Port Kennedy Business Enterprise Park
Structure Plan

Lot 17 and Lot 4 Port Kennedy Drive – Port Kennedy

Prepared For DevelopmentWA
December 2024 | 717-278

DevelopmentWA element.

Acknowledgment of Country

We acknowledge the Whadjuk people of the Noongar nation as traditional owners of the land on which we live and work.

We acknowledge and respect their enduring culture, their contribution to the life of this city, and Elders, past and present.

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Endorsement Page

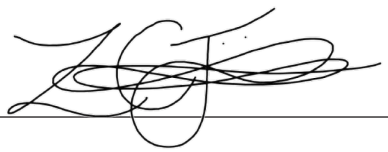
THIS STRUCTURE PLAN IS PREPARED UNDER THE PROVISION OF THE CITY OF ROCKINGHAM TOWN PLANNING SCHEME NO. 2

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

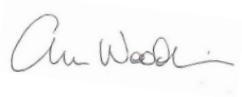
22 JANUARY 2025

SIGNED FOR AND ON BEHALF OF THE

WESTERN AUSTRALIAN PLANNING COMMISSION



AN OFFICER OF THE COMMISSION DULY AUTHORISED BY THE COMMISSION PURSUANT TO SECTION 24 OF THE *PLANNING AND DEVELOPMENT ACT 2005* FOR THAT PURPOSE, IN THE PRESENCE OF:



WITNESS

23 JANUARY 2025 — DATE

23 JANUARY 2035 — DATE OF EXPIRY

Record of Amendments Made to Port Kennedy Business Enterprise Park Structure Plan

Amendment No.	Summary of the Amendment	Amendment type	Date approved by WAPC

Executive Summary

Project Vision: Port Kennedy Business Enterprise Park will provide an employment hub for the south-west region, encapsulating a strong sense of place for employees and visitors, whilst preserving and regenerating the environmental values of the site.

The Port Kennedy Business Enterprise Park (PKBEP) Structure Plan has been prepared to guide the future subdivision, development and conservation of 67 hectares of land at Lot 17 and Lot 4 Port Kennedy Drive, Port Kennedy. This will enable coordinated subdivision and development for the purposes of Service Commercial, Office and Light Industry uses.

The document has been prepared in accordance with the requirements of the *Planning and Development (Local Planning Schemes) Regulations 2015* and other identified relevant local and State level planning policies and strategies. The structure plan considers the environmental, planning and engineering matters appropriate to implement the development of the site in an orderly and managed manner.

Project Objectives

The PKBEP Structure Plan has been designed with a number of key objectives in mind, these are:

- Facilitate a diverse range of employment generating land uses, including a range of light industrial, service commercial and office uses.
- Create a flexible design layout with a diversity of lot types which can respond to the needs of industry.
- Develop the site in an environmentally sensitive manner and protect and enhance its environmental assets.
- Create a unique sense of place within the PKBEP through the application of landscape and environmental features.
- Contribute to the City's tree canopy objectives, reducing the urban heat island effect and improving urban amenity, aligning with the vision of the City of Rockingham's Greening Plan.
- Provide a suitable interface and managed land use permissibility along the northern boundary of the subject site so to avoid land use conflict and protect the existing residential amenity of the adjoining land.
- Create a logical and permeable movement network throughout the site, including connectivity with the existing Port Kennedy Business Park to the west of Bakewell Drive, to facilitate potential land use synergies.
- Enable pedestrian access opportunities from the St Michelle residential estate to the north down to the proposed wetland viewing areas located within the conservation lot.
- Maximise commercial exposure opportunities for future business operators located along the Port Kennedy Drive and Ennis Avenue interfaces.

Purpose

The Structure Plan framework will inform how lots may potentially be configured as part of future subdivision applications to the Western Australian Planning Commission (WAPC), whilst still being flexible enough to respond to the market needs of the private sector.

Design Approach

A multidisciplinary design approach has been employed by the specialist consultant team to ensure that the design approach has been informed by all relevant environmental, planning and engineering matters. The specialists involved in this process have included:

- DevelopmentWA – project management and commercial analysis.
- Element Advisory – structure plan preparation and urban design.
- PGV Environmental – environmental.
- Plan E Landscape Design – landscape design.
- Porters – traffic and transport analysis and civil engineering.
- Strategen JBS&G – bushfire management and local water management.

Background

The PKBEP is located approximately 50 kilometres south of the Perth CBD and 12 kilometres south of Rockingham City centre. It is located to the east of the existing developed Port Kennedy Business Enterprise Area, which has been progressively developed for a range of Service Commercial, Office and Light Industry uses since the 1980's.

The subject site was previously reserved 'Parks and Recreation' under the Metropolitan Region Scheme (MRS) and was rezoned to 'Industrial' in 1994. Under the *City of Rockingham Local Planning Scheme No.2* (LPS2), the site is currently zoned Port Kennedy Business Enterprise.

The subject site lies within a wetland corridor, however the wetlands on site are not part of the Becher Point Wetland, which is listed as a Ramsar site (Wetlands of International Importance). However the site is identified as featuring a Threatened Ecological Community (TEC) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which is listed as Endangered under the EPBC Act and is listed as Critically Endangered at the State level. The TEC comprises Swan Coastal Plain (SCP) 19 'Sedgelands in Holocene dune swales of the southern Swan Coastal Plain', which includes two sub-types, SCP 19a, being 'sedgelands in Holocene dune swales' and SCP 19b, being 'woodlands over sedgelands in Holocene dune swales'.

The PKBEP Structure Plan includes a notional Conservation Area located on the western part of the site, which is approximately 18 hectares in area. This will protect a large proportion of the significant wetlands and TEC19 on the site subject to further environmental investigation. In addition, a further wetland will be retained centrally within the business estate as part of a dedicated Public Open Space local park. This will result in a total of 19 wetlands being protected under the Structure Plan. It is noted that historic environmental approvals allow for all vegetation and wetlands on the site to be cleared. The proposed retention of 19 wetlands in the Structure Plan is considered a much better environmental outcome for the site.

A summary of the key statistics of the Structure Plan are summarised below.

Item	Details
Gross Structure Plan Area	67.07ha
Area of Port Kennedy Business Enterprise Zone (Inc. Roads)	49.06ha
Conservation Area (for further investigation)	18 ha
Open Space/Drainage	0.17ha
Estimated Lot Yield	117 lots

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Figures

Part One: Implementation

1. Implementation

1.1 Structure Plan Area

The Port Kennedy Business Enterprise Park (PKBEP) Structure Plan applies to Lot 17 and Lot 4 Port Kennedy Drive Port Kennedy, located within the City of Rockingham approximately 50 kilometres south of the Perth CBD and 12 kilometres south of Rockingham City centre.

The site is generally bound by residential development to the north, Ennis Avenue to the east, Port Kennedy Drive to the south and Bakewell Drive to the west as shown on the PKBEP Structure Plan Map.

Refer to the Port Kennedy Business Enterprise Park Structure Plan Map (Plan 1)

The Structure Plan Map outlines the proposed extent of the Conservation Lot, the proposed area of Public Open Space and the general road layout and lot configuration. The proposal aligns with the requirements of the *City of Rockingham Local Planning Scheme No.2* (LPS2).

1.2 Structure Plan Content

The PKBEP Structure Plan comprises the following sections:

- **Part One** – Implementation. This section contains the Structure Plan Map and sets out the requirements that shall be considered when assessing subdivision and development applications for land within the Structure Plan area.
- **Part Two** – Explanatory Section. This section provides the planning context and justification for the Structure Plan Map and the text provisions, standards or requirements contained in Part One of the Structