APPENDIX 19
ATTACHMENT 1

Natural Area
CONSULTING MANAGEMENT SERVICES

City of Joondalup

Hillarys – Kallaroo Coastal Foreshore Reserve Management Plan

15 November 2016

Natural Area Holdings Pty Ltd
99C Lord Street, Whiteman, WA, 6076
Ph: (08) 9209 2767
info@naturalarea.com.au
www.naturalarea.com.au

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Contents

Acknowledgements

Natural Area Consulting Management Services (Natural Area) wish to acknowledge and thank the following for assistance and input into the plan during its development:

- City of Joondalup staff
- Eco Logical Australia personnel.

Abbreviations and Acronyms

Abbreviation	Description
AHD	Australian Height Datum
BoM	Bureau of Meteorology
the City	City of Joondalup
CoJ	City of Joondalup
Cwlth	Commonwealth
DAFWA	Department of Agriculture and Food WA
DEC	Department of Environment and Conservation (now Department of Parks and Wildlife)
DER	Department of Environment Regulation (WA)
DotE	Department of the Environment (Cwlth)
DPaW	Department of Parks and Wildlife (WA)
DRF	Declared rare flora
EDOWA	Environmental Defenders Office of WA (Inc)
ELA	Eco Logical Australia
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
GIS	Geographical information system
GPS	Global positioning system
ha	Hectare
IUCN	International Union for Conservation of Nature
Km	Kilometre
Km/h	Kilometres per hour
m^2	Square metres
Natural Area	Natural Area Consulting Management Services
NIASA	Nursery Industry Accreditation Scheme Australia
PMST	Protected Matters Search Tool
SLIP NRM	Shared Land Information Portal – Natural Resource Management
WA	Western Australia
WALGA	Western Australian Local Government Association
WA Herb	Western Australian Herbarium

Executive Summary

Natural Area Consulting Management Services (Natural Area) was contracted by the City of Joondalup to prepare a Management Plan for the Hillarys – Kallaroo Foreshore Reserve. This plan identifies management strategies that will assist the City with ongoing management of the site over the next five years, with a focus on maintaining both the environmental and recreational values of the area. This Management Plan is consistent with the overarching *Coastal Foreshore Natural Areas Management Plan* whilst providing site-specific recommendations for management of the Hillarys – Kallaroo Foreshore Reserve.

The site is located approximately 21 km north-west of the Perth Central Business District in the suburbs of Hillarys and Kallaroo. The site extends from just north of Hillarys Boat Harbour in Hillarys to Merrifield Place in Kallaroo. It is split into two portions:

- the northern portion being the Kallaroo Foreshore extending south of Merrifield Place to the Whitfords Avenue and Northshore Drive roundabout
- the southern portion the Hillarys Foreshore extends from this roundabout south to the Hillarys Boat Harbour (Figure 2).

The Hillarys – Kallaroo Coastal Foreshore Reserve is characterised by thin sandy beaches in the south that become wider towards the north of the site, with a strip of vegetated dunes to the east that vary in width. Infrastructure includes car parks, shaded and non-shaded seating and picnicking areas, barbeques, playgrounds, grassed and non-grassed recreational areas, along with access ways to the beach. There are a number of swimming beaches, including those designated as dog and horse beaches. The use of this area as a horse beach is currently being considered by council.

The majority of the native vegetation at Hillarys – Kallaroo Foreshore Reserve is in Very Good – Excellent condition (Eco Logical Australia, 2016), and is part of the regional ecological linkage chain that extends along the coast from Burns Beach in the north to North Beach in the south. A range of mammal, bird, reptile and invertebrate species were observed within the reserve during spring surveys undertaken by Eco Logical Australia in 2015. The range and diversity of species recorded indicates a healthy ecological community within the reserve.

1.0 Introduction

1.1 Background

The City of Joondalup (the City) is situated on the Swan Coastal Plain, approximately 30 km north of the Perth Central Business District. The City covers an area of 96.5 kilometres that encompasses a diverse range of natural areas including 17 kilometres of coastal foreshore, a chain of wetlands and a variety of bushland ecosystems (Figure 1). The City's southern boundary is approximately 16 kilometres from the Perth Central Business District, and is bounded by the City of Wanneroo to the east and north, the City of Stirling to the south, and the Indian Ocean to the west.

There are a number of regionally, nationally and internationally significant natural areas located within the City including Yellagonga Regional Park, Marmion Marine Park, and Bush Forever sites that contain species of high conservation value. The City of Joondalup is committed to conserving and enhancing the City's natural assets to ensure the long-term protection of the environment for future generations.

1.2 Natural Area Management Plans

The City is developing Natural Areas Management Plans and associated Action Plans to provide strategic and operational management of the City's natural areas to protect native vegetation and ecosystems. Natural Areas Management Plans describe the potential environmental impacts and risks of activities and environmental threats in natural areas, and the associated management strategies that are implemented to minimise potential impacts.

Environmental threats have the potential to degrade natural areas and reduce biodiversity values. Environmental threats addressed in this Plan include weeds, plant disease, fire, non-native fauna species, human impacts, access and infrastructure.

1.3 Study Area

The study area for the Hillarys-Kallaroo Foreshore Reserve Management Plan is the Hillarys-Kallaroo Foreshore Reserve, in the suburbs of Hillarys and Kallaroo (Figure 2). The reserve is located approximately 21 km north-west of the Perth Central Business District, and covers an area of approximately 79 ha which includes native vegetation, parkland areas, carparks, tracks and roads. The site extends south of Merrifield Place in Kallaroo to Hillarys Boat Harbour in the south, and is bounded by Northside Drive to the south, Whitfords Avenue and Northshore Drive to the east, Merrifield Place to the north and the Indian Ocean to the west.

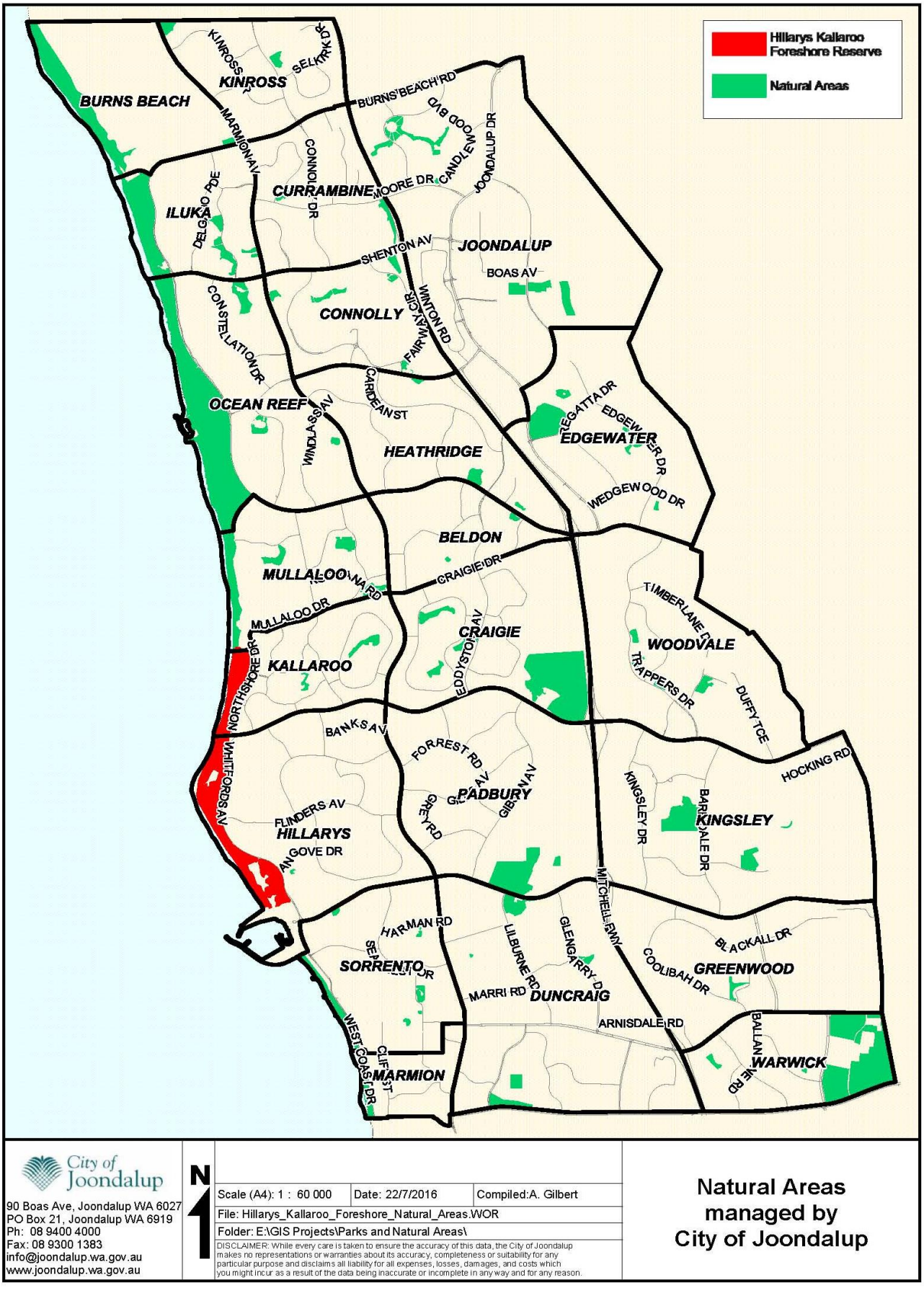


Figure 1: Location of Hillarys – Kallaroo Foreshore Reserve

Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 01/06/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 2

Hillarys Kallaroo Foreshore Reserve

0 N 250
Meters

1.4 Purpose

The purpose of the Hillarys – Kallaroo Foreshore Reserve Management Plan is to:

- provide information to assist the City of Joondalup in prioritising maintenance schedules
- guide the future development of the City's Conservation Capital Works Program
- increase opportunities for grant funding by having a detailed schedule of projects
- provide guidance to City employees, contractors and Friends Groups operating within the Hillarys – Kallaroo Foreshore Reserve.

1.5 Aims and Objectives

The aims of the Hillarys – Kallaroo Foreshore Reserve Management Plan are to:

- establish a baseline description of the environment to guide future environmental planning and recommended management actions
- outline key environmental threats and management strategies to minimise impact and protect conservation and recreational values
- outline management actions to address key threats, including monitoring and reporting.

The objective of the Hillarys – Kallaroo Foreshore Reserve Management Plan is to provide mechanisms to protect and enhance the biodiversity values of the natural area whilst maintaining appropriate community access and awareness.

1.6 Strategic Context

In order to ensure the Hillarys – Kallaroo Foreshore Management Plan complements other management initiatives within the City, along with relevant legislation, policies, guidelines and documents were reviewed and are summarised in this Section.

1.6.1 Local Government

Strategic Community Plan

The City of Joondalup's *Strategic Community Plan 2012 – 2022* is the long-term strategic planning document, which outlines the commitment of the City to achieve its commitment to achieving the visions and aspirations of its community and stakeholders.

Environmental Plan

The City of Joondalup's *Environmental Plan 2014 – 2019* was developed to guide the City's strategic response to local environmental pressures.

Biodiversity Action Plan

The City of Joondalup *Biodiversity Action Plan 2009 – 2019* was prepared to provide direction for biodiversity management activities within the City, with retention and enhancement of biodiversity a key priority. Development of individual Natural Area Management Plans was included as a management action.

Figure 3: City of Joondalup Strategic Environmental Framework

***Local Biodiversity Program* (formerly *Perth Biodiversity Project*)**

The City of Joondalup was one of 32 local governments participating in the Western Australian Local Government Association's (WALGA's) Perth Biodiversity Project, which documented the local biodiversity within its boundaries. The aim of the program was to support local governments to effectively integrate biodiversity conservation into land use planning to protect and manage local natural areas.

As part of the Program, the City of Joondalup assessed all natural areas in 2004 and at later times using the ecological criteria of the Natural Area Initial Assessment, resulting in a priority ranking of natural areas. The Natural Area Initial Assessments include a desktop assessment and field survey and document information such as:

- vegetation complexes
- threatened or significant flora or ecological communities
- structural plant communities
- weed species
- vegetation condition assessment
- ecological criteria ranking
- a viability estimate
- fauna species observed.

While funding for the program ceased in 2014, the assessment template continues to provide a useful assessment tool.

Pest Plant Local Law 2012

The purpose of the *Pest Plant Local Law 2012* is to prescribe pest plants within the City of Joondalup that are likely to adversely affect the value of the property in the district or the health, comfort or convenience of the inhabitants of the district.

Pest plants are generally highly adaptable and will establish quickly after a disturbance event such as fire, or through unrestricted access. If pest plants are allowed to establish they have the potential to out-compete the City's unique floral biodiversity. The *Pest Plant Local Law 2012* requires the owner or occupier of private land within the City of Joondalup district to destroy, eradicate or otherwise control scheduled pest plants on notice by the City. Currently one weed species is scheduled under the Local Law – Caltrop (*Tribulus terrestris*). Caltrop was not identified in the Hillarys – Kallaroo Foreshore Reserve.

1.6.2 State Government

Relevant Legislation, Policies and Documents

Aboriginal Heritage Act 1972

The Act makes provision 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. The Hillarys – Kallaroo Foreshore Reserve is not listed on any State or Federal Aboriginal heritage inventory or register.

Biosecurity and Agriculture Management Act 2007

The Act provides for the control of declared flora and fauna species (declared organisms) that are known to be a significant environmental threat and makes provision for the management, control and prevention of these declared plants and animals. No flora listed as declared pests were recorded in the Hillarys – Kallaroo Foreshore Reserve.

Bushfires Act 1954

The Act makes provision for diminishing the dangers resulting from bush fires and for the prevention, control and extinguishment of bush fires.

Cat Act 2011

The Act makes provision for the control and management of cats, and promotes and encourages the responsible ownership of cats.

Dog Act 1976

The Act requires dog owners to register their dogs and encompasses the ownership and keeping of dogs and the obligations and rights of dog owners. Local governments are responsible for administering, monitor compliance and enforcing the Act within their respective districts.

Environmental Protection Act 1986

The Act provides authority to the Environmental Protection Authority (EPA) for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment in Western Australia.

Heritage of Western Australia Act 1990

The Act provides for and encourages the conservation of places that have significance to the cultural heritage in the State. The Hillarys – Kallaroo Foreshore Reserve is not listed on any State or Federal cultural heritage inventory or register.

State Planning Policy 2.6 – State Coastal Planning Policy 2013

The purpose of the policy is to provide guidance for decision making in the coastal zone throughout Western Australia, with objectives including:

- considering coastal processes during development
- identifying appropriate and sustainable land use
- providing for public use and access of coastal areas
- the development of coastal reserves to protect, conserve and enhance coastal biodiversity, ecosystem functioning, and indigenous and non-indigenous cultural significance.

State Planning Policy 2.8 – Bushland Policy for the Perth Metropolitan Region

This policy aims to provide direction and an implementation framework that will ensure bushland protection and management issues in the Perth Metropolitan Region are appropriately addressed, and integrated with broader land use planning and decision-making.

State Planning Policy 3.7 – Planning in Bushfire Prone Areas

This strategy aims to implement effective risk-based land use planning and development to protect life and reduce the impact of bushfire on property and infrastructure, by identifying bushfire prone areas to be addressed in regards to bushfire risk management within strategic planning documents, strategic planning proposals, and subdivision and development applications.

WA Planning Commission 'Bush Forever' Strategy 2000

The Strategy identifies regionally significant bushland in the Perth Metropolitan Region to be retained, managed and protected forever. The Hillarys – Kallaroo Foreshore Reserve forms part of Bush Forever Site 325, which extends from Burns Beach south to Hillarys.

Weed Prioritisation Process 2013

The Department of Parks and Wildlife prepared the weed prioritisation process to assist with the on-ground management of weeds in a particular location, considering their ecological impact, rate of dispersal and population trend.

Wildlife Conservation Act 1950

The Act provides the statute relating to conservation and legal protection of flora and fauna. Four fauna species listed under the *Wildlife Conservation Act 1950* are considered to either use or possibly use Hillarys – Kallaroo Foreshore Reserve, these being:

- Black-striped Snake (*Neelaps calonotos*) (snake) – **Priority 3**
- Quenda (*Isoodon obesulus fusciventer*) (mammal) – **Priority 5**
- Graceful Sun Moth (*Synemon gratiosa*) (insect) – **Priority 4**
- Peregrine Falcon (*Falco peregrinus*) (bird) – **Specially Protected Fauna.**

The Quenda was captured on a trail camera during the October 2015 fauna survey undertaken by Eco Logical Australia[1].

1.6.3 Federal Government

Environment Protection and Biodiversity Conservation Act 1999

The Act provides for the protection of the environment and the conservation of biodiversity, and for related purposes. Ten *Environment Protection and Biodiversity Conservation* (*EPBC*) *Act 1999* listed species have been recorded as occurring or potentially occurring within Hillarys – Kallaroo Foreshore Reserve[1], these being:

- Australian Painted Snipe (*Rostratula australis*) – **Endangered**
- Carnaby's Cockatoo (Calyptorhynchus latirostris) – **Endangered**
- Cattle Egret (*Ardea ibis coromanda*) – **Migratory Species**
- Chuditch (*Dasyurus geoffroii*) – **Vulnerable**
- Eastern Great Egret (*Ardea modesta*) – **Migratory Species**
- Fork-tailed Swift (*Apus pacificus*) – **Migratory Species**
- Grey Wagtail (*Motacilla cinerea*) – **Migratory Species**
- Osprey (*Pandion haliaetus*) – **Migratory Species**
- Rainbow Bee-eater (*Merops ornatus*) – **Migratory Species**
- Western Ringtail Possum (*Pseudocheirus occidentalis*) – **Vulnerable.**

The Rainbow Bee-eater and Osprey were observed by Eco Logical Australia[1] during the October 2015 fauna surveys.

Australia's Biodiversity Conservation Strategy 2010-2030

The Strategy aims to protect biological diversity and maintain ecological processes and systems.

National Weeds Strategy 1997

The *National Weeds Strategy 1997* provides a strategic framework for managing weeds at a national level. As part of the implementation of the National Weeds Strategy, 32 Weeds of National Significance are identified as nationally agreed priority plant species for control and management based on the criteria of invasiveness and impact characteristics, potential and current area of spread and economic, environmental and social impacts. The Hillarys – Kallaroo Foreshore Reserve contains no known Weeds of National Significance.

Threatened Species Strategy 2015

The *Threatened Species Strategy 2015* outlines the Federal Government's approach to threatened flora and fauna species recovery through reversing population declines.

[1] Eco Logical Australia (2016)

1.6.4 International Conventions or Listings

International Union for Conservation of Nature (ICUN) Red List of Threatened Species

The ICUN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the ICUN Red List Categories and Criteria. The Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is an ICUN Red List species that has been recorded within the Hillarys – Kallaroo area.

