water from a riverbed, construction site, caisson, or mine shaft, by pumping or evaporation.

Environmental Incident
Any event or impact on the environment involving Perth Airport and/or its contractor's actions or assets that is capable of:
- causing harm to the environment or any person or property,
- causing pollution, and/or
- coming to the attention of an environmental regulatory agency.

Estate
The grounds and tenancies associated with the Perth Airport land holdings.

Eulerian model
Defines specific reference points in a gridded system that monitors atmospheric properties, including temperature, pressure, chemical concentration of tracers, over time.

Events per year (EY)
Used as the measure of the rarity of a rainfall events that are likely to occur once or more than once per year. E.g. two EY is used to indicate a rainfall event that is likely to occur two times per year or more.

Excavator
A machine used for excavating soil or sediment material and may include a backhoe excavator, bulldozer, dredge or other similar equipment.

Fauna
The animals of a given region or period considered as a whole.

Flora
The plants of a particular region or period, listed by species and considered as a whole.

Grade separation
Method of aligning a junction of two or more surface transport axes at different heights (grades) so that they will not disrupt the traffic flow on other transit routes when they cross each other

Gaussian model
In probability theory and statistics, a Gaussian process is a particular kind of statistical model where observations occur in a continuous domain, e.g. time or space. In a Gaussian process, every point in some continuous input space is associated with a normally distributed random variable.

General Aviation (GA)

Refers to all flights other than military and scheduled airline flights, both private and commercial.

Greater Perth

Used to describe Perth's Greater Capital City Statistical Area (GCCSA), a geographical area designed to represent the functional extent of Western Australia's capital city. Greater Perth consists of the area defined by the Perth Metropolitan Region, with the City of Mandurah and the Pinjarra Level 2 Statistical Area of the Shire of Murray

Greenfield Area

An undeveloped or agricultural tract of land that is a potential site for industrial or urban development.

Ground Disturbing Activities

The disturbance of earth or waters involving machinery including clearing, excavation, backfilling and compacting, but excludes geotechnical investigations, surveying, fencing and rehabilitation works.

Ground-based

Located on the ground as opposed to in an aircraft or in airspace.

Habitat Tree

Mature native tree containing hollows that may be suitable for habitat of native fauna.

Hardstand

A hard-surfaced area on which heavy vehicles or airplanes can be parked.

Hydraulics

Study of the motion of liquids using the laws of physics. In this case, flow in open channels, pipes, weirs and another stormwater infrastructure.

Hydrology

Study of the stormwater runoff generated by rainfall in connection with geography and geology. e.g. An asphalt road generates more runoff per square meter than a lawn does.

Initial Ground Disturbing Activities

The disturbance of earth or waters involving machinery including clearing and excavation to a depth of 0.5 metres, but excludes geotechnical investigations, surveying, excavation in excess of 0.5 metres, backfilling, compacting, fencing and rehabilitation works.

Lagrangian model

Takes the perspective of a finite element or so-called 'air parcel'. Over time both the position and properties of this air parcel are calculated according to the mean wind field data. The path along which air parcel travels is called its trajectory.

Landside

That portion of an airport not designated as airside and to which the general public normally has free access.

Living Stream

A constructed or retrofitted waterway that mimics the characteristics of a natural stream. Water quality improvement is achieved by aquatic vegetation and natural biological processes helping to oxygenate the water and removing nutrients plus non-nutrient contaminants.

Movement

Either a take-off or a landing by an aircraft.

Movement areas

That part of an aerodrome to be used for the surface movement of aircraft, including the manoeuvring areas and aprons.

N65 Contour

N65 contour map for Perth Airport illustrates the average number of events per day over 65 decibels dBA for a particular area. This corresponds to an outdoor sound level of 65 decibels dBA and an indoor noise level of approximately 55 decibels dBA.

Native Vegetation

Any local indigenous plant community containing throughout its growth the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance. It excludes plantations and vegetation that has been established for commercial purposes.

Noise Contour

Developed by the [then] Commonwealth Department of Infrastructure and Transport to illustrate the average number of events per day that exceed a certain sound level.

Noise Event

An event begins when the noise level exceeds a certain threshold value set in the noise monitor (which will be above the background noise level) and ends when the noise level drops below it.

Phytophthora

A group of fungi of the genus *Phytophthora*, which cause a serious plant disease.

Pollution

The direct or indirect alteration of the environment to its detriment or degradation, to the detriment of an environmental value, or is of a prescribed kind from an emission (as defined by the *Environmental Protection Act 1986* (State)).

Precinct

A space or place of definite or understood limits.

Priority Flora

Flora that is recognised by the Department of Biodiversity Conservation and Attractions as being under threat and in urgent need of further study; but is not yet declared rare flora under the *Wildlife Conservation Act 1950* (State). Priority Flora is divided into Priority 1, Priority 2, Priority 3 and Priority 4 listings, with Priority 1 being the flora most under threat.

Receptor

Various devices that receive information, signals etc

Retention Storage

An area that will store water until it has infiltrated into the ground and/or evaporated.

Slot

A slot is a permission given by Perth Airport in relation to a single aircraft for a planned operation to use (subject to the other relevant conditions of use) the full range of airfield infrastructure necessary to arrive at or depart from Perth Airport on a specific date and time.

Step-Change

A significant change, especially an improvement

Taxiway

A defined path on an aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another.

Water level indicator

A round steel post with a flat marked gauge plate of white background and black one-centimetre increment gauge markings each with a total nominal length of two metres.

Watercourse

A river, creek, gully, brook or irrigation channel that contains or has contained water, but excludes wetlands.

Wetland

Land that is permanently, seasonally or intermittently waterlogged or inundated with water, but excludes watercourses.

Windrow

Line of stockpiled material, such as soil or vegetation.

Acronym / Abbreviation

AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
ASS	Acid Sulfate Soils
ACC	Airport Control Centre
ACERT	Airport Carbon and Emissions Reporting Tool
ACM	Asbestos Containing Material
AEO	Airport Environment Officer
AEP	Annual Exceedance Probability
AEPR	Airport Environment Protection Regulations 1997
AF	Ascot Formation
AH Act	Aboriginal Heritage Act 1972
AHD	Australian Height Datum
Airports Act	Airports Act 1996
APU	Auxiliary Power Unit
AQI	Air Quality Index
ARFF	Aviation Rescue and Fire Fighting
ARI	Average Return Interval
ARR	The ARR document is a national guideline that can be used for the estimation of design flood characteristics in Australia and is published and supported by the Australian federal government
AS	Australian Standards
ATSIHP Act	Aboriginal and Torres Strait Islander Heritage Protection Act 1984
BAM Act	Biosecurity and Agriculture Management Act 2007
BC Act	Biodiversity Conservation Act 2016
BS	Bassendean Sand
CA	Catchments Areas
CAMBA	China-Australia Migratory Bird Agreement
CD	Completely Degraded
CEMP	Construction Environmental Management Plan
CH_4	Methane
CMS	Convention on the Conservation Migratory Species of Wild Animals (also referred to as the Bonn Convention)
CMS	Conservation of Migratory Species of Wild Animals (CMS)
CO	Carbon monoxide
$CO_{2\text{-}e}$	Carbon dioxide equivalent
CORTN	Calculation of Road Traffic Noise
CSR	Chromium reducible sulfur
D	Degraded
dB	Decibels of noise
dBA	A-weighted decibel
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions (State)
DCCEE	Department of Climate Change and Energy Efficiency (Commonwealth)
DCH8	Dash 8-300
DD	Data Deficient
DEE	Department of the Environment and Energy (Commonwealth)
DIDMS	Dieback Information Database Management System
DITRDC	Department of Infrastructure, Transport, Regional Development & Communications (Commonwealth)
DMP	Dewatering Management Plan (DMP)
DoE	Department of Environment (now DEE) (Commonwealth)
DPaW	Department of Parks and Wildlife (now DBCA) (State)
DPLH	Department of Planning, Lands and Heritage (State)
DRR	Disease risk road
DSEWPAC	Department of Sustainability, Environment, Water, Population and Communities (now DEE) (Commonwealth)
DWER	Department of Water and Environmental Regulation (WA)
EGR	Engine Ground Running