2.0 Description of Physical Environment

2.1 Geology, Soils and Landforms

2.1.1 Soils of the Swan Coastal Plain

The Hillarys – Kallaroo Foreshore Reserve is situated within the City of Joondalup, which is located within the Swan Coastal Plain. The Swan Coastal Plain comprises two major divisions, namely Swan Coastal Plain 1 Dandaragan Plateau, and Swan Coastal Plain 2 – Perth Coastal Plain. The Hillarys – Kallaroo Foreshore Reserve is located within the Perth subregion, which is broadly characterised as including areas of Jarrah and Banksia woodlands on sandy soils in a series of sand dunes, along with wetland areas, often within the interdunal swales. The majority of the soils of the Swan Coastal Plain were formed by material deposited by rivers and wind. A series of dune systems has been formed with the youngest dunes being the Quindalup Dunes nearest the coast, followed by the Spearwood Dunes and the oldest Bassendean Dunes are the farthest inland[2] (Figure 4).

The Hillarys – Kallaroo Foreshore Reserve is located on the youngest formation, the Quindalup Dune System, which are still being actively formed. The Natural Resource Management Shared Land Information Portal (SLIP NRM Portal) indicates one soil type occurs within the site boundary, namely the Quindalup Dunes soil with four soil phases[3], which are listed and described in Table 1.

Table 1: Soil types Hillarys – Kallaroo Foreshore Reserve

Soil Code	Soils type	Description
211Qu_Qu	Quindalup South unstable sand Phase	Presently unstable calcareous sand.
211Qu_Q4	Quindalup South youngest dune Phase	Irregular foredunes with slope up to 20%, consisting of loose pale brown calcareous sand with no soil profile development.
211Qu_Q3	Quindalup South third dune Phase	Irregular dunes with slopes up to 20%, consisting of loose calcareous sand with little surface organic staining and developing cementation at depth.
211Qu_Q2	Quindalup South second dune Phase	A complex pattern of dunes with moderate relief on Holocene dunes of calcareous sand with organic staining to about 20 cm, then becoming pale brown sands, and some cementation below 1 m

(Source: Department of Agriculture and Food (WA), 2016)

The Reserve is a narrow sandy beach associated with a wider vegetated zone that ranges from 98 to 396 m wide, and ranges in height from 1 - 25 m Australian Height Datum (AHD), with the highest points occurring on three separate hills, two in the south and one in the north of the site[3] (Figure 5).

[2] Government of Western Australia (2000)
[3] Department of Agriculture and Food (WA) (2016b)

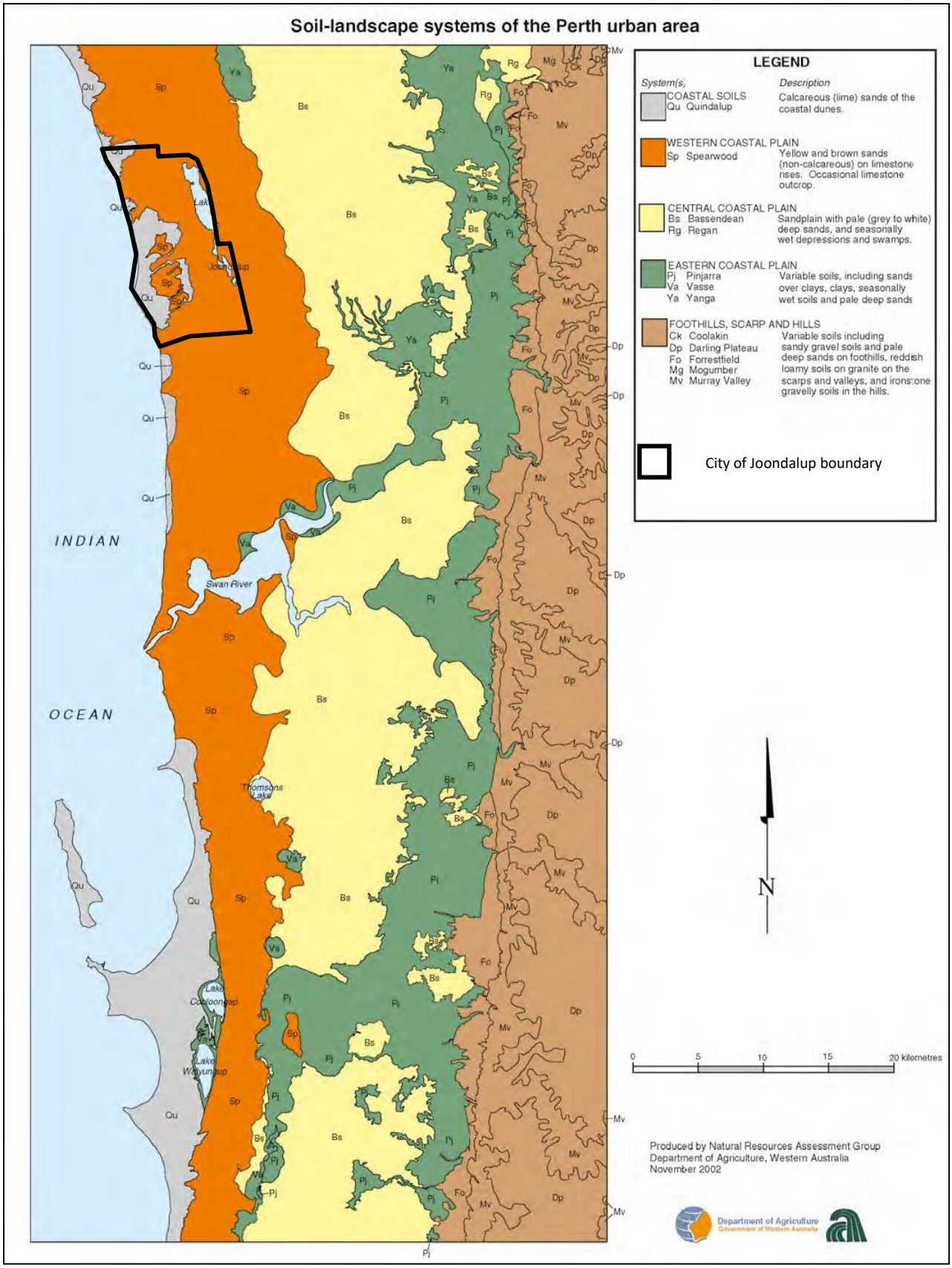


Figure 4: Soils of the Swan Coastal Plain (Department of Agriculture, 2002)

Figure 5: Topography at Hillarys – Kallaroo Foreshore Reserve narrow beach and wide vegetated high relief dunes

2.1.2 Acid Sulphate Soils

Acid sulphate soils are naturally occurring soils that contain iron sulphides, primarily in the form of pyrite materials, and are typically found in areas of low-lying coastal wetlands and tidal flats. If left undisturbed, acid sulphate soils do not pose a significant risk to humans or the environment. Exposure to air causes the formation of sulphuric acid, which can lead to the heavy metals being released into the surrounding environment[4].

Acid sulphate soils are categorised as potential acid sulphate soils or actual acid sulphate soils. Potential acid sulphate soils have not been oxidised by exposure to air whilst actual acid sulphate soils have been disturbed or exposed to oxygen and become acidic.[5] The risk of acid sulphate soils is based on their likelihood of occurring within soil profiles and has been mapped by the then Department of Environment Conservation (DEC), now the Department of Environment Regulation (DER), using available desktop information and limited ground-truthing within areas where intensive on-ground mapping and soil analysis work has been undertaken. Review of this mapping indicated that no potential acid sulfate soils are known or likely in the Hillarys – Kallaroo Foreshore Reserve on the basis of origin of the geological units present, depth to groundwater and partial 'ground truthing' or onsite investigation.

2.1.3 Erosion

Sand within the coastal dunes systems is primarily held in place by vegetation, with erosion occurring where vegetation is absent or its cover reduced. Erosion is a naturally occurring process on the coast particularly during winter months, when rainfall and wind speed increase. Human factors can increase the rate and extent of erosion via activities such as people and pets walking on the dunes instead of keeping to nominated pathways, or the installation of infrastructure in dune areas. Over time, projected climate change impacts are expected to include[6]:

- stronger winds during storm events
- increased storm surge potential
- lower rainfall, potentially leading to water stress on plants and impacts to flora and fauna habitat

[4] Department of Environment (2004)
[5] Department of Environment and Conservation, n.d.
[6] City of Joondalup (2014b)

- sea level rise and associated coastal inundation.

Accordingly, erosion is likely to be an ongoing issue that will impact on rehabilitation and ongoing maintenance requirements. Climate change risks with the City of Joondalup are outlined in the *Climate Change Strategy 2014 – 2019*[7], as are proposed mitigation and adaptation strategies. Since the building of the Hillarys Boat Harbour, trends from shoreline movement analysis indicate that the southern shoreline showed recession of sand while the northern area of Kallaroo Foreshore showed accretion of sand[8].

The Hillarys – Kallaroo Foreshore Reserve was found to be in good condition during site assessments, with the only erosion recorded occurring along the beach in front of foredunes, particularly the southern area just north of Hillarys Boat Harbour (Figure 6). A reduction of vegetation cover was noted in this area and fences were being destabilised and buried. This erosion is associated with the interruption to natural sand movement as a result of the boat harbour, creating an erosion zone immediately north of the structure.

Figure 6: Erosion along the foredunes and beach affecting stability of fencing

While the majority of the site is currently showing minimal signs of erosion, ongoing monitoring is recommended to prevent or mitigate any threatening processes that could result in erosion. Considerations for management of erosion will include:

- areas affected
- causes
- natural, conservation and human values of the affected area
- priorities for action in terms of feasibility of success in the medium to longer term
- techniques used to restore or stabilise affected areas.

The City has undertaken a coastal vulnerability study[8]. The objective of this study was to identify and prioritise the risks to the City's coastal zone in regards to the impacts of climate change and propose short and long term strategies to mitigate these risks.

The City's Coastal Monitoring Program was established in 2015/16 to monitor shoreline movements over time. The Program aims to:

[7] City of Joondalup (2014)
[8] M P Rogers and Associates (2012)

- provide valuable information that can be used to inform planning decisions in the coastal zone
- inform maintenance and asset replacement schedules of coastal infrastructure
- provide early warning of any increased vulnerability of assets
- guide the timing and need for coastal adaptation works
- identify the requirement for updates to hazard and vulnerability assessments
- improve the City's understanding of coastal processes and monitor actual shoreline erosion compared to modelled erosion.

The Coastal Monitoring Program includes: photo monitoring at identified sites (every six months), shoreline mapping from aerial photography (annually), beach profile surveys (every two years) and analysis and report (every two years).

Erosion from both natural and human causes can largely be managed through sand stabilisation and access control. Revegetation and rehabilitation activities are often the most effective means of stabilising sand dune areas. These can include:

- applying appropriate revegetation techniques that will allow plants to become established and stabilise the soil
- erecting sand trap fencing that allows wind-borne sand to collect and create incipient dunes over time
- applying some form of stabilising material such as biodegradable jute or coir matting, brushing or mulch to exposed areas to provide a stable surface that will allow seedlings to become established and grow
- use of signage to provide information about erosion and the need to keep off the dunes
- establishing barriers to deter human (and their pets) access to vegetated areas, and allowing bare areas to regenerate.

2.1.4 Recommended Management Actions

Action	Detail
Holistic consideration of erosion	Erosion issues to be considered holistically, with the most appropriate management options being determined on a case by case basis and recognising that all exposed sand does not need to be covered by vegetation, reflecting what would occur within a natural environment.
Brushing	Brushing materials will be of suitable species that do not contain seed pods or other materials that can propagate and result in the presence of weeds at the site.
Early consideration of erosion	Address erosion issues as early as possible to avoid larger areas to be rehabilitated later.
Wider context	Consider erosion in the wider context of climate change impacts that could occur over time.

2.2 Hydrology

2.2.1 Groundwater

The City of Joondalup is located on Perth's largest source of groundwater, the Gnangara Groundwater System, comprising four main aquifers: superficial (shallow, unconfined), Mirrabooka (deeper, semi confined), Leederville (deep, mostly confined) and the Yarragadee (deep, mostly confined). The Gnangara

Mound extends across most of the superficial aquifer and refers to the water table creating a mound shape (Figure 7). Groundwater levels in the superficial aquifer have been declining over recent years due to pressure from extraction and the impacts of climate change.

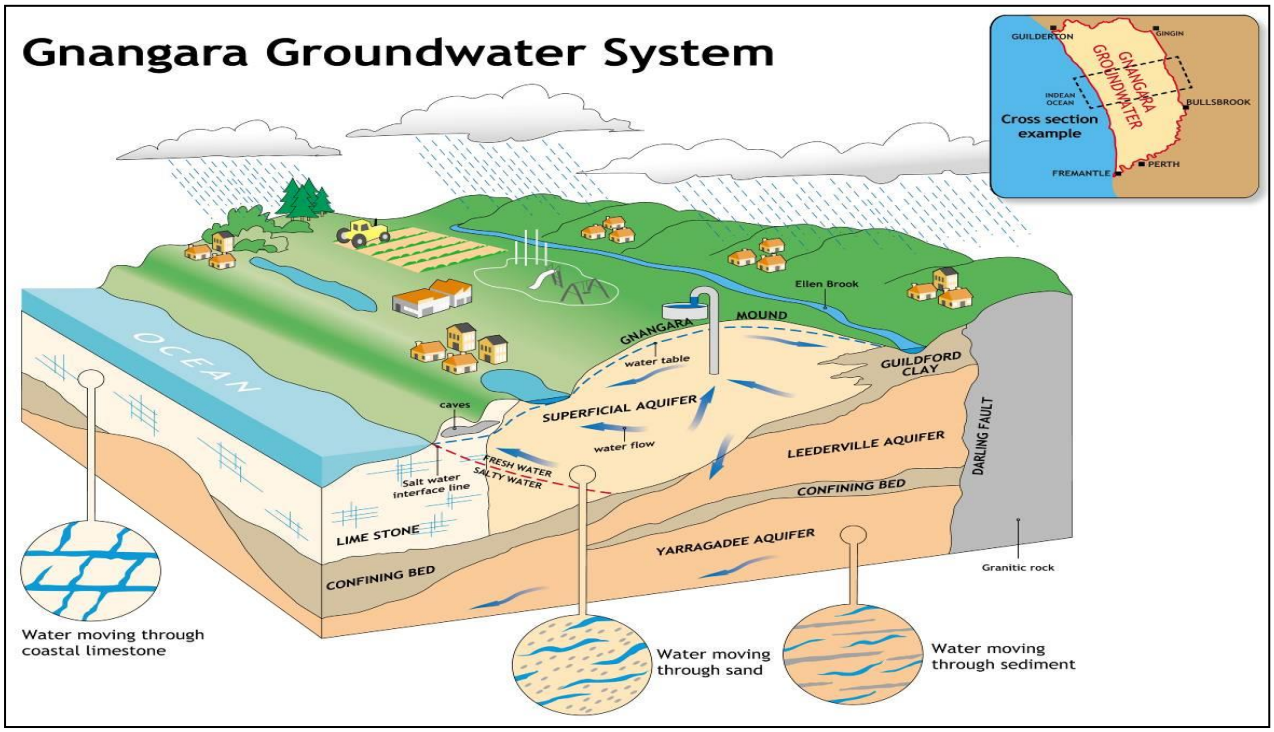


Figure 7: Gnangara Groundwater System[9]

2.2.2 Drainage

Hillarys – Kallaroo Foreshore Reserve has one small lake present at the southern end of the site, within the parkland area. Depth to groundwater in the site ranges from 0 m to 21 m below ground level[10], which is consistent with a site located on the coast, where ground water enters into the ocean (Figure 8).

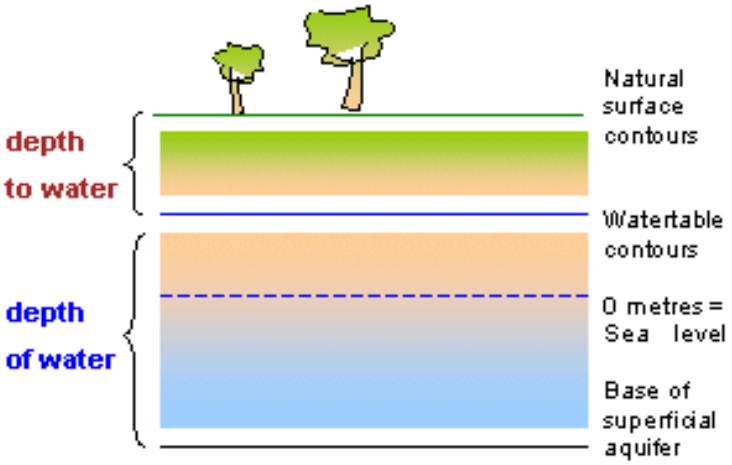


Figure 8: Groundwater Depth Explanation[11]

[9] Department of Water (n.d.)
[10] Department of Water (2016)
[11] Department of Environment (2004)

2.3 Climate

The City of Joondalup experiences a Mediterranean climate of hot dry summers with an average temperature of 30.9 °C during the day and mild wet winters with an average daytime temperature of 18.5 °C. The average annual rainfall from 1944 to 2016 was 767.4 mm, with approximately 80 percent of the annual rainfall occurring between the months of May and September (Figure 9)[12].

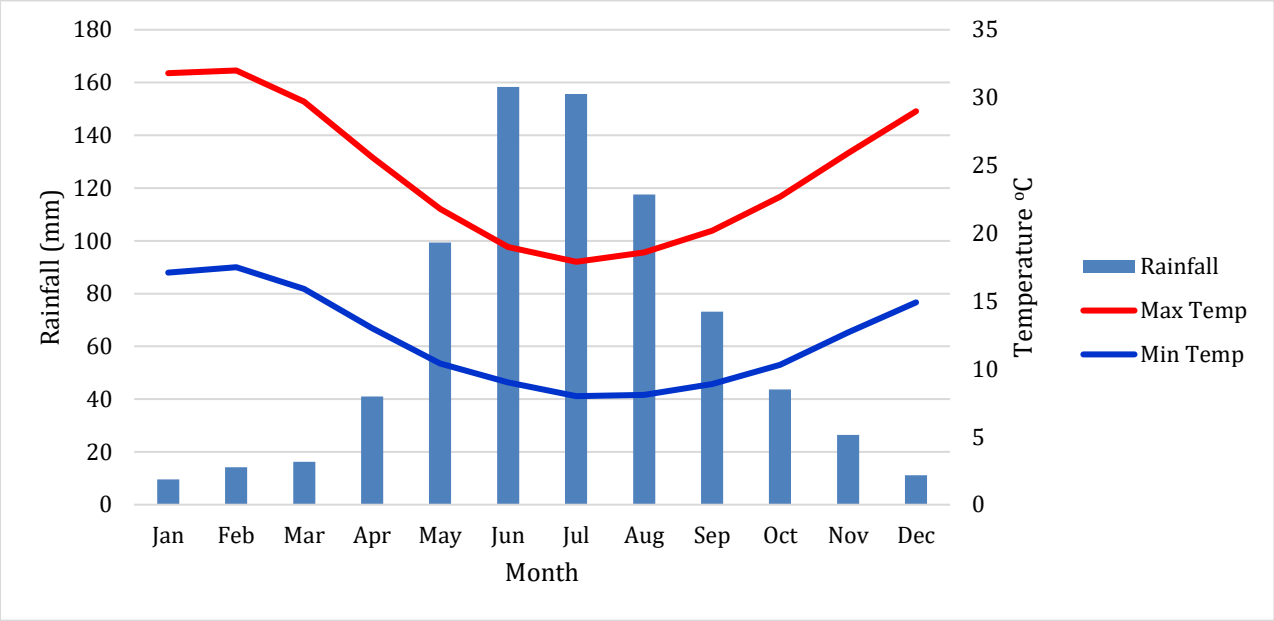


Figure 9: Climate data for Perth

2.4 Vegetation

Flora surveys were undertaken by Eco Logical Australia in October 2015 and this section provides their results.

2.4.1 Vegetation Complexes

Vegetation complexes are classified by the soil and landforms contained in medium to large areas along the Swan Coastal Plain. Regional scale mapping indicates that the Hillarys – Kallaroo Coastal Foreshore Reserve occurs within the 'Quindalup Complex on Quindalup Dunes' (Figure 10). The Quindalup Complex is a coastal dune complex consisting mainly of two alliances – the strand and foredune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera*[13].

The pre-European extent remaining within the Swan Coastal Plain IBRA region for the Quindalup Complex is 55.38%[14]. The pre-European extent remaining within the City of Joondalup is 12.55%[15].

[12] Bureau of Meteorology (2016)
[13] Heddle *et al*. (1980)
[14] WALGA (2013)
[15] WALGA (2010)

2.4.2 Floristic Community Types

According to *Bush Forever Vol. 2* seven Floristic Community Types (FCTs) have either been sampled within or inferred to occur within Bush Forever Site 325, with five likely to occur on site due to soil and landforms present[16]. These include:

- 29a Coastal shrublands on shallow sands (sampled within Bush forever Site 325)
- 29b *Acacia* shrublands on taller dunes (inferred)
- S11 Northern *Acacia rostellifera — Melaleuca acerosa* shrublands (inferred)
- S13 Northern *Olearia axillaris — Scaevola crassifolia* shrublands (inferred)
- S14 *Spinifex longifolius* grasslands and low shrublands (inferred).

According to Eco logical Australia two FCTs were recorded on site during 2015 site assessments, including FCT 29a and FCT 29b. Both these FCTs are listed as Priority Ecological Communities[17].

2.4.3 Vegetation Communities

Three vegetation communities were recorded by Eco Logical Australia in October 2015 within the study area[17] (Table 2 and Figures 11 and 12):

Vegetation community 1 (ArAcTOS): *Acacia rostellifera* and *Acacia cyclops* tall open shrubland over *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena, Rhagodia baccata* subsp. *baccata* and *Acanthocarpus preissii* low shrubland over *Lepidosperma gladiatum* open sedgeland. It is common for *Acacia rostellifera* to form dense thickets in this vegetation community. Other associated species include *Acacia lasiocarpa* var. *lasiocarpa, Clematis pubescens, Hardenbergia comptoniana, Leucopogon parviflorus, Poa poiformis, Scaevola crassifolia and Templetonia retusa. Spinifex hirsutus* is commonly found on the dunes adjacent to the beach.

Vegetation community 2 (SgOaS): *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena*, *Acacia lasiocarpa* var. *lasiocarpa* and *Acanthocarpus preissii* low shrubland over *Lomandra maritima* open herbland. Other associated species include *Conostylis candicans*, *Gompholobium tomentosum*, *Hardenbergia comptoniana*, *Hibbertia subvaginata*, *Lepidosperma squamatum*, *Leucopogon parviflorus*, *Rhagodia baccata* subsp. *baccata* and *Santalum acuminata*. This vegetation community was recorded on the higher dune system in the north of the study area. They key difference to vegetation community 1 was the absence of *Acacia rostellifera* and *Acacia cyclops* in the upper stratum.

Vegetation community 3 (OaApRbLOS): *Olearia axillaris, Acanthocarpus preissii* and *Rhagodia baccata* subsp*. baccata* low shrubland over *Spinifex hirsutus* very open grassland. Other associated species include *Scaevola crassifolia, Lepidosperma gladiatum* and *Carpobrotus virescens*.

Two parkland and three revegetation areas were also recorded by Eco Logical Australia during the October 2015 surveys within the site (Figures 11 and 12); these areas were not assessed for vegetation condition[17]. Parkland areas comprised grassed areas with remnant native and planted non-native trees.

[16] Government of Western Australia (2000)
[17] Eco Logical Australia (2016)

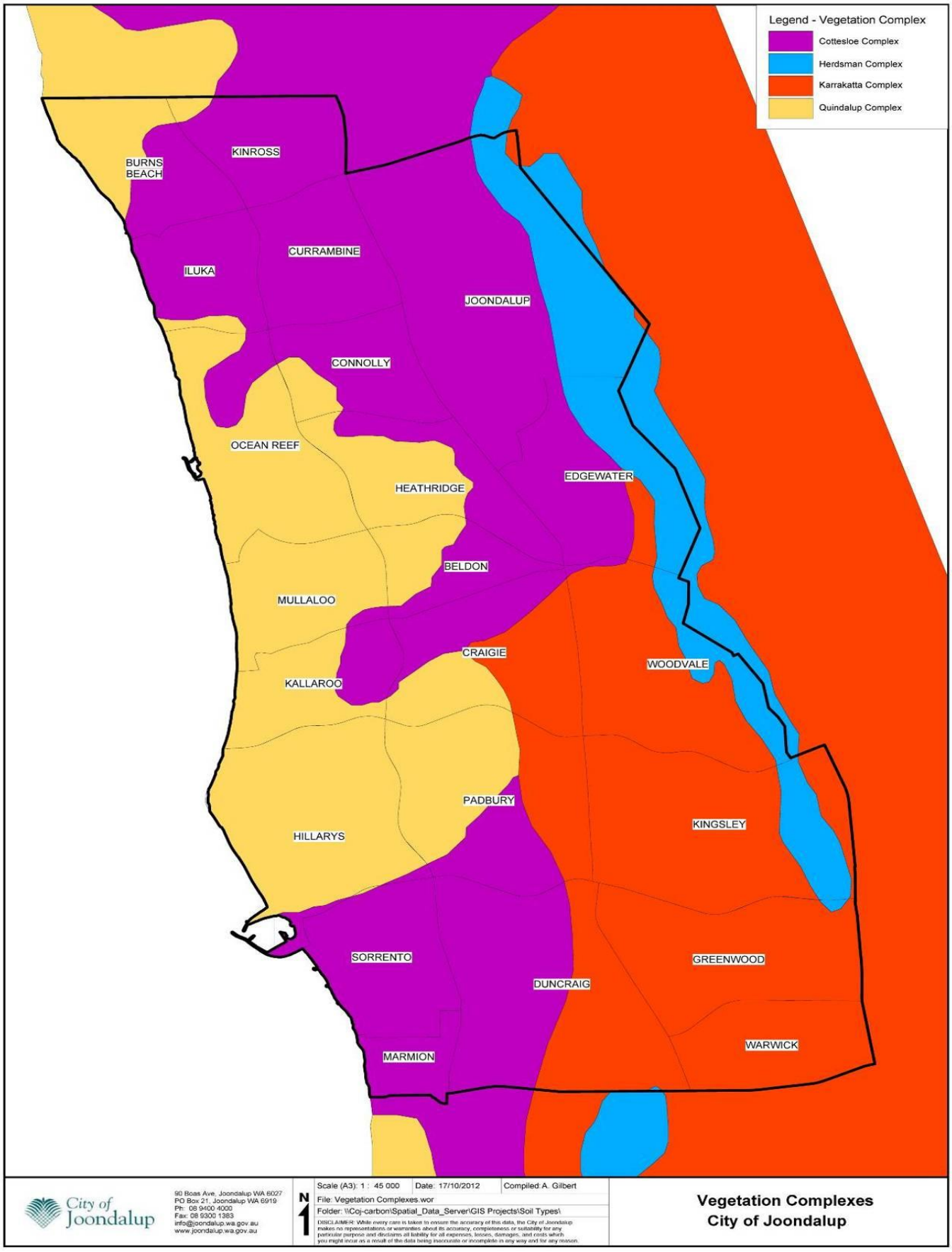


Figure 10: City of Joondalup Vegetation Complexes

Table 2: Vegetation communities identified within the study area[18]

Vegetation community	Description	Condition	Extent within study area
1: ArAcTOS	*Acacia rostellifera* and *Acacia cyclops* tall open shrubland over *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena*, *Rhagodia baccata* subsp. *baccata* and *Acanthocarpus preissii* low shrubland over *Lepidosperma gladiatum* open sedgeland.	Excellent to Completely Degraded	52.1 ha
			
2. SgOaS	*Spyridium globulosum* and *Olearia axillaris shrubland* to open shrubland over *Melaleuca systena, Acacia lasiocarpa* var. *lasiocarpa* and *Acanthocarpus preissii* low shrubland over *Lomandra maritima* open herbland.	Excellent to Good	7.8 ha
			
3. OaApRbLOS	*Olearia axillaris, Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland over *Spinifex hirsutus* very open grassland.	Excellent to Good	7.2 ha
			

[18] Eco Logical Australia (2016)

Figure 11: Vegetation types Hillarys – Kallaroo Foreshore Reserve (north) (Eco Logical Australia, 2016)

Figure 12: Vegetation types Hillarys – Kallaroo Foreshore Reserve (south) (Eco Logical Australia, 2016)

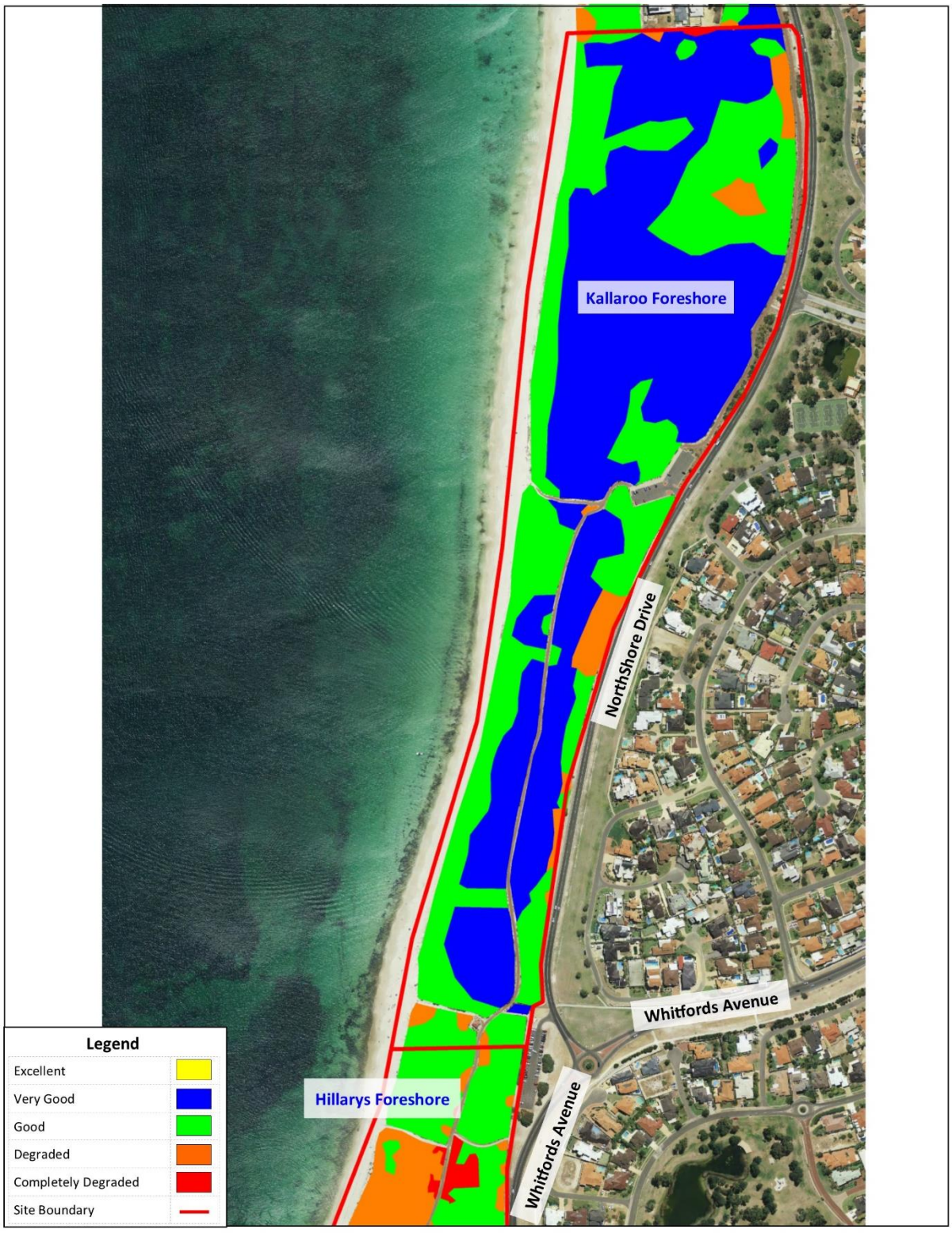
2.4.4 Vegetation Condition

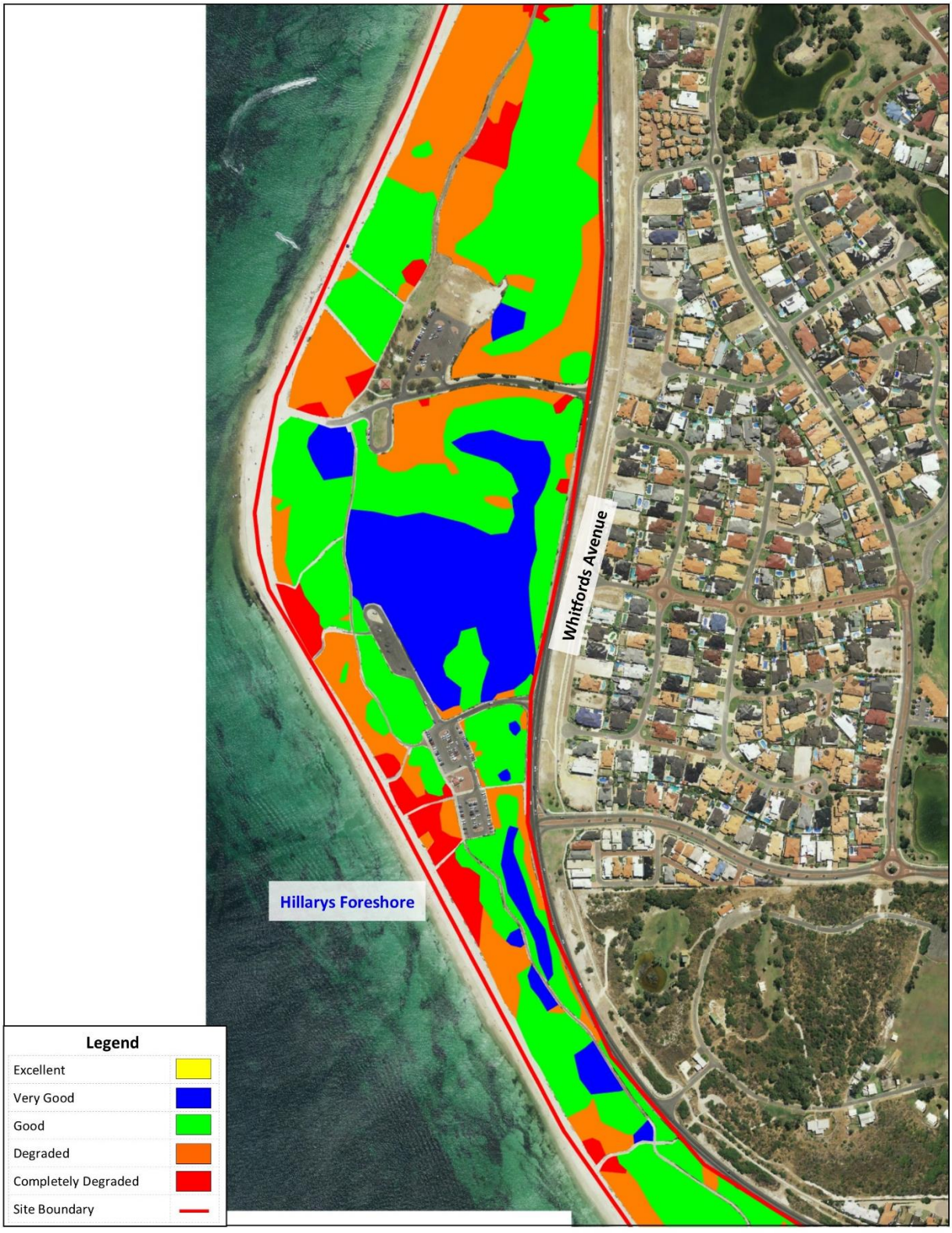
Vegetation condition assessments were undertaken by Natural Area in 2012, with little change noted during the on-ground site assessments in 2016. Vegetation condition assessments include observations regarding the numbers of native species, weed cover, species diversity, amount of understorey, health condition of most species' populations and physical disturbance.

Vegetation condition at the Hillarys – Kallaroo Foreshore Reserve ranges from Completely Degraded to Very Good, with the majority of the site in Good to Very Good condition, and none of the site considered to be in Excellent or Pristine condition (Table 3; Figures 13, 14 and 15). Vegetation in the Kallaroo Foreshore portion of the site was classified as mostly Good to Very Good condition, with small areas recorded as Degraded along Northshore Drive and in isolated pockets in the north-east and south-west corners of this sector. An isolated patch recorded as Completely Degraded is also present along the northern boundary (Figure 13). The majority of vegetation in the Hillarys Foreshore portion is considered to be in Good and Very Good condition, although large areas recorded as Degraded are found along the foredune areas and adjacent to car parks, parkland and roads, with smaller portions in these areas considered Completely Degraded (Figures 13, 14 and 15).

Table 3: Vegetation Condition at Hillarys – Kallaroo Foreshore Reserve

Vegetation Condition	Pristine	Excellent	Very Good	Good	Degraded	Completely Degraded
Area (ha)	0	0	19.9	36	10.6	1.8
Area (%)	0	0	29.1	52.7	15.6	2.6


Kallaroo Foreshore
Hillarys Foreshore
NorthShore Drive
Whitfords Avenue
Whitfords Avenue
Legend
Excellent
Very Good
Good
Degraded
Completely Degraded
Site Boundary
Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 09/11/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50
Figure: 13
Vegetation condition - Hillarys Kallaroo Foreshore Reserve (map 1)
0
N
200
Meters



Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 09/11/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 14

Vegetation condition - Hillarys Kallaroo Foreshore Reserve (map 2)

0 N 200
Meters

Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 09/11/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 15

Vegetation condition - Hillarys Kallaroo Foreshore Reserve (map 3)

0 N 200

Meters

3.0 Biodiversity Conservation

The Hillarys – Kallaroo Foreshore Reserve supports a range of flora and fauna species, and provides an important ecological linkage to adjacent coastal reserves. The long term protection of biodiversity values within the reserve is critical to ensure the conservation of this habitat. The protection and enhancement of biodiversity within the reserve also benefits the community through the provision of ecological services, including:

- the production of oxygen and capture of carbon dioxide
- noise and air quality regulation
- cooling of urban environments
- supporting seed dispersal and pollination
- a number of recreational and cultural experiences[19].

A number of environmental threats pose a risk to the biodiversity of the Hillarys – Kallaroo Foreshore Reserve. The key environmental threats include:

- weeds
- pathogens and disease
- non-native fauna species
- human impacts
- access and infrastructure
- fire.

Management strategies to mitigate the effects of key environmental threats have been established and are discussed in the following sections.

3.1 Flora

The Hillarys – Kallaroo Foreshore Reserve is located in the Southwest Australian biodiversity hotspot, which is one of the world's 34 biodiversity hotspots. It extends from Shark Bay in the North to Israelite Bay in the south, with over 2,900 endemic plant species occurring within the region. Approximately 30% of the original vegetation extent of this area remains, with habitat loss primarily due to agricultural expansion[20].

Flora surveys enable collection of scientific data related to the occurrence and distribution of flora species and vegetation communities. Information obtained from flora surveys is used as a baseline to monitor the ecological health of flora populations and vegetation communities. Eco Logical Australia was engaged to undertake a desktop and field flora survey of the Hillarys – Kallaroo Foreshore Reserve in October 2015.

[19] City of Joondalup (2014a)
[20] Conservation International (2016)

3.1.1 Flora Survey Methodology

Desktop and on-ground flora survey methodology for the Hillarys – Kallaroo Foreshore Reserve was undertaken by Eco Logical Australia in October 2015 in accordance with *EPA Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*. The survey methodology undertaken is explained in *Whitfords Nodes Foreshore Flora, Fauna and Fungi Survey*[21].

3.1.2 Native Flora

Native flora is an important part of the Hillarys – Kallaroo Foreshore Reserve ecosystem, providing food and habitat for fauna present. Reduction in flora species or vegetation cover can lead to a loss of fauna that depend on it for resources and shelter. A total of 79 flora taxa were recorded within the Reserve, including 51 native and 28 introduced taxa[22]. Of note was the *Lomandra maritima,* which is a known habitat species for the Graceful Sun Moth (*Synemon gratiosa*) which is listed as a Priority 4 species under the *Wildlife Conservation Act 1950* (WA). No Threatened or Priority flora species were recorded within the Hillarys – Kallaroo Foreshore Reserve[22].

3.1.3 Weeds

Weeds can be native or introduced species that have colonised an area where they did not originally exist. An environmental weed generally reproduces quickly, and requires action to reduce its negative impact on economic, social and environmental values of the area. Weeds are commonly introduced and distributed within bushland areas through seed dispersal by water, wind, animals such as birds, fire, the dumping of garden waste, and human or vehicle movement in natural areas. Weeds can have major economic, environmental and social impacts in Australia and can:

- displace native plant species
- alter nutrient cycling and soil quality within ecosystems
- harbour pests and diseases
- increase fire fuel loads
- impact negatively on native flora and fauna and their habitats
- compete with native species for resources[22].

Over 28,000 known alien plant species have been introduced to Australia with approximately 10% now being established in the environment.[23] Garden plants are the main source of Australia's weeds, accounting for 66% of recognised weed species.[24]

A total of 28 weed species were recorded within the Hillarys – Kallaroo Foreshore Reserve by Eco Logical Australia during the October 2015 surveys. No weeds of national significance (WoNS) or declared pests listed under the BAM Act were recorded within the Reserve. Three species are listed on the City of Joondalup's priority weed list, including Geraldton Carnation Weed (*Euphorbia terracina*), Gazania (*Gazania linearis*) and Rose Pelargonium (*Pelargonium capitatum*)[22].

[21] Eco Logical (2016)
[22] Department of the Environment (2015)
[23] Groves, Bowden and Lonsdale (2005)
[24] DSEWPC (2013)

3.1.4 Revegetation

The City of Joondalup encourages natural bushland regeneration through weed management and conservation fencing to allow the vegetation to re-establish itself and maintain species diversity and populations. Revegetation is undertaken on an as required basis in Degraded, Completely Degraded, or other areas where further planting is considered to be beneficial using local provenance species.

The Hillarys – Kallaroo Foreshore Reserve has been subjected to weed control and revegetation in particular areas, which has increased biodiversity and reduced weed abundance. Areas of Good vegetation condition (Figure 16) that would benefit from additional planting along with a proposed planting list is provided in Appendix 7, including species that are not present or under-represented on site.

Figure 16: Area of Good vegetation condition suitable for revegetation activities

3.1.5 Current Management Approach

The City undertakes an integrated approach to weed management, including:

- prevention of weed introduction through hygiene measures
- regular monitoring and reporting of weed populations
- on ground weed control, including prioritisation of natural areas and priority weeds to target
- community education initiatives
- fire prevention measures
- hand weeding by bushland friends group volunteers and contractors.

Weed monitoring is conducted by the City every six months at the Hillarys – Kallaroo Foreshore Reserve to establish the extent and distribution of weeds species and to identify priority weeds.

Previously Natural Area Initial Assessments were conducted in the Reserve to assess site specific ecological values, biodiversity significance and threatening processes. This system will be replaced with a flora, fauna and fungi survey as part of a management plan review being undertaken every five years within the Hillarys – Kallaroo Foreshore Reserve.

In accordance with the Natural Area's Annual Maintenance Schedules and Weekly Bushland Schedules, on ground weed management occurs through weed spraying and hand weeding methods. In addition to this, contractors are engaged to spray weeds and hand weed. City of Joondalup personnel act in accordance with internal spraying procedures and conduct trials periodically to evaluate the most effective management

methods. Resources, such as the DPaW FloraBase website or *Southern Weeds and their Control* (DAFWA Bulletin 4744), are also consulted in regards to weed control.

Environmental weeds are classified as priority if they meet any of the following criteria:

- weed of national significance (WoNS)
- declared plant listed under the *Biodiversity and Agriculture Management Act 2007* (WA)
- high priority weed according to the Swan Regional Ranking
- pest plant under *Local Government Act 1995* (WA)
- major threat to vegetation
- major threat to the structure of vegetation communities
- contribute to a high fuel load, for example dry grasses.

A list of weeds and their priority rating according to the DPaW Swan Regional Ranking is provided in Appendix 5, with the recommended weed treatment methodology for high priority weed species detailed in Appendix 6.

The City of Joondalup *Weed Management Plan* is being developed to provide an ongoing strategic approach to the management of natural areas and parks in order to reduce the incidence of weeds. A number of education initiatives are undertaken to raise the awareness of weeds with the community, these include:

- delivery of gardening workshops
- development and distribution of two weed brochures – *Environmental Weeds* and *Garden Escapees* (available in hard copy and on the City's website)
- weed education workshops for local Friends Groups.

3.1.6 Recommended Management Actions

To monitor, conserve and protect native flora in the Hillarys – Kallaroo Foreshore Reserve, the following management actions are proposed.

Action	Detail
Weed survey	Continue to undertake weed surveys every six months.
Targeted weed control	Continue to undertake a targeted weed control program, as described in Appendix 6.
Ongoing weed control	Continue to undertake coordinated approach to regular weed control by implementing the Natural Area's Annual Maintenance Schedule.
Weed Management Plan	Implement the City of Joondalup Weed Management Plan when it is developed to provide an ongoing strategic approach to the management of natural areas in order to reduce the incidence of weeds.
Restoration	Conduct restoration as outlined in the Revegetation Strategy in Appendix 7.
Friends Group	Encourage the formation of a Friends Group for the Hillarys-Kallaroo Foreshore Reserve.

3.2 Fungi

It is estimated that there are 10 times more species of fungi than plants in the world, equating to approximately 140,000 fungi and 14,000 plant species in Western Australia. The amount of species of fungi present in bushland can be an indicator of ecosystem health. Fungi are strongly interconnected with plants and animals as fungi are recyclers that break down litter and debris to provide nutrients for plants. Native plants such as eucalypts, wattles and orchids have beneficial partnerships with fungi. Fungi also provide food and/or habitat for fauna such as bandicoots and beetles[25].

Fungi surveys are important to provide baseline information, and to highlight changes in fungi occurrence over time. Undertaking surveys also enables comparison of ecological data with other City of Joondalup natural areas. The most common time to see the fruiting bodies of fungi is after autumn and winter rains.

3.2.1 Fungi Field Survey

Two fungi species were identified within the Hillarys – Kallaroo Foreshore Reserve during the October 2015 opportunistic field survey conducted by Eco Logical Australia[26], the *Schizophyllum commune* (Split-Gill Fungus) and *Pycnoporus coccineus* (Scarlet Bracket Fungus). The low numbers of fungi observed is probably due to dry conditions as the fungi survey occurred at a later than optimal time to see fruiting bodies, which is usually May – July after autumn rains. Other species likely to occur are expected to be similar to those observed within the Marmion Coastal Foreshore Reserve and other City of Joondalup bushland areas.

3.2.2 Current Management Approach

The City of Joondalup currently monitors fungi in the Reserve through surveying for incidental sightings of fungi species every 5 years.

3.2.3 Recommended Management Action

To monitor fungi health in the Hillarys – Kallaroo Foreshore Reserve, the following management action is proposed:

Action	Detail
Opportunistic fungi survey	Continue to undertake opportunistic fungi sightings during other site activities.
Fungi survey	Engage consultants to undertake a comprehensive fungi survey in winter after substantial rain, such as mid-June to end of July to supplement previous incidental fungi survey.

3.3 Plant Diseases

Vegetation can be subject to diseases that result in plant health decline and potentially death in the longer term. Pathogens are the organisms such as fungi, bacteria and viruses that cause plant diseases; with many introduced into new areas through movement of infected plant material or soils, whilst some are naturally

[25] Bougher (2009)
[26] Eco Logical Australia (2016)

occurring in the soil. Some pathogens will result in rapid plant death while others will lead to the slow decline in plant health over time[27].

Phytophthora dieback is a water-borne fungus and the most common plant disease encountered on the Swan Coastal Plain, with the most common species encountered being *Phytophthora cinnamomi*. While *Phytophthora cinnamomi* is considered the most destructive, other varieties are being described which may have similar impacts, such as *Phytophthora multivora* which is known to attack a variety of species including *Eucalyptus gomphocephala*, *E. marginata* and *Agonis flexuosa* and a range of Banksia species[28]. The nature of the vegetation combined with the presence of limestone based soils within the foreshore reserve mean that *Phytophthora cinnamomi* is unlikely. However, *Phytophthora multivora* is known to be tolerant of alkaline conditions as it has been found in Tuart forests underlain by limestone soils south of Mandurah and as far as Cape Naturaliste, where it has been associated with individual spot deaths and areas of tree decline. *Phytophthora multivora* has been recorded in urban areas of Perth, including inland dune systems and within the City's parks[28]. If suspected within the foreshore reserve or other natural areas, it should be treated in the same manner as *Phytophthora cinnamomi*.

Armillaria luteobubalina has been identified within a number of parks within the City of Joondalup. *Armillaria* is a soil-borne fungus that causes root rot of a wide variety of plants including many species of native flora. The fungus is native to Australia and can cause major damage to natural ecosystems. *Armillaria luteobubalina* is commonly known as the 'Honey Fungus' due to the colour of the fruiting body seen above the ground during certain times of the year (Figure 17). Fruiting bodies (mushrooms) are not evident at all infected sites and their presence is usually a sign that the fungus is well established in that area[28].

Figure 17: *Armillaria luteobubalina*

At present, there is no reliable mechanism for the complete eradication of *Phytophthora* species and the control of *Armillaria luteobubalina* is both expensive and labour intensive.

3.3.1 Current Management Approach

The City of Joondalup has developed a Pathogen Management Plan to protect native vegetation and ecosystems by establishing the level of risk for areas to be infected by pathogens, prioritisation of areas and

[27] City of Joondalup (2012)

detail preventative and management actions to be implemented within the City, including guidelines for dieback-free purchasing, a hygiene procedure, sampling of high-risk areas and aerial mapping.

The City engages consultants to undertake pathogen sampling in natural areas that are assessed to be at a high risk of infestation. In addition to this aerial photography is acquired every two years and is analysed to assess changes in the vigour and health of trees and plants over time. Sampling undertaken by Arbor Consulting[28] near Pinnaroo in 2016 confirmed the presence of:

- *Diplodia* species and *Quambalaria cyanescens* (Marri Canker) in Hibbertia
- *Phytophthora* sp. in *Acacia rostellifera*
- *Quambalaria cyanescens* and *Neofusicoccum australe* in Hibbertia.

In order to reduce the risk of spreading pathogens between vegetated areas, City of Joondalup personnel currently spray vehicles, shoes and tools with methylated spirits and brush down before they enter and leave bushland reserves. Contractors working within natural areas are required to adhere to the City's hygiene protocols.

3.3.2 Recommended Management Action

To prevent pathogen spread and protect biodiversity values at the Hillarys – Kallaroo Foreshore Reserve, the following management action is recommended:

Action	Detail
Pathogen Management	Implement recommendations from the Pathogen Management Plan that are applicable to the management of the Hillarys – Kallaroo Foreshore Reserve, particularly in sites affected by pathogens.
Sampling and mapping	Undertake additional sampling and high-resolution mapping of Phytophthora in affected sites.

3.4 Fauna

Fauna surveys were undertaken by Eco Logical Australia in October 2015 to establish a species baseline inhabiting the Reserve, and document their occurrence, distribution and minimum population numbers. Outcomes of the Eco logical Australia fauna surveys are presented in this section.

3.4.1 Fauna Survey Methodology

Desktop and field fauna survey activities were undertaken by Eco Logical Australia in accordance with *EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*, along with the principles outlined in *EPA Position Statement No. 3: Terrestrial Biological Surveys as an element of Biodiversity Protection, and the Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*. Detailed methodology undertaken by Eco Logical Australia for the October 2015 fauna surveys can be found in *Whitfords Nodes Foreshore Flora, Fauna and Fungi Survey*[29].

[28] Arbor Consulting, 2016
[29] Eco Logical Australia, 2016

3.4.2 Native Fauna

Fauna and flora are interconnected in complex relationships with each other and with factors such as soil, water, climate and landscape. The decline of native fauna can cause loss of plant species and changes to ecological communities, for example, the loss of pollinating fauna species can reduce or even cease plant reproduction. A total of 16 native species of vertebrate fauna were recorded within the site by Eco Logical Australia in October 2015, of which ten were birds, five were reptiles and two were mammals[30].

Mammals

Eco Logical Australia recorded two native and five introduced mammals within the site[30] (Appendix 4). One common bat species the *Chalinolobus gouldii* (Gould's Wattled Bat) was recorded, and is likely to use the site for foraging and roosting in larger trees present at the south of the site[30].

Birds

Thirty bird species were recorded Eco Logical Australia during 2015 surveys (Appendix 4). Most species recorded are common on the Swan Coastal Plain and widespread throughout the South West of WA. Two conservation significant species were recorded the Rainbow Bee-eater (*Merops ornatus*), and the Osprey (*Pandion haliaetus*) which was recorded to be nesting on the communication tower in the south of the site[30]. Both species are listed as Schedule 5 under the *Wildlife Conservation Act 1950* (WA), and as Migratory under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth). One additional species, the White-breasted Robin (*Eopsaltria georgiana*), was opportunistically observed during the 2016 site assessment undertaken by Natural Area (Figure 18).

Figure 18: White-breasted Robin (*Eopsaltria georgiana*)

Reptiles

Sixteen reptile species were recorded during the 2015 survey[30] (Appendix 4), and all were common to the Perth region. No priority or threatened reptiles were recorded. Reptiles captured were in good health and signs of breeding populations were indicated by the capture of immature or sub-adult aged reptiles[30]. The presence of the Burton's Legless Lizard (*Lialis burtonis*) which preys on small skink lizards indicates an abundance of small skinks in the site[30]. The number of species captured including three of the largest skink species occurring on the Swan Coastal plain indicates a high diversity of reptiles within the site[30].

Amphibians

No amphibians were recorded during the 2015 survey, and may be due to dry weather conditions at the time[30]. Two species the Western Banjo Frog (*Limnodynastes dorsalis*) and the Turtle Frog (*Myobatrachus gouldii*) have been recorded in nearby bushlands within 5 km of the site[30] (Appendix 4).

Invertebrates

A total of 53 invertebrate species from 17 orders were recorded opportunistically by Eco Logical Australia during the 2015 fauna survey[30] (Appendix 4). This number represents a portion of the invertebrates expected to be at the site, with the diversity of species expected to be high due to the good condition of vegetation present[30].

3.4.3 Non-native Fauna

Non-native fauna impact native fauna and flora through predation, competition for food and shelter, spreading diseases and destroying habitat. These impacts can result in the diminishing or extinction of native species.[30] Non-native animals such as cats, foxes, rabbits, mice, birds, millipedes and bees inhabit the City's bushland, wetland and coastal areas.

Introduced Mammals

Five introduced mammal species were recorded during the October 2015 surveys[30] including the *Domestic cat (*Felis catus*), * House Mouse (*Mus musculus*), * European Rabbit (*Oryctolagus cuniculus*), * Black Rat (*Rattus rattus*), and *European Red Fox (*Vulpes vulpes*)[30]. Most of these species were captured in traps or on motion detection cameras, except for the European Rabbit and the European Red Fox where no individuals were observed but several Rabbit warrens and one Fox den were recorded on site[31].

Introduced Birds

Four introduced bird species were recorded during the October 2015 survey within the site, including the * Domestic Pigeon (*Columba livia*), * Spotted Turtle-Dove (*Streptopelia chinensis*), * Laughing Turtle-Dove (*Streptopelia senegalensis*) and the * Rainbow Lorikeet (*Trichoglossus haematodus* subsp. *moluccanus*)[30] (Appendix 4). These species are common throughout the Perth metropolitan Region[31]. Introduced birds have a negative impact on native species by increasing competition with native species for food and nesting resources.

Introduced Invertebrates

Two introduced invertebrates were recorded during October 2015 site assessments including the *European Honey Bee (*Apis mellifera*), which was recorded in several locations across the site, however no bee hives were recorded[30]. This species can negatively impact native bird species by increasing competition for nesting hollows, and can pose a safety risk to people utilising the site. The introduced Portuguese Millipede (*Ommatoiulus moreleti*) was also recorded throughout the site[30]. This species is considered to be a pest at high population levels, and is avoided by many predators[31]. This species is common within bushland and suburban areas across the Perth Metropolitan Region[30].

[30] DSEWPC (2012)
[31] Department of Agriculture and Food (WA) (2016a)

3.4.4 Fauna Habitat

Three vegetation communities were identified by Eco Logical Australia on site during the October 2015 surveys, comprising low coastal shrubland, tall open shrubland throughout the majority of the study area, and higher dune systems in the north of the study area[30]. In terms of habitat type these vegetation communities can be classed as Quindalup dune mixed shrublands on sandy soils[30].

This habitat type supports a range of coastal shrubland birds and terrestrial reptiles[30]. The small lake in the parkland at the south of the site also provides habitat for aquatic species, amphibians, wetland birds and is also a source of water for a range of fauna species on site[30]. Large trees in the parkland areas also provide nesting and roosting habitat for birds[30].

3.4.5 Ecological Corridors

Naturally connected landscapes and ecosystems are generally healthier than fragmented ones, supporting and protecting a greater diversity of species, providing pathways for species movement and can store carbon more effectively than degraded landscapes[32]. In urban areas, infrastructure can divide landscapes creating barriers for native fauna movement, which may make it necessary to provide wildlife crossings such as underpasses, tunnels, viaducts or overpasses to enable wildlife movement.

The Hillarys – Kallaroo Foreshore Reserve is part of an ecological linkage coastal strip that extends from Burns Beach in the north to North Beach in the south and inland to Ern Halliday within the City of Joondalup and Star Swamp in the City of Stirling (Figure 19).

3.4.6 Current Management Approach

The City of Joondalup is implementing a number of management actions to monitor native fauna and address the environmental impacts of domestic and pest animals within the City's natural areas. Monitoring of native fauna occurs through fauna surveys. Control of non-native fauna is undertaken as required within bushland, wetland and coastal areas. Control methods employed include trapping, baiting and exclusion methods such as fencing.

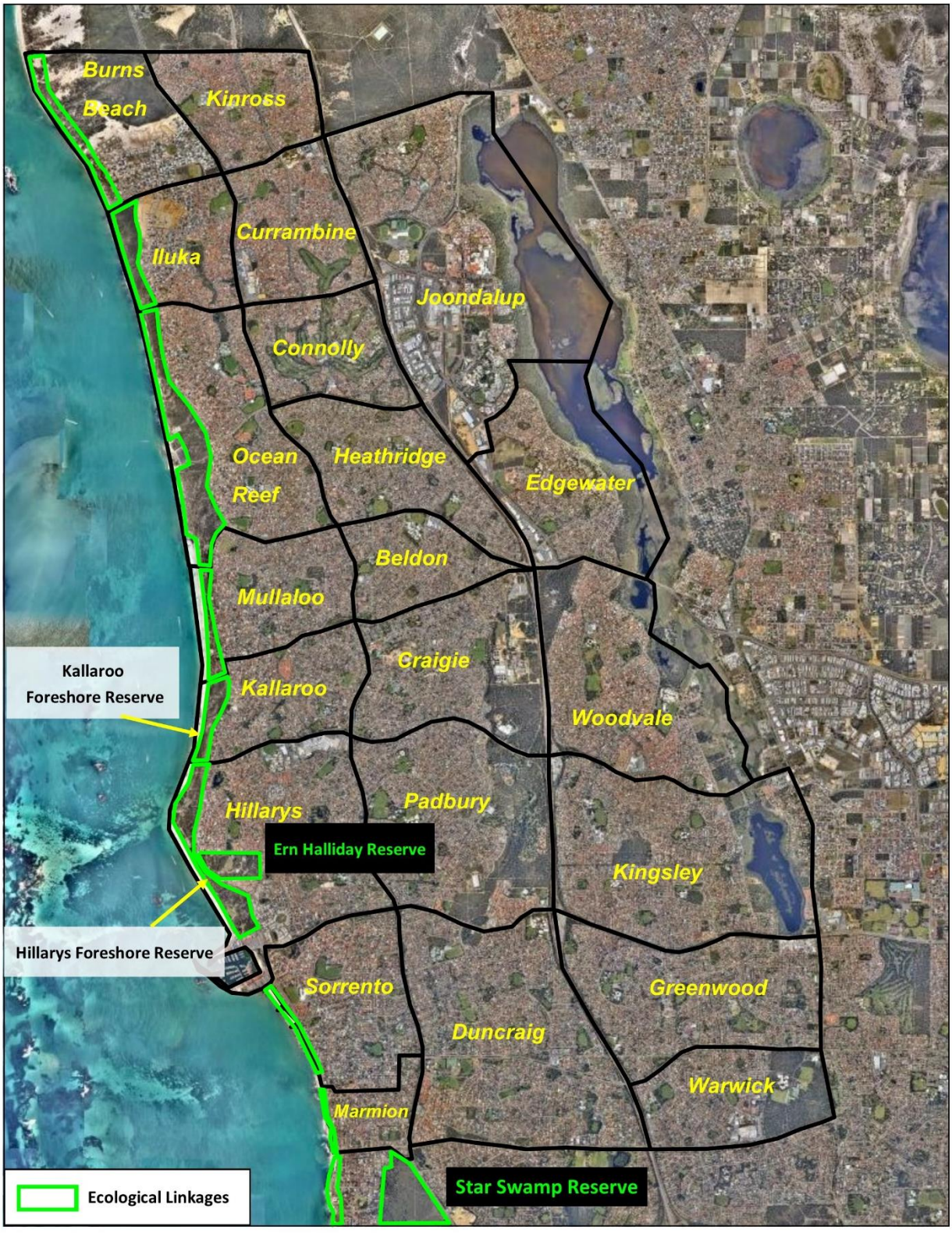
The City's current management practices have greatly reduced the incidence of pest animal populations within the City, however continued and coordinated action is required to ensure that populations remain at controllable numbers and that the impacts on natural areas remain at a minimum. The City also promotes responsible pet ownership and encourages the community to ensure that domestic pets do not have a negative impact on the natural environment.

3.4.7 Recommended Management Actions

Action	Detail
Feral animal control	Continue to implement regular fox and rabbit control to reduce pressures on native fauna and flora.

[32] NWCPAG (2012)

Action	Detail
Dog control	Dogs are controlled in accordance with the *Dog Act 1976* (WA) and City of Joondalup's policies and procedures in relation to removal on land managed by the City.
Cat control	Cats are controlled in accordance with the *Cat Act 2011* (WA) and City of Joondalup's policies and procedures in relation to their trapping and removal on land managed by the City.



Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 23/05/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 19

Ecological linkages

Hillarys Kallaroo Foreshore Reserve

0 N 2.0

kilometers

3.5 Social and Built Environment

3.5.1 History and Heritage

The Hillarys – Kallaroo Foreshore Reserve is not listed on any State or Federal Aboriginal or non-Aboriginal heritage inventory or register.[33] The foreshore area is part of the Marmion Marine Park, which is listed on the State Heritage Resister.

3.5.2 Social Value

The Reserve provides a number of recreational activities, including picnicking, walking, jogging and cycling along the pathways. Water based activities include swimming and surfing.

Key external stakeholders associated with the management of the Reserve include:

- Joondalup Community Coastcare Forum
- Department of Fire and Emergency Services
- Department of Transport who manage Hillarys Boat Harbour
- Department of Education
- Department of Planning.

3.5.3 Access and Infrastructure

Access includes the dual use path, access to the beach and parking areas, while infrastructure includes parking, bins, bicycle racks, drink fountains, seating, and ablution blocks. Each are discussed, with their locations shown in Figures 26, 27 and 28.

Parking

Within the suburb of Kallaroo there is one carpark off Northshore Drive. Within the suburb of Hillarys there are four carparks that allow access to the adjacent parks, the beach and the pedestrian pathways. Two adjoining car parks within Hillarys just north of Flinders Avenue provide access to the horse beach and the dog beach. With the northern car park providing parking for horse floats, whilst the southern car park provides access for dogs and their owners to the dog beach. Bike racks are provided in four locations adjacent carparks and pedestrian pathways (Figure 20).

Figure 20: Bike racks available at Hillarys – Kallaroo Foreshore Reserve

[33] Department of Aboriginal Affairs (2016)

Fencing

Fencing (Figure 21) exists around the perimeter of vegetated bushland areas, consisting of pine post with square ringlock wire mesh and two high tensile string wires at the top, and PVC sleeves over pine posts and chainmesh fencing along some upgraded paths leading to the beach. Fencing along the front of the foredunes particularly at the southern end of the site is in poor condition due to sand build up and erosion in the primary dunes, resulting in some posts coming out of the ground, and some being buried allowing easier inappropriate access into the dunes. Other areas of fencing were also assessed as being in poor condition due to it being worn and rusted, damaged or vandalised.

a) b)

c) d)

Figure 21: Fencing: a) pine post and square ringlock and wire fencing, b) PVC sleeves over pine posts and chainmesh fencing, c) fencing buried due to coastal erosion of sand dunes, d) fencing damaged along beach access path.

Access Points

Twelve access ways provide pedestrian access to the beach (Figure 22). They provide access from the recreational parkland areas, car parks and the dual-use path. All beach access ways are constructed of bitumen or concrete and allow access for those with disabilities, with no stairways present. The western beach ends of the concrete and bitumen path infrastructure or paths adjacent higher dunes are vulnerable to erosion, and pose an ongoing maintenance issue.

Vulnerable access ways were in a good state of repair at the time of the 2016 site assessment. The southern beach access ways just north of the Hillarys Boat Harbour showed signs of erosion. Current beach access within the Hillarys – Kallaroo Foreshore Reserve is adequate. Three pedestrian access points allow access to

the lookouts on the high dunes in the south-east of the site, all were limestone paths and were in good condition.

Beach access

Access to bitumen dual use pathway from northern carpark

Figure 22: Access points within Hillarys – Kallaroo Foreshore Reserve

Paths and Trails

A dual use path starts at the south-east corner and goes through the centre of the reserve before coming out at the northern Kallaroo carpark, and following Northshore Drive. This pathway is made of bitumen with some sections of concrete. Twelve access footpaths lead off this pathway to the beach and eight continue through to Whitfords Avenue and Northshore Drive, these pathways were all concrete except the northern path which was bitumen. Three limestone pathways provide access to the two lookouts in the south-west of the site (Figure 28). All pathways were found to be in good condition during the 2016 site assessment.

Access and Inclusion

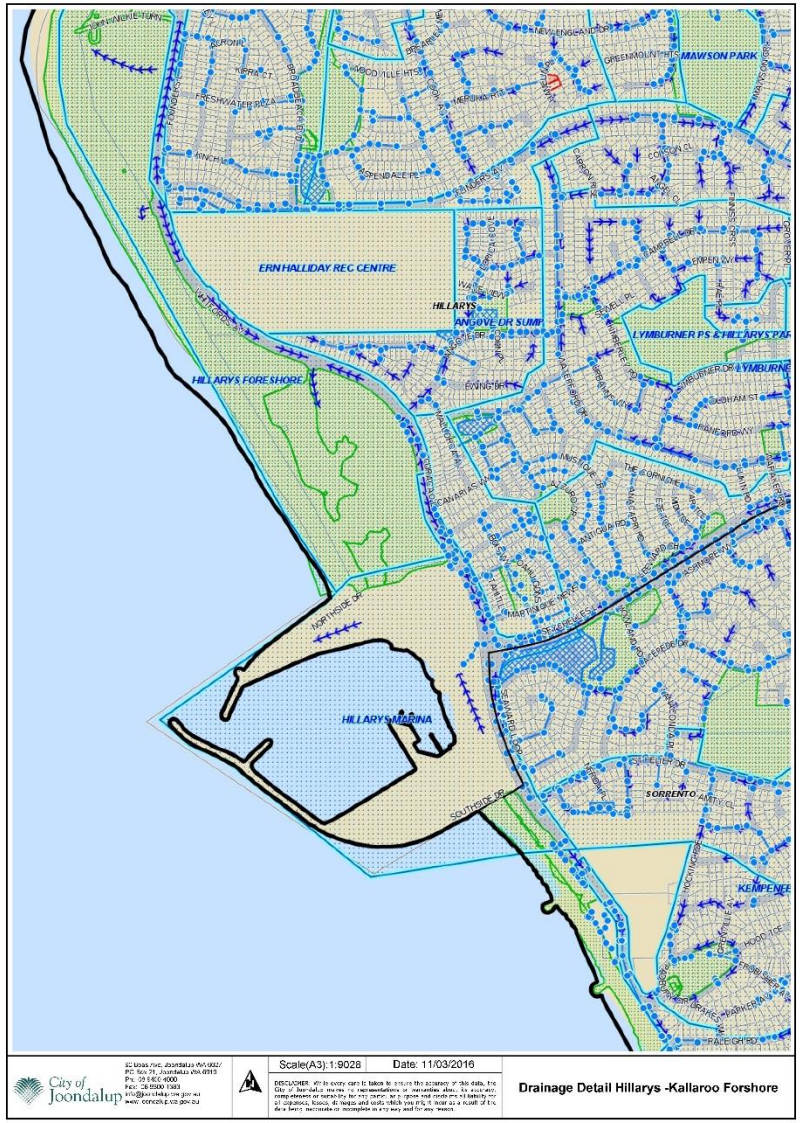
Four million Australians (20%) reported having a disability in the Survey of Disability, Ageing and Carers conducted in 2009. The study considers disability to include any impairments, activity limitations and participation restrictions, which impede everyday activities for a period of at least 6 months. In 15 years' time the number of West Australians with a disability is expected to increase from 1 in 5 people (20%) to 1 in 4 people (25%).

The City of Joondalup has an *Access and Inclusion Plan 2015-2017*, outlining that 'the City is committed to ensuring that its activities and services are inclusive of all members, including people with disabilities and their families or carers, and people from culturally and linguistically diverse backgrounds'. There is adequate access for people with disability to move along the dual use pathway, the limestone access ways, and to use the two observation platforms currently in place. Currently all pathways and access points to the beach allow access (have no stairway) by those with disabilities.

Stormwater Drainage

There are five drainage outlets or soak wells located within the Reserve, which allow stormwater to drain to the ocean (Figure 23). The areas around these drains are at increased risk of potential erosion, and weed and rubbish introduction via the stormwater drains. No erosion was noted around stormwater drains within the reserve during the 2016 site assessment undertaken by Natural Area. It is recommended that the drains be regularly inspected for erosion and other damage, and that maintenance activities include rubbish removal to improve the current capacity of the drains.

A



B

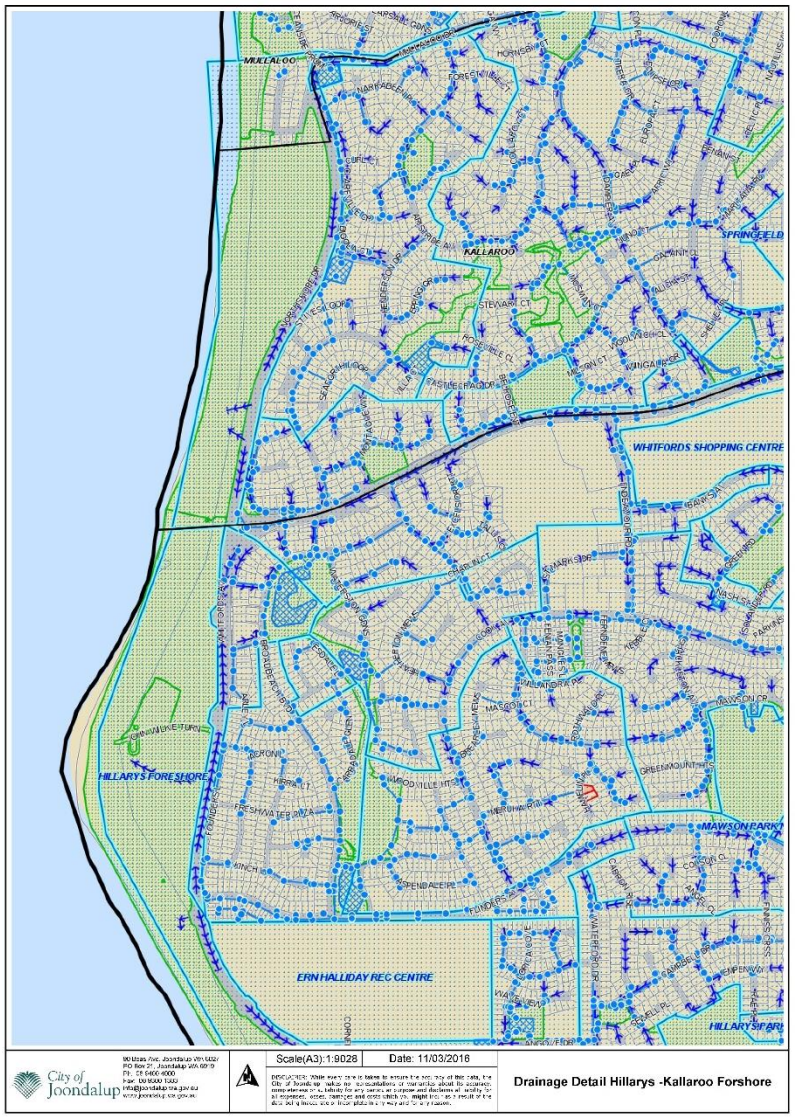


Figure 23: Drainage, Hillarys – Kallaroo Foreshore Reserve **–** a) Hillarys south b) Hillarys north and Kallaroo

Signage

Signage within the site inform the Reserve users of the flora and fauna present on site, safety precautions, conservation values, penalties that apply for vandalism and unauthorised access, locations of amenities available (wayfinding signage), permitted activities, and appropriate use of the dual use path (Figure 24). The majority of the signs were in good condition with a few showing signs of wear and graffiti.

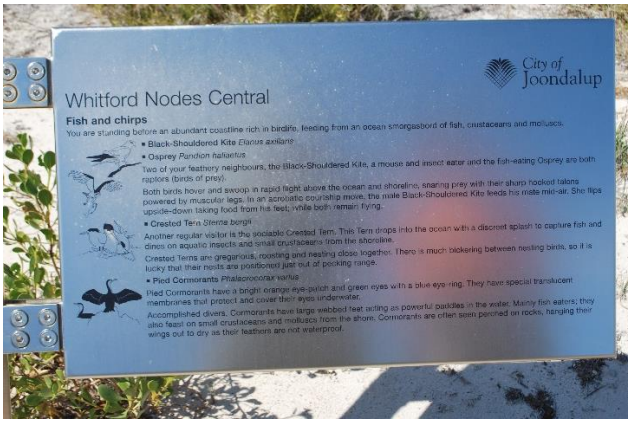


Figure 24: Examples of signage within the Hillarys – Kallaroo Foreshore Reserve

Toilets

Three ablution blocks are located adjacent the southern carparks within Hillarys Foreshore Reserve, and one is located adjacent the northern carpark approximately 50 m west along the beach access pathway.

Seating

There are a number of shade structures with picnic tables on the recreation turfed areas and at the two southern lookouts in Hillarys Foreshore Reserve. Bench seats are provided within the recreation parkland areas, adjacent carparks and pathways throughout the site. All structures are currently in good repair but will require ongoing maintenance as they are situated in a salty environment and are subject to weathering (Figures 26, 27 and 28).

Rubbish Bins

Rubbish bins are located at all access ways off the dual use pathway to the beach, and within the parkland areas near carparks and picnic areas where people congregate to enjoy the views or sit down and rest (Figures 26, 27, and 28). Minimal rubbish was recorded during 2016 site assessments, with the majority being plastic bags, paper and cardboard bordering vegetated areas adjacent parklands and roads that was most likely blown into the vegetated areas by wind. There was one location where it looked like bags and clothes had been dumped in the small bush pocket just south of the communications tower (Figure 25).

Figure 25: Rubbish observed within Hillarys – Kallaroo Foreshore Reserve

3.5.4 Recommended Management Actions

To enhance the social and built environment in the Hillarys – Kallaroo Foreshore Reserve, the following management actions are proposed:

Action	Detail
Water erosion from drainage	Erosion and water pooling around the storm drains be monitored and restored when water erosion is found.
Signage maintenance	Continue inspections in conjunction with other monitoring activities on a regular basis, and repair or replace damaged or vandalised signs as required.
Inappropriate signage	Any advertisement signage affixed to the fencing or other locations in the Reserve by business owners or individuals be removed when observed.
Rubbish	Monitoring of rubbish around the reserve continue, with removal occurring when observed.

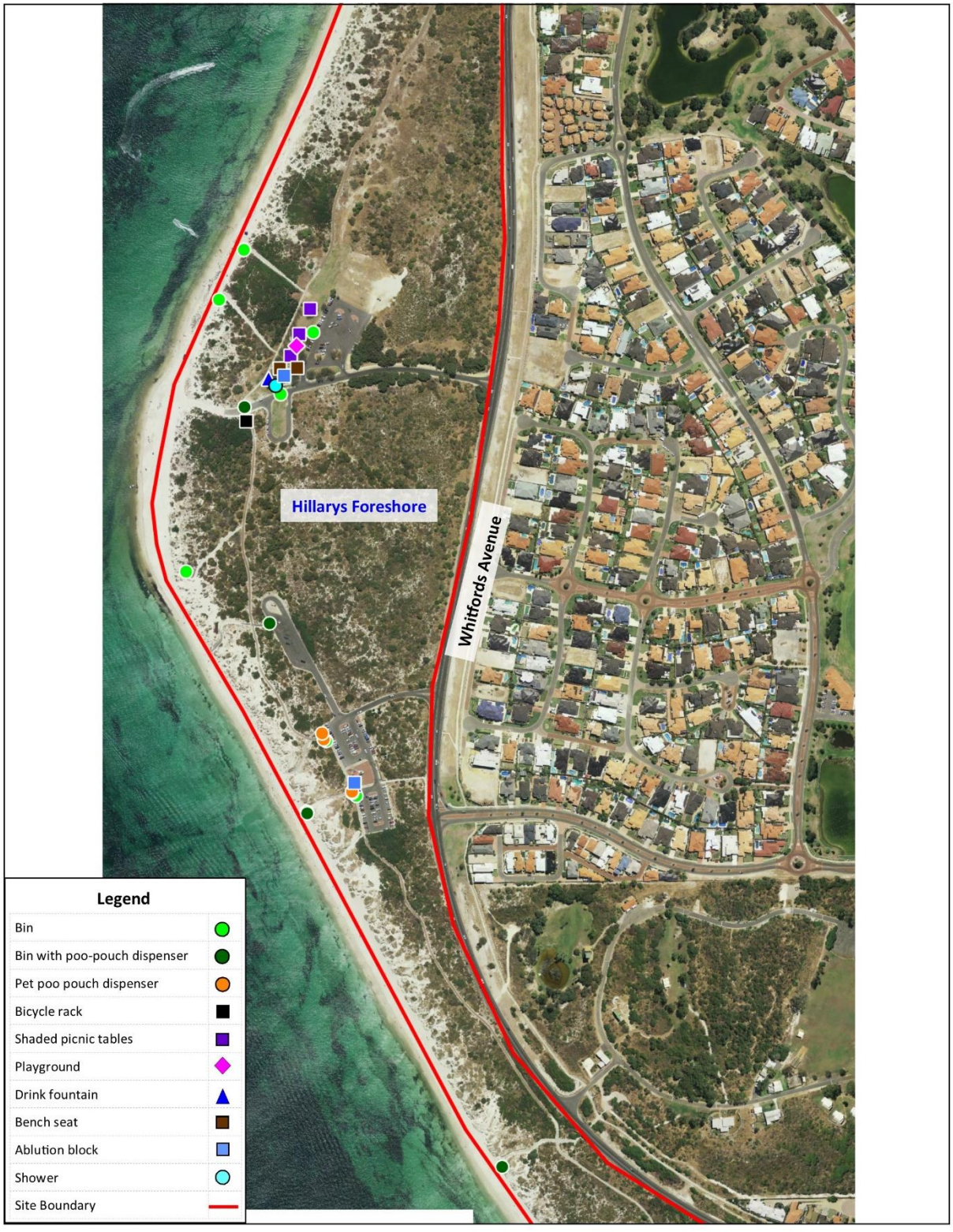
Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 27/05/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Figure: 26

Infrastructure and Amenities - Hillarys Kallaroo Foreshore Reserve (map 1)

0 N 200

Meters



Client: City of Joondalup
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Image Source: City of Joondalup
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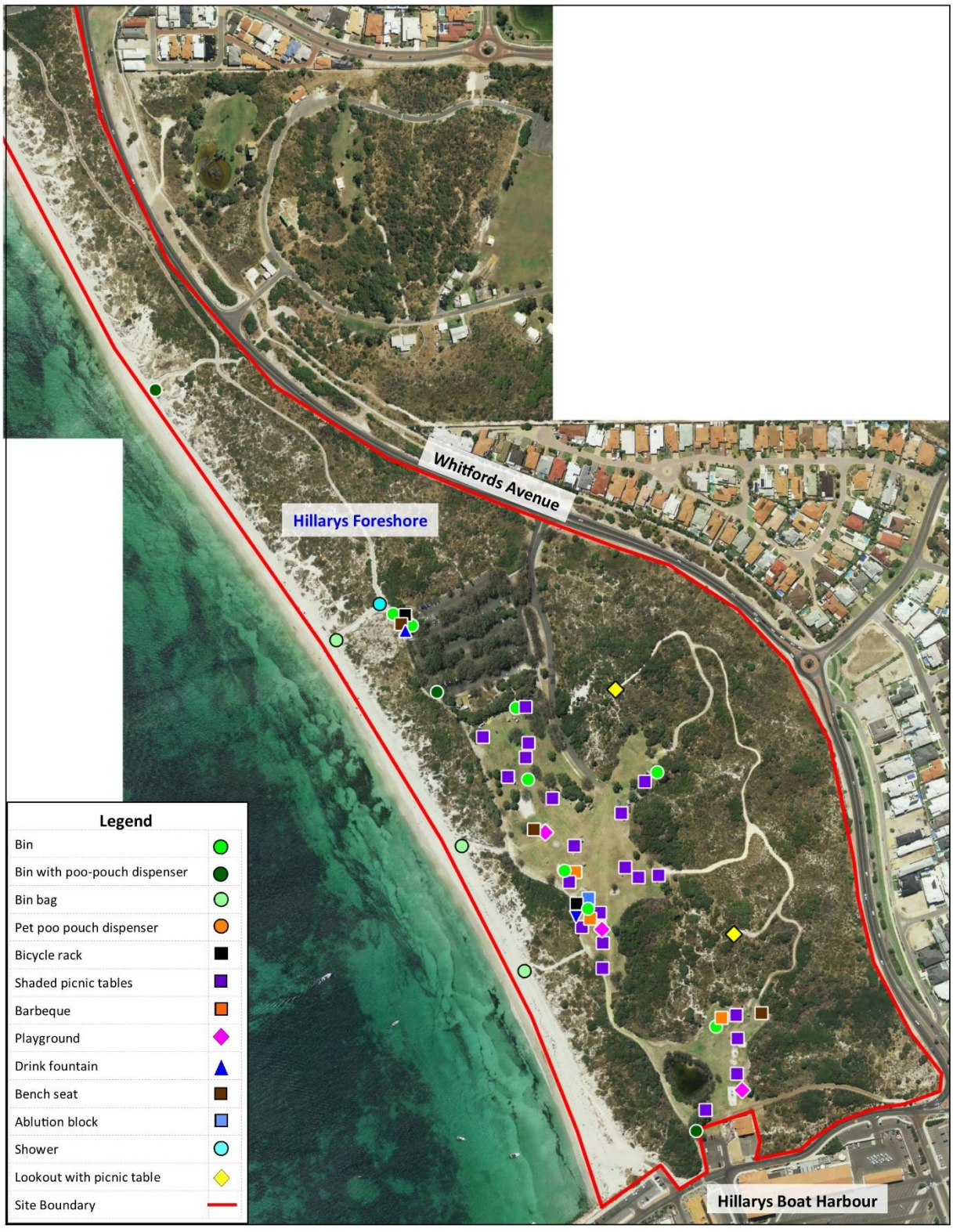
Projection: MGA Zone 50

Figure: 27

Infrastructure and Amenities - Hillarys Kallaroo Foreshore Reserve (map 2)

0 N 200

Meters



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Map Prepared by: S. Hynes
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Image Source: City of Joondalup
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Projection: MGA Zone 50

Figure: 28

Infrastructure and Amenities - Hillarys Kallaroo Foreshore Reserve (map 3)

0 N 100

Meters

3.6 Fire Management

Fire is an important natural feature of the Western Australian landscape, as it helps to shape the diversity of plant communities with many Australian native plants having adapted fire-reliant methods of reproduction. Human activities such as accidents and arson have resulted in an increased incidence of fire within many urban bushland reserves that threatens biodiversity, reduces the ability of native species to complete their lifecycle and can encourage the growth of fire promoting invasive weeds. A high intensity fire may damage infrastructure such as property, signage, fences and gates. Fire suppression methods may also compromise the environmental values of the Reserve, such as clearing native vegetation for firebreaks.

Bushfires are unplanned fires that can be caused by events such as lightning, planned burning operations, escape from industrial activities, damaged power transmission lines, discarded cigarette butts or deliberate arson. Bushfires can cause significant damage to people, property and the environment.[34] Management of the Hillarys – Kallaroo Foreshore Reserve is the responsibility of the City of Joondalup, which has a 'duty of care' to take all reasonable precautions to prevent any bushfire from spreading onto neighbouring property. The City of Joondalup does not currently have a prescribed burn management regime for the area. The Department of Fire and Emergency Services (DFES) work with the community and government to prevent, prepare for, respond to and recover from a diverse range of emergencies, including fire.[35]

Objectives

The objectives of fire management within the Hillarys – Kallaroo Foreshore Reserve are to:

- protect life, property and environment in Hillarys and Kallaroo, and adjacent residential areas
- fulfil obligations under the *Bushfires Act 1954* (WA)
- protect the ecological and amenity values
- protect landscape values (including flora and fauna) from uncontrolled fire and inappropriate suppression techniques
- reduce the frequency, impact and area of unplanned fires
- minimise the spread of disease and weeds during fire-fighting operations and when establishing emergency firebreaks, and during post-fire clean-up activities
- minimise impacts on air quality.

Fire Risk

As the vegetation present consists of coastal heath and shrubland the site has a low to moderate risk of fire. Flammable material such as dry grass, leaves, twigs, loose bark and other fine fire fuels present in the reserve also increase the risk of fire ignition and spread. The highest risk for the site is from deliberately lit fires within the vegetated dune areas. The steep slopes throughout the site pose a safety risk to fire respondents in the event of a fire, especially if there is low visibility due to smoke. Fuel loads assessments are carried out every year to determine fire risk based on fuel load, assessments should be undertaken using methodology described in the Department of Fire and Emergency Services (DFES) *Visual Fuel Load Guide for the Swan Coastal Plain and Darling Scarp*[36]. Fire fuel load assessments were undertaken within the Hillary's –

[34] EDOWA (2011)
[35] DFES (2016a)
[36] DFES (2015)

Kallaroo Foreshore Reserve during 2016, with a fuel load ranging from 9.2 – 13.8 t/ha in Hillary's and 13.8 – 17.2 t/ha in Kallaroo.

Fire Prevention

The City of Joondalup implements a number of on ground measures to reduce the risk of fire, including undertaking:

- controlled access
- management of non-native flora (weed) species
- fuel load assessment and management
- maintenance and installation of fire access tracks (fire access ways and strategic firebreaks).

Weed control and maintenance of fire access tracks are conducted in accordance with the City's Natural Area's Maintenance Schedule. The City of Joondalup is currently developing a Bushfire Risk Management Plan in 2016 outlining the City's strategy for assessing fire risk, prevention, response and recovery. There are numerous water hydrants located around the Reserve, which are installed and maintained by the Water Corporation.

Fire occurrences

A review of historical aerial imagery indicates that one fire occurred within the Hillarys – Kallaroo Foreshore Reserve since 1953[37]; however, as there were up to 10 years or more in between photos prior to 1995 there is a possibility that more fires may have occurred during these times. It is also probable that small fires will not show on aerial imagery.

Fire incidence information provided by DFES[38] indicates that:

- a total of 29 fires occurred within the site between 01 January 2000 until July 2016, 26 of which were in Hillarys and three within Kallaroo
- 16 occurred within the landscape, with the other 13 described as other/rubbish/vehicle
- nine fires occurred within the Whitfords Nodes area, four around the horse/dog beaches and the car park, three around Pinnaroo Point, three within the Hillarys beach reserve, with the others at various locations within the foreshore reserve
- 25 were considered suspicious or deliberate, with two associated with cigarettes and two with other open flames or fires
- all burnt one hectare or less.

Fire Response

The closest fire station is the Duncraig Fire Station on Hepburn Avenue, Duncraig, and are responsible for suppressing fires within the Hillarys – Kallaroo Foreshore Reserve. The Western Australia Police are responsible for the evacuation of residents and visitors, if required.

[37] Landgate (2016)
[38] DFES (2016b)

3.6.1 Recommended Management Actions

To prevent fire occurrences and minimise the environmental impact of fire occurrences in Hillarys – Kallaroo Foreshore Reserve, the following management actions are proposed:

Action	Detail
Assess fire fuel load	Continue to annually assess and report fire fuel load using the DFES *Visual Fuel Load Guide for the Swan Coastal Plain and Darling Scarp* to inform fire prevention actions required.
Develop and implement Fire Management Plan	Develop and implement a Bushfire Risk Management Plan, outlining the City's strategy for assessing fire risk, prevention, response and recovery.
Monitor fire occurrences	Continue to monitor fire occurrences through mapping and updating Geographic Information System (GIS) layers detailing fire incidents and frequency to inform fire prevention actions.
Revise weed control after fire incidents	Revise weed control after fire incidents to aid regrowth by selecting appropriate chemicals, targeting weeds if safe to do so for new seedlings, and spraying grasses using backpacks.

3.7 Education and Training

The City implements an Annual Environmental Education Program to address key environmental issues and encourage greater environmental stewardship by the community. For example, the City has run an Adopt a Coastline Program for a number of years that allows school students to be involved in on-ground coastal activities such as weeding, planting, and care of dune systems.

The City of Joondalup actively encourages community participation to raise awareness of key environmental issues within the City. The City of Joondalup Natural Areas Team currently conducts regular plant identification training, including weed management. New members in the Natural Areas team undertake training for the identification and management of pathogens.

3.7.1 Recommended Education and Training Management Actions

Action	Detail
Environmental Education Program	Implement initiatives of a 'Think Green Biodiversity' campaign (part of the Environmental Education Program) targeting environmental issues such as: ▪ pathogens ▪ weeds ▪ fire ▪ flora and fauna awareness ▪ prevention of hand feeding wildlife ▪ responsible pet ownership.
Schools Connection Program	Continue implementing the Adopt a Coastline Program within Hillarys and Kallaroo.
Natural Areas Team Training	Conduct regular Natural Areas Team plant identification training, including weed management, to increase the effectiveness of weed control activities.

4.0 Implementation Plan

4.1 Auditing and Inspection

Inspections of the Hillarys – Kallaroo Foreshore Reserve are conducted by the City of Joondalup as per the Natural Area's Maintenance Schedule.

4.2 Key Performance Indicators

A review of the Hillarys – Kallaroo Coastal Foreshore Management Plan will be undertaken annually through reporting against progress made in implementing recommended management actions.

Ongoing reporting against Council endorsed Natural Key Performance Indicators will also be undertaken to ascertain whether current management practices are leading to positive environmental outcomes. These indicators will be measured and reported on an annual, biennial and five yearly basis, as shown in Table 4.

Table 4: Natural Area Key Performance Indicators

Key Performance Indicator	Source	Reporting Period
Density of weeds per area – expressed as a percentage.	Data obtained from site investigations of transects positioned within natural areas.	Annual 2016/17- 2021/22
Waste present in natural areas – items per hectare	This data is collected on an annual basis from ten of the City's reserves.	Annual 2016/17- 2021/22
Percentage of natural areas protected within City reserves	Areas (hectares) included in the City's proposed Conservation Reserves within the District/Local Planning Scheme (previously Schedule 5 and City of Joondalup Bush Forever sites).	Annual 2016/17- 2021/22
Overall change in vegetation vigour (condition) per area – expressed as an increase or decrease in the Vegetation Condition Index (VCI)	Source- Data obtained from analysis of remote multi spectral imagery. The imagery is currently obtained every two years.	Biennial (every two years) 2017/2018 2019/2020 2021/2022
Canopy Cover – expressed as a percentage per natural area	Source- Data obtained from analysis of remote multi spectral imagery. The imagery is currently obtained every two years.	Biennial (every two years) 2017/2018 2019/2020 2021/2022
Vegetation condition per area – expressed using the Keighery Scale* of vegetation condition, expressed as a percentage for each classification (pristine to degraded).	Data obtained through on site floristic survey undertaken to inform the review of the Management Plan, service provided by specialised consultants.	Five Yearly 2021/2022

4.3 Routine Reporting

Assessing the management of the Hillarys – Kallaroo Foreshore Reserve will be undertaken annually reporting progress against the implementation plan.

4.4 Management Plan Review

The Hillarys – Kallaroo Foreshore Reserve Management Plan is to be reviewed every 5 years. The next review is due to occur in 2020/21, which will include a flora, fauna and fungi survey.

4.5 Management Actions

A summary of the recommended management actions is provided below.

Biodiversity Conservation Area	Recommended Management Action	Detail
Physical Environment	Holistic consideration of erosion	Erosion issues to be considered holistically, with the most appropriate management options being determined on a case by case basis and recognising that all exposed sand does not need to be covered by vegetation, reflecting what would occur within a natural environment.
Physical Environment	Brushing	Brushing materials will be of suitable species that do not contain seed pods or other materials that can propagate and result in the presence of weeds at the site.
Physical Environment	Wider context	Consider erosion in the wider context of climate change impacts that could occur over time.
Flora	Weed survey	Continue to undertake weed surveys every six months.
Flora	Targeted weed control	Continue to undertake a targeted weed control program, as described in Appendix 6.
Flora	Ongoing weed control	Continue to undertake coordinated approach to regular weed control by implementing the Annual Bushland Schedule.
Flora	Targeted Weed Control	Continue to prioritise the control of high and very high priority weeds within the Hillarys – Kallaroo Foreshore Reserve, determining the best method of control for this species.
Flora	Weed Management Plan	Implement the City of Joondalup Weed Management Plan to provide an ongoing strategic approach to the management of natural areas in order to reduce the incidence of weeds.
Flora	Restoration	Conduct revegetation as outlined in the Revegetation Strategy in Appendix 7.
Flora	Friends Group	Encourage the formation of a Friends Group for the Hillarys-Kallaroo Foreshore Reserve.
Flora	Friends Group	Continue to support the activities of the ‘friends of’ groups within the Reserve

Biodiversity Conservation Area	Recommended Management Action	Detail
Fungi	Opportunistic fungi survey	Continue to undertake opportunistic fungi sightings during other site activities.
Fungi	Fungi survey	Engage consultants to undertake a comprehensive fungi survey in winter after substantial rain, such as mid-June to end of July to supplement previous incidental fungi survey.
Plant Disease	Pathogen Management	Implement recommendations from the Pathogen Management Plan that are applicable to the management of the Hillarys – Kallaroo Foreshore Reserve, particularly in sites affected by pathogens.
Plant Disease	Sampling and mapping	Undertake additional sampling and high-resolution mapping of Phytophthora in affected sites.
Fauna	Feral animal control	Continue to implement regular fox and rabbit control to reduce pressures on native fauna and flora.
Fauna	Dog control	Dogs are controlled in accordance with the *Dog Act 1976* (WA) and City of Joondalup's policies and procedures in relation to removal on land managed by the City.
Fauna	Cat Control	Cats are controlled in accordance with the *Cat Act 2011* (WA) and City of Joondalup's policies and procedures in relation to their trapping and removal on land managed by the City.
Social and Built Environment	Water erosion from drainage	Erosion and water pooling around the storm drains be monitored and restored when water erosion is found.
Social and Built Environment	Signage maintenance	Continue inspections in conjunction with other monitoring activities on a regular basis, and repair or replace damaged or vandalised signs as required.
Social and Built Environment	Inappropriate signage	Any advertisement signage affixed to the fencing or other locations in the Reserve by business owners or individuals be removed when observed.
Social and Built Environment	Rubbish	Monitoring of rubbish around the reserve continue, with removal occurring when observed.
Fire Management	Assess fire fuel load	Continue to annually assess and report fire fuel load using the DFES *Visual Fuel Load Guide for the Swan Coastal Plain and Darling Scarp* to inform fire prevention actions required.
Fire Management	Develop and implement Fire Management Plan	Develop and implement a Bushfire Risk Management Plan, outlining the City's strategy for assessing fire risk, prevention, response and recovery.
Fire Management	Monitor Fire occurrences	Continue to monitor fire occurrences through mapping and updating Geographic Information System (GIS) layers detailing fire incidents and frequency to inform fire prevention actions.

Biodiversity Conservation Area	Recommended Management Action	Detail
Fire Management	Revise weed control after fire incidents	Revise weed control after fire incidents to aid regrowth by selecting appropriate chemicals, targeting weeds if safe to do so for new seedlings, and spraying grasses using backpacks.
Education	Environmental Education Program	Implement initiatives of a 'Think Green Biodiversity' campaign (part of the Environmental Education Program) targeting environmental issues such as: ▪ pathogens ▪ weeds ▪ fire ▪ flora and fauna awareness ▪ prevention of hand feeding wildlife ▪ responsible pet ownership.
Education	Schools Connection Program	Continue implementing the Adopt a Coastline Program within Hillarys and Kallaroo.
Education	Natural Areas Team Training	Conduct regular Natural Areas Team plant identification training, including weed management, to increase the effectiveness of weed control activities.

5.0 References

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Appendix 1: Bush Forever Vegetation Structural Classes

Life Form/Height Class	Canopy Percentage Cover			
	100 – 70%	**70 – 30%**	**30 - 10%**	**10 – 2 %**
Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland
Trees 10 – 30 m	Closed forest	Open forest	Woodland	Open woodland
Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland
Tree Mallee	Closed tree mallee	Tree mallee	Open tree mallee	Very open tree mallee
Shrub Mallee	Closed shrub mallee	Shrub mallee	Open shrub mallee	Very open shrub mallee
Shrubs over 2 m	Closed tall scrub	Tall open scrub	Tall shrubland	Tall open shrubland
Shrubs 1 – 2 m	Closed heath	Open heath	Shrubland	Open shrubland
Shrubs under 1 m	Closed low heath	Open low heath	Low shrubland	Low open shrubland
Grasses	Closed grassland	Grassland	Open grassland	Very open grassland
Herbs	Closed herbland	Herbland	Open herbland	Very open herbland
Sedges	Closed sedgeland	Sedgeland	Open sedgeland	Very open sedgeland

(Source: Government of Western Australia, 2000)

Appendix 2: Vegetation Condition Rating Scale

Category		Description
1	Pristine	Pristine or nearly so, no obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

(Source: Government of Western Australia, 2000)

Appendix 3: Flora Species List from Eco Logical Australia (2016)

Sorted by family
*Denotes introduced species

Family	Species
Aizoaceae	**Tetragonia decumbens*
Aizoaceae	*Carpobrotus virescens*
Apiaceae	*Daucus glochidiatus*
Asparagaceae	**Agave americana*
Asparagaceae	*Acanthocarpus preissii*
Asparagaceae	*Lomandra maritima*
Asphodelaceae	**Asphodelus fistulosus*
Asteraceae	**Arctotheca calendula*
Asteraceae	**Gazania linearis*
Asteraceae	**Lactuca serriola*
Asteraceae	**Sonchus oleraceus*
Asteraceae	*Olearia axillaris*
Asteraceae	*Pithocarpa cordata*
Asteraceae	*Senecio pinnatifolius*
Brassicaceae	**Brassica tournefortii*
Brassicaceae	**Cakile maritima*
Casuarinaceae	*Allocasuarina lehmanniana* subsp. *lehmanniana*
Chenopodiaceae	*Rhagodia baccata* subsp. *baccata*
Chenopodiaceae	*Threlkeldia diffusa*
Convolvulaceae	**Cuscuta epithymum*
Crassulaceae	**Crassula glomerata*
Cupressaceae	*Callitris preissii*
Cyperaceae	**Cyperus tenellus*
Cyperaceae	*Ficinia nodosa*
Cyperaceae	*Lepidosperma gladiatum*
Cyperaceae	*Lepidosperma squamatum*
Cyperaceae	*Schoenus clandestinus*
Cyperaceae	*Schoenus grandiflorus*
Dilleniaceae	*Hibbertia subvaginata*

Family	Species
Ericaceae	*Leucopogon parviflorus*
Ericaceae	*Leucopogon* sp.
Euphorbiaceae	**Euphorbia paralias*
Euphorbiaceae	**Euphorbia terracina*
Fabaceae	**Medicago littoralis*
Fabaceae	*Acacia cochlearis*
Fabaceae	*Acacia cyclops*
Fabaceae	*Acacia lasiocarpa* var. *lasiocarpa*
Fabaceae	*Acacia rostellifera*
Fabaceae	*Acacia saligna* subsp. *saligna*
Fabaceae	*Acacia truncata*
Fabaceae	*Gastrolobium capitatum*
Fabaceae	*Hardenbergia comptoniana*
Fabaceae	*Templetonia retusa*
Geraniaceae	**Pelargonium capitatum*
Goodeniaceae	*Scaevola crassifolia*
Gyrostemonaceae	*Tersonia cyathiflora*
Haemodoraceae	*Conostylis candicans*
Hemerocallidaceae	*Dianella revoluta*
Lamiaceae	*Hemiandra glabra*
Lauraceae	*Cassytha flava*
Myrtaceae	*Agonis flexuosa*
Myrtaceae	*Eucalyptus gomphocephala*
Myrtaceae	*Eucalyptus utilis*
Myrtaceae	*Melaleuca lanceolata*
Myrtaceae	*Melaleuca systena*
Onagraceae	**Oenothera drummondii*
Papaveraceae	**Fumaria capreolata*
Poaceae	**Avena barbata*
Poaceae	**Briza maxima*
Poaceae	**Bromus diandrus*
Poaceae	**Ehrharta longiflora*
Poaceae	**Lagurus ovatus*

Family	Species
Poaceae	**Lolium perenne*
Poaceae	*Austrostipa flavescens*
Poaceae	*Poa poiformis*
Poaceae	*Spinifex hirsutus*
Portulacaceae	*Calandrinia calyptrata*
Primulaceae	**Lysimachia arvensis*
Ranunculaceae	*Clematis pubescens*
Rhamnaceae	*Spyridium globulosum*
Rubiaceae	**Galium murale*
Rubiaceae	*Opercularia vaginata*
Santalaceae	*Exocarpos sparteus*
Santalaceae	*Santalum acuminatum*
Scrophulariaceae	*Myoporum insulare*
Solanaceae	**Solanum nigrum*
Thymelaeaceae	*Pimelea ferruginea*
Urticaceae	*Parietaria cardiostegia*
Verbenaceae	**Verbena rigida* var. *rigida*

Appendix 4: Eco Logical Australia (2016) Fauna List for Hillarys – Kallaroo Foreshore

Fauna list sorted by fauna groups then family, note that Natural Area results from opportunistic sightings in February 2016 have been added to the table.
*Denotes introduced species

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
MAMMALS										
Canidae	**Canis lupus*	Dog							+	+
	**Vulpes vulpes*	Red Fox		X		•		+		+
Dasyuridae	*Dasyurus geoffroii*	Chuditch	VU	S3	VU		•			
Felidae	**Felis catus*	Cat		X		•		+		+
Leporidae	**Oryctolagus cuniculus*	Rabbit		X		•		+	+	+
Muridae	**Mus musculus*	House Mouse		X				+	+	
	**Rattus rattus*	Black Rat		X			•	+		
Peramelidae	*Isoodon obesulus* subsp. *fusciventer*	Quenda			P5		•	+		
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat					•	+		

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
BIRDS										
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill					•			
	Acanthiza inornata	Western Thornbill					•			
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill					•		+	
	Gerygone fusca	Western Gerygone					•			
	Sericornis frontalis	White-browed Scrub Wren					•	+		
	Smicrornis brevirostris	Weebill					•			
Accipitridae	*Accipiter fasciatus*	Brown Goshawk					•			
	Accipiter cirrocephalus	Collared Sparrowhawk					•			
	Circus approximans	Swamp Harrier					•			
	Haliaeetus leucogaster	White-bellied Sea Eagle	M			•				
	Pandion haliaetus	Osprey	M	S5	IA	•		+	+	
Acrocephalidae	*Acrocephalus australis*	Australian Reed Warbler					•			
Anatidae	*Anas gracilis*	Grey Teal					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Anas platyrhynchos	Mallard				•	•			
	Anas rhynchotis	Australasian Shoveler					•			
	Aythya australis	Hardhead					•			
	Anas superciliosa	Pacific Black Duck					•	+		
	Biziura lobata	Musk Duck					•			
	Chenonetta jubata	Australian Wood Duck					•			
	Cygnus atratus	Black Swan					•			
	Malacorhynchus membranaceus	Pink-eared Duck					•			
	Oxyura australis	Blue-billed Duck					•			
	Stictonetta naevosa	Freckled Duck					•			
	Tadorna tadornoides	Australian Shelduck					•			
Apodidae	*Apus pacificus*	Fork-tailed Swift	M	S5	IA	•				
Ardeidae	*Ardea alba* subsp. *modesta*	Eastern Great Egret	M	S5	IA		•			
	Ardea ibis	Cattle Egret	M	S5	IA	•	•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Ardea ibis subsp. *coromanda*	Eastern Cattle Egret	M	S5	IA		•			
	Ardea modesta	Great Egret	M	S5	IA	•				
	Ardea pacifica	White-necked Heron					•			
	Nycticorax caledonicus	Nankeen Night Heron					•			
Artamidae	*Cracticus torquatus*	Grey Butcherbird					•	+		
	Cracticus tibicen	Australian Magpie					•	+	+	
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew					•			
	Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	EN	S2	EN	•	•			
	Cacatua galerita	Sulphur-crested Cockatoo					•			
	Cacatua pastinator	Western Long-billed Corella					•			
	Cacatua tenuirostris	Eastern Long-billed Corella					•			
	Cacatua sanguinea	Little Corella					•	+	+	
	Eolophus roseicapillus	Galah						+	+	

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike					•	+	+	
	Lalage tricolor	White-winged Triller					•			
	Vanellus tricolor	Banded Lapwing					•			
Columbidae	**Columba livia*	Domestic Pigeon		X		•	•	+		
	Ocyphaps lophotes	Crested Pigeon					•			
	**Streptopelia chinensis*	Spotted Turtle-Dove		X		•	•	+	+	
	**Streptopelia senegalensis*	Laughing Turtle-Dove		X		•	•	+	+	
Corvidae	*Corvus bennetti*	Little Crow					•			
	Corvus coronoides	Australian Raven					•	+	+	
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo					•			
Dicruridae	*Grallina cyanoleuca*	Magpie-lark					•	+		
Estrildidae	*Lonchura castaneothorax*	Chestnut-breasted Mannikin					•			
Falconidae	*Falco berigora*	Brown Falcon								
	Falco cenchroides	Nankeen Kestrel					•	+	+	

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Falco longipennis	Australian Hobby					•			
	Falco peregrinus	Peregrine Falcon								
Fringillidae	*Carduelis carduelis*	European Goldfinch				•	•			
Halcyonidae	**Dacelo novaeguineae*	Laughing Kookaburra		X			•	+		
	Todiramphus sanctus	Sacred Kingfisher					•			
Hirundinidae	*Hirundo neoxena*	Welcome Swallow					•	+		
	Petrochelidon nigricans	Tree Martin						+		
Laridae	*Larus novaehollandiae*	Silver Gull						+	+	
	Larus pacificus	Pacific Gull							+	
Locustellidae	*Megalurus gramineus*	Little Grassbird					•			
Maluridae	*Malurus splendens*	Splendid Fairy Wren					•	+		
	Malurus lamberti	Variegated Fairy-wren					•			
Megapodiidae	*Leipoa ocellata*	Malleefowl	VU	S3	VU	•				
Meliphagidae	*Anthochaera lunulata*	Western Wattlebird					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Anthochaera carunculata	Red Wattlebird					•	+	+	
	Acanthorhynchus superciliosus	Western Spinebill					•			
	Epthianura albifrons	White-fronted Chat					•			
	Lichenostomus virescens	Singing Honeyeater					•	+	+	
	Lichmera indistincta	Brown Honeyeater					•	+	+	
	Manorina flavigula	Yellow-throated Miner					•			
	Phylidonyris novaehollandiae	New Holland Honeyeater					•	+		
Meropidae	*Merops ornatus*	Rainbow Bee-eater	M	S5	IA	•	•	+		
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella					•			
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler								
Pardalotidae	*Pardalotus striatus*	Striated Pardalote					•			
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill							+	
	Acanthiza inornata	Western Thornbill								

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Gerygone fusca	Western Gerygone						+		
	Pardalotus striatus	Striated Pardalote								
	Smicrornis brevirostris	Weebill						+		
Passeridae	**Passer domesticus*	House Sparrow				•				
	**Passer montanus*	Eurasian Tree Sparrow				•				
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican					•			
Petroicidae	*Eopsaltria georgiana*	White-breasted Robin							+	
Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant					•			
	Phalacrocorax fuscescens	Black-faced Cormorant							+	
	Phalacrocorax sulcirostris	Little Black Cormorant					•		+	
	Phalacrocorax varius	Australian Pied Cormorant					•			
Podargidae	*Podargus strigoides*	Tawny Frogmouth					•			
Podicipedidae	*Podiceps cristatus*	Great Crested Grebe					•			
	Tachybaptus novaehollandiae	Australasian Grebe					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Poliocephalus poliocephalus	Hoary-headed Grebe					•			
Psittacidae	*Barnardius zonarius*	Australian Ringneck								
	Platycercus icterotis	Western Rosella					•			
	Platycercus zonarius	Twenty-eight Parrot								
	Polytelis swainsonii	Superb Parrot								
	Trichoglossus haematodus	Rainbow Lorikeet					•	+	+	
	Purpureicephalus spurius	Red-capped Parrot								
Rallidae	*Fulica atra*	Eurasian Coot					•			
	Gallirallus philippensis	Buff-banded Rail					•			
	Gallinula tenebrosa	Dusky Moorhen					•			
	Porphyrio porphyrio	Purple Swamphen					•			
	Porzana tabuensis	Spotless Crake					•			
Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt					•			
	Himantopus himantopus	Black-winged Stilt					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail					•	+	+	
	Rhipidura fuliginosa	Grey Fantail						+		
Rostratulidae	*Rostratula australis*	Painted Snipe	M	S2	EN	•				
	Rostratula benghalensis subsp. *australis*	Australian Painted Snipe	M	S2	EN	•				
	Tringa nebularia	Common Greenshank	M	S5	IA		•			
Strigidae	*Ninox novaeseelandiae*	Southern Boobook Owl								
Sturnidae	*Sterna bergii*	Crested Tern							+	
	Acridotheres tristis	Common Myna, Indian Myna				•				
	Sturnus vulgaris	Common Starling				•				
Threskiornithidae	*Platalea flavipes*	Yellow-billed Spoonbill					•			
	Platalea regia	Royal Spoonbill					•			
	Plegadis falcinellus	Glossy Ibis	M	S5	IA		•			
	Threskiornis molucca	Australian White Ibis					•			
	Threskiornis spinicollis	Straw-necked Ibis					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
Turnicidae	*Turnix velox*	Little Buttonquail								
Zosteropidae	*Zosterops lateralis.*	Silvereye					•	+	+	
REPTILES										
Agamidae	*Pogona minor* subsp. *minor*	Western Bearded Dragon					•	+		
Chelidae	*Chelodina oblonga*	Oblong Turtle					•			
Elapidae	*Brachyurophis semifasciatus*	Southern Shovel-nosed Snake					•			
	Neelaps bimaculatus	Black-naped Snake					•			
	Neelaps calonotus	Black-striped Snake			P3		•			
	Notechis scutatus	Western Tiger Snake					•			
	Parasuta gouldii	Black-headed Snake					•			
	Pseudechis australis	Mulga Snake					•			
	Pseudonaja affinis subsp. *affinis*	Dugite					•	+	+	
	Simoselaps bertholdi	Jan's Banded Snake					•	+		
Gekkonidae	*Christinus marmoratus*	Marbled Gecko					•	+		

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Diplodactylus polyophthalmus	Speckled Stone Gecko					•			
	Strophurus spinigerus	South-western Spiny-tailed Gecko						+		
Pygopodidae	*Aprasia repens*	Sand-Plain Worm-Lizard					•	+		
	Lialis burtonis	Burtons Legless Lizard					•	+		
Boidae	*Morelia spilota* subsp. *imbricata*	South-west Carpet Python					•			
Scincidae	*Acritoscincus trilineatum*	South-western Cool Skink					•			
	Cryptoblepharus buchananii	Snake-eyed Skink; Fence Skink					•			
	Ctenotus australis	Western Limestone Ctenotus					•		+	
	Ctenotus fallens	West-coast Striped Skink					•	+	+	
	Cyclodomorphus celatus	Western Slender bluetongue						+	+	
	Egernia kingii	King's Skink						+	+	
	Hemiergis quadrilineata	Two-toed Earless Skink					•	+		
	Lerista elegans	Elegant Burrowing Skink					•	+	+	
	Lerista lineopunctulata	West Coast Line-spotted Lerista					•	+		

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Lerista praepedita	Worm Lerista					•			
	Menetia greyii	Common Dwarf Skink					•	+		
	Morethia lineoocellata	Western Pale-flecked Morethia								
	Morethia obscura	Shrubland Morethia Skink					•			
	Tiliqua occipitalis	Western Bluetongue					•	+		
	Tiliqua rugosa subsp. *rugosa*	Bobtail						+		
Typhlopidae	*Ramphotyphlops australis*	Southern Blind Snake					•			
Varanidae	*Varanus gouldii*	Gould's Sand Goanna					•			
	Varanus tristis	Black-tailed Tree Goanna					•			
AMPHIBIANS										
Hylidae	*Litoria adelaidensis*	Slender Tree Frog					•			
	Litoria moorei	Motorbike Frog					•			
Myobatrachidae	*Crinia insignifera*	Squelching Froglet					•			
	Crinia glauerti	Clicking Frog					•			

Family	Scientific Name	Common Name	Conservation status			Database searches		Source		
								This survey	Previous surveys/Natural Area Field Assessments	
			EPBC Act	WC Act	Parks and Wildlife	PMST	NatureMap	ELA 2015	Natural Area Consulting 2014/16	Whitfords Nodes Foreshore (CoJ 2009, 2012)
	Heleioporus eyrei	Moaning Frog					•			
	Limnodynastes dorsalis	Western Banjo Frog					•			
	Myobatrachus gouldii	Turtle Frog					•			

(Source: Eco Logical Australia, 2016)

Appendix 5: Key Weed Species in Hillarys – Kallaroo Foreshore Reserve

Species Name	Common Name	Prioritisation	Photograph
Carpobrotus edulis	Hottentot Fig	High priority (DPaW Swan Environmental Weed List)	
Euphorbia paralias	Sea Spurge	Moderate priority (DPaW Swan Environmental Weed List)	
Euphorbia terracina	Geraldton Carnation Weed	Moderate priority (DPaW Swan Environmental Weed List)	
Gazania linearis	Gazania	Moderate priority (DPaW Swan Environmental Weed List)	

Species Name	Common Name	Prioritisation	Photograph
Tetragonia decumbens	Sea Spinach	High priority (DPaW Swan Environmental Weed List)	

Significant Weeds Identified and their Potential Environmental Impact

Species	Common Name where applicable	DEC Swan Region Environmental Weed List			Recommended Control Priority
		Ecological Impact H: high M: medium L: low U: unknown	Rate of dispersal R: rapid M: moderate S: slow	General trend D: decreasing S: stable I: increasing U: unknown	
Agave americana	Century Plant	M	M	S	Moderate
Asphodelus fistulosus	Onion Weed	U	R	I	Moderate
Avena barbata	Wild Oat	H	R	I	Moderate
Bromus diandrus	Great Brome	H	R	I	High
Carpobrotus edulis	Hottentot Fig	H	S	U	High
Ehrharta longiflora	Annual Veldt Grass	H	R	S	High
Euphorbia terracina	Geraldton Carnation Weed	H	R	I	Very High
Gazania linearis	Gazania	H	R	I	Moderate
Oenothera drummondii	Primrose	L	M	I	Moderate
Pelargonium capitatum	Rose Pelargonium	H	R	I	High
Tetragonia decumbens	Sea Spinach	H	R	I	High

(Source: Department of Parks and Wildlife, 2012)

Appendix 6: Weed Management

Weed control is an ongoing management issue within Hillarys – Kallaroo Foreshore Reserve. It will contribute to the reduction of competition with natives for resources, and result in enhanced vegetation condition and fauna habitat. The City of Joondalup personnel and contractors currently undertake weed control and are involved in the manual removal of weeds across the Reserve. Weed control activities will be undertaken in accordance with the City's operational procedures and guidelines.

Weed management can be achieved through the use of manual, chemical, or biological treatment methods, with manual and chemical treatments being the most common to remove weeds from coastal and terrestrial bushland areas. Characteristics of particular target species determine what weed control method is used. The presence of native flora will need to be taken into account when determining the most appropriate weed control technique for an area, especially the location of significant flora. The table below describes the different type of weed treatments recommended for those species observed on site. Treatment rates were taken from the recommended rates from off label permit no. 13333 issued by the Australian Pesticides and Veterinary Medicines Authority (2012). It is recommended that herbicides such as metsulfuron and triasulfuron be used once a year at the recommended dose in the reserve to reduce residual effect in soils, which can lead to some species becoming resistant to their effects and associated death of non-target species. The recommended treatment and treatment times are shown in weed control methodology table (DPaW, FloraBase 2015; Brown and Brooks, 2002). Chemical weed control activities will be in accordance with the City's operational procedures and guidelines.

Weed treatment types

Treatment Number	Treatment Type	Targeted Species	Application Method and Comments
1	Glyphosate Spray	Annual and perennial grass and broadleaf weeds	Spot spray – non-selective
2	Selective grass herbicide (such as Quizalofop or Fusilade Forte)	Annual and perennial grasses	Spot spray, or overall spray in broad leaf host situations – selective grass spray
3	Metsulfuron	Annual broadleaf weeds and bulbs	Spot spray – semi selective
4	Glyphosate glove/Metsulfuron glove sponge wipe	One-leaf Cape Tulip	Wipe Leaves with sponge prior to or just on flowering
5	Triclopyr, Picloram, or Glyphosate	Woody weeds and trees	Cut and paint or basal bark (summer)
6	Manual removal /hand weeding	Carnation Weeds, Fleabane, Pigface, and similar	Gloves required due to caustic sap of Carnation Weed
7	Triasulfuron	Carnation Weeds, Brassicaceae weeds post emergence and other annual	Spot spray - selective

(Source: DPaW, FloraBase 2015; Brown and Brooks, 2002)

Weed Control Methodology

Species Name	Common Name	Treatment Number	Timing
Agave americana	Century Plant	5 or 6	Year round
Arctotheca calendula	Cape Weed	1 or 6	June – November
Asphodelus fistulosus	Onion Weed	3 or 6	July – October
Avena barbata	Wild Oats	2	July – November
Brassica tournefortii		1 or 7	May – September
Briza maxima	Blowfly grass	2	July – August
Bromus diandrus	Brome Grass	2	June – September
Cakile maritima	Sea Rocket	1 or 6	June – November
Crassula glomerata		1 or 6	July – September
Cynodon dactylon	Couch	2	November – February
Cyperus tenellus	Tiny Flat-sedge	1 or 6	November – December
Ehrharta longiflora	Annual Veldt Grass	2	June – August (before flowering)
Euphorbia paralias	Sea Spurge	1	June – October
Euphorbia terracina	Geraldton Carnation Weed	1, 6 or 7	Manual: June – November Herbicide: August – September
Fumaria capreolata	Whiteflower Fumitory	3 or 6	July – September
Gazania linearis	Gazania	1	June – October
Hordeum leporinum	Barley Grass	2	June – August
Lactuca serriola	Prickly Lettuce	1 or 6	September – November
Lagurus ovatus	Hare's Tail Grass	2 or 6	Manual: July – December Herbicide: June – August
Lobularia maritima	Sweet Alyssum	1 or 6	Manual: year round Herbicide: April – September
Lolium perenne	Perennial Ryegrass	1, 2 or 6	July – October
Lysimachia arvensis	Blue Pimpernel	1	June – November
Oenothera drummondii	Beach Primrose	1	July – September
Pelargonium capitatum	Rose Pelargonium	1	June – October
Solanum nigrum	Black Berry Nightshade	1 or 6	June – November
Sonchus oleraceus	Sowthistle	1 or 6	Manual: June – November Herbicide: June – September
Tetragonia decumbens	Sea Spinach	1	June – October

Implementation Schedule

A recommended implementation schedule is provided below outlining all the works set outlined in Appendix 5 and 6. The schedule is set up for rehabilitation works to commence in the spring of 2016 with completion of prescribed works in 2019.

Year 1 (2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or Picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones												
Informal monitoring												

Year 2 (2017)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or Picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Year 3 (2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or Picloram												
Metsulfuron												

Year 3 (2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Year 4 (2019)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate Spray												
Selective Grass Spray												
Triclopyr or Picloram												
Metsulfuron												
Triasulfuron												
Hand Weeding												
Revegetation all zones (Infill)												
Informal monitoring												

Appendix 7: Restoration and Regeneration

Restoration within the Hillarys – Kallaroo Foreshore Reserve will enhance biodiversity within the site and stabilise the dunes and reduce erosion. Restoration will focus on the vegetation condition areas assessed as Good. It is recommended that this revegetation program be carried out over a five-year period, from 2017 until 2021, and that planting occur from June to August each year.

Area classified as having Good vegetation condition located on site are recommended to be prioritised for restoration to reduce potential impacts of erosion. Rehabilitation areas were focussed on areas with a lot of bare ground, particular areas bordering vegetated areas and areas on hillslopes to reduce erosion and the introduction of weeds into vegetated areas. These seven revegetation areas are shown in the figures below. Revegetation for the site has been split into seven areas, including:

- Area 1 – 2120 m^2 (1060 plants)
- Area 2 – 1660 m^2
- Area 3 – 2390 m^2
- Area 4 – 2020 m^2
- Area 5 – 2436 m^2
- Area 6 – 4828 m^2
- Area 7 - 3396 m^2

Planting density of 1 plant/m^2 is recommended, taking into consideration existing native plants on site the planting numbers have been reduced to half of what is required for the areas. Tubestock is recommended to be sourced from a NIASA accredited nursery and grown from provenance seed, hardened off and in good condition prior to planting. Note that some species are difficult to grow and consideration will need to be given to the collection of suitable seed, with germination often taken more than one season. It is recommended that guarding and staking of new planting occurs to mitigate detrimental impacts of strong winds, salt spray and erosion due to the close proximity to the ocean. Indicative plant species numbers for the priority restoration areas are provided in the Table below, noting that the numbers will be lower than those listed above to account for existing native vegetation.

Indicative Plant Numbers for Priority Restoration Areas

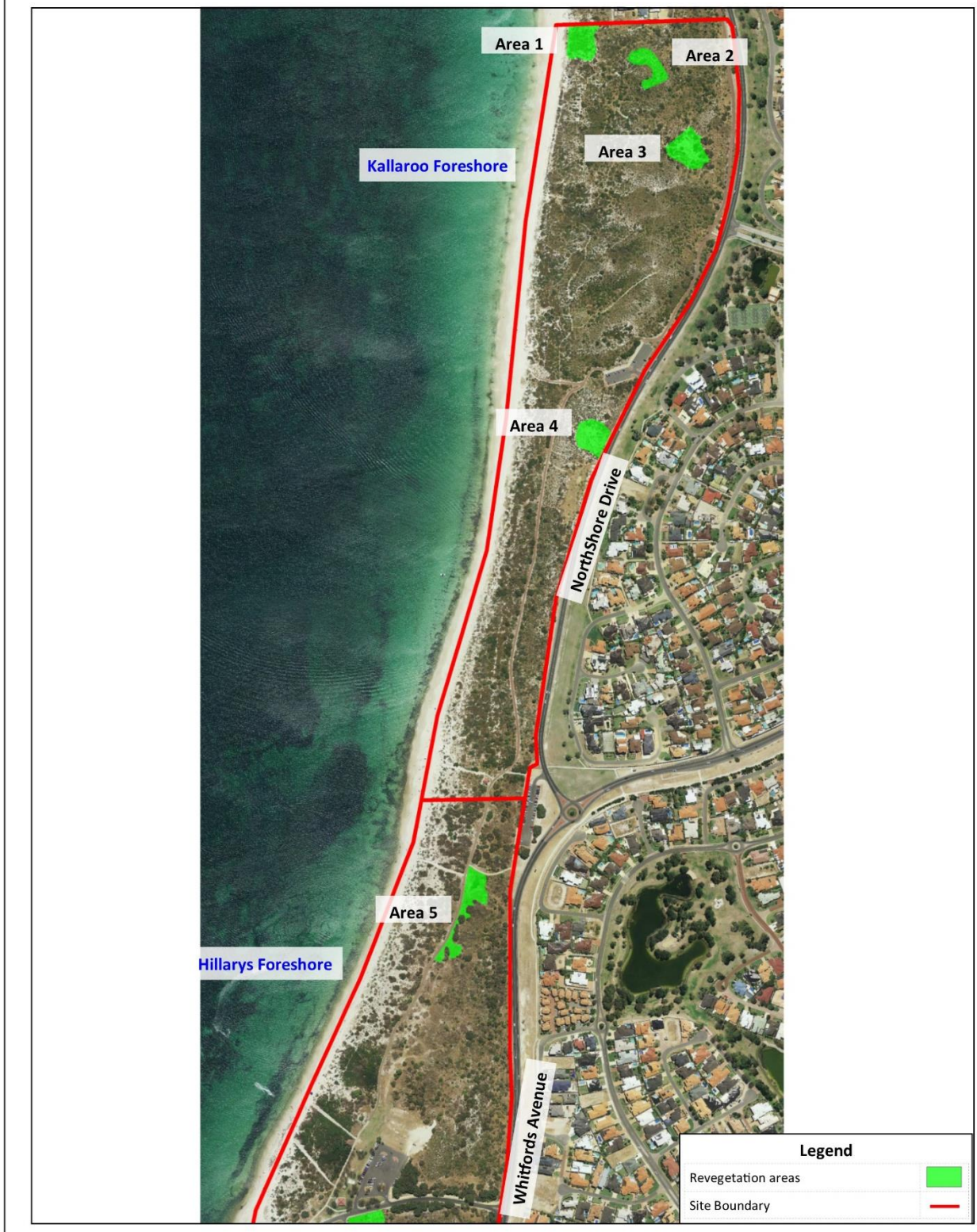
Species Name	Form	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Acacia lasiocarpa var. *lasiocarpa*	Small shrub	80	50	100	80	100	154	100
Acacia truncata	Small shrub	80	50	50	50	50	60	50
Acanthocarpus preissii	Small shrub	80	70	100	80	80	150	100
Austrostipa flavescens	Grass	50	40	70	50	50	100	100
Carpobrotus virescens	Ground cover	100	30	50	50	80	150	80
Clematis pubescens	Climber			50	30	50	100	50
Conostylis candicans	Herb	50	50	100	50	80	150	50
Ficinia nodosa	Sedge	20	50	50	40	50	100	50
Gastrolobium capitatum	Small shrub				20	20	60	78
Gompholobium tomentosum	Small shrub				30	20	60	80
Hardenbergia comptoniana	Climber	45	50	60	20	30	100	60
Hemiandra glabra	Ground cover	25	40	50				30
Hemiandra pungens	Ground cover		30	50	50	50	100	30
Hibbertia subvaginata	Small shrub				20			20
Lepidosperma gladiatum	Sedge		50	50	50			80
Lomandra maritima	Herb	50	30	50	50	60	100	
Melaleuca huegelii	Shrub				20			20
Melaleuca systena	Small shrub	50	50	50	30	80	150	50
Myoporum insulare	Shrub		10	20	20	20	40	20
Olearia axillaris	Shrub	100	50	50	50	100	200	100

Species Name	Form	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Phyllanthus calycinus	Small shrub			40	30			100
Pimelea ferruginea	Small shrub				20	20	40	50
Pithocarpa cordata	Small shrub			20	20	40	80	20
Rhagodia baccata subsp. *baccata*	Shrub	60	40	45	30	50	100	80
Santalum acuminatum	Shrub			20	20			50
Scaevola crassifolia	Shrub	100	50	50	30	58	100	100
Spinifex hirsutus	Grass	70						
Spinifex longifolius	Grass	100	50			50	100	
Spyridium globulosum	Shrub			40	30	50	100	50
Templetonia retusa	Shrub			30	20		50	50
Threlkeldia diffusa	Ground cover		40		20	30	70	50
	Area totals	**1060**	**830**	**1195**	**1010**	**1218**	**2414**	**1698**
	Total							

The Hillarys – Kallaroo Foreshore Reserve has undergone a substantial amount of restoration over the last ten years, and most of the planting required is infill planting throughout the site in areas of Good vegetation condition. Additional species recommendations are based upon underrepresented species within the site and the following reference sites within the City of Joondalup; the Marmion Coastal Foreshore Reserve, Iluka Coastal Foreshore, and the Ocean Reef Foreshore. Recommended additional species for revegetation are listed in the table below; these should be used in addition to existing planting lists.

Proposed Additional Revegetation Species List

Species Name	Common Name	Comments
Anthocercis littorea	Yellow Tailflower	Not recorded within the site but found within the Joondalup Coastal Foreshore
Clematis linearifolia	Slender Clematis	Not found on site, but is common in coastal areas of Perth and would be suitable within the secondary and tertiary dunes
Conostylis aculeata subsp. *cygnorum*		Not found within the site, would be suitable across the site except the primary dunes
Diplolaena dampieri	Southern Diplolaena	Not found in the area but is recorded within the Joondalup coast line, would be suitable to be planted in the tertiary dunes
Exocarpos sparteus	Broom Ballart	Not found within the site, but would be suitable to plant in the secondary and tertiary dunes
Leptomeria preissiana		Not found on site but suitable to be planted in the secondary and tertiary dunes
Leucophyta brownii		Not found on site, it prefers primary and secondary dune habitat
Lomandra maritima	Maritime Mat Rush	Found within the site, it is an important plant as it provides habitat for the Priority 4 Graceful Sun Moth (*Synemon gratiosa*), suitable to be planted near existing plants. Larger plants would be best as they have better survival success than tubestock for this species.
Myoporum insulare	Blueberry Tree	Some large shrubs situated at the south of the site but in low abundance, suitable to plant in secondary and tertiary dunes
Senecio pinnatifolius	Variable Groundsel	Found on site in low abundance suitable to be planted throughout the site



Client: City of Joondalup
Project: Hillarys Kallaroo Foreshore Reserve Management Plan
Map Prepared by: S. Hynes
Date: 01/06/2016
Image Source: City of Joondalup
Datum: GDA94
Projection: MGA Zone 50

Proposed revegetation areas
Hillarys Kallaroo Foreshore Reserve

0 N 100
Meters

Client: City of Joondalup
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Proposed revegetation areas
Hillarys Kallaroo Foreshore Reserve

0 N 100
Meters