EIS	Environmental Impact Statement (EIS)
EMF	Environmental Management Framework
EMP	Environmental Management Plan
EMS	Environmental Management System
EN	Endangered
ENM	Environmental Noise Model
EPA	Environmental Protection Authority (WA)
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPNR	Western Australian Environmental Protection (Noise) Regulations 1997
EY	Events per Year
F100	Fokker 100
FAC	Federal Airports Corporation
FCT	Floristic Community Type
fGPU	Fixed Ground Power Unit
FOLS	Fuels and Organic Liquid Storage
GA	General Aviation
gDWm^2	Grams dry weight per square metre
GF	Guildford Formation
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Index
GIS	Geographic Information System
GS	Gnangara Sand
GSE	Ground Service Equipment
HIAL	High Intensity Approach Lighting
hrs	Hours
HSL	Health Screening Levels
ICOMOS	International Council on Monuments and Sites
IF	Influencing Factor
JAMBA	Japan-Australia Migratory Bird Agreement
kg	Kilograms
km	Kilometre
KS	Kardinya Shale Member fines dominated
kt	Kilotonnes
LOR	Laboratory limit of reporting
m	Metre
m^2	Square metre
m^3	Cubic metre
mAHD	Metres Australian Height Datum
Main Roads	Main Roads Western Australia
MDP	Major Development Plan
MDS	Perth Airport Master Drainage Strategy
mg	Milligrams
MG	Fill
mg/L	Milligrams per litre
ML	Megalitre
ML/y	Megalitres per year
MM	Mirrabooka Member
MMS	Maintenance Management System
MNES	Matters of National Environmental Significance
MOS	Manual of Standards
MSDS	Materials Safety Data Sheet
MWh	Megawatt hour
NCA	Noise Catchment Area
NE	Not Evaluated
NEPM	National Environment Protection Measure

ng/m^3	Nanograms per metre cubed
NGER	National Greenhouse and Energy Reporting
NMD	Northern Main Drain
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NPI	National Pollutant Inventory
NRP	New Runway Project
NT Act	Native Title Act 1993
NZTA	New Zealand Transport Agency Model Development Guidelines
O_3	Ozone
°C	Temperature in degrees Celsius
OEMP	Operational Environmental Management Plan
OF	Osborne Formation
OHP	Other Heritage Place
OU/m^3	Odour units
OW	Open Water
PASS	Potential Acid Sulfate Soils
PEC	Priority ecological communities
PFAS	Per- and poly-Fluoroalkyl Substances
PFOA	perfluorooctanoic acid
PFOS	Perflorooctanesulfonate
PM_{10}	Particulate matter with aerodynamic diameter less than 10 µg/m^3
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5 µg/m^3
PMP	Probable Maximum Precipitation
PMPDF	Probable Maximum Precipitation Design Flood
ppm	Parts per million
RAV	Restricted Access Vehicles
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
ROM	Regional Operations Model
RV	Revegetation
RWI Act	Rights in Water and Irrigation Act 1914
SCP	Swan Coastal Plain
SL	South Lake
SMD	Southern Main Drain
SO_2	Sulfur dioxide
SO_x	Oxides of sulfur
SPL	Sound Pressure Level
SWALSC	South West Aboriginal Land and Sea Council
SWIS	South West Interconnected System
TEC	Threatened Ecological Community
TFP	TFP Database
TVOC	Total Volatile Organic Compounds
ULP	Unleaded petrol
VEM	Visual Envelope Map
VHT	vehicle hours travelled
VKT	vehicle kilometres travelled
VOC	Volatile Organic Compound
VSAs	Vegetation and Substrate Associations
WAPC	Western Australian Planning Commission
WC Act	Wildlife Conservation Act 1950
WONS	Weeds of National Significance
WST	Western Standard Time

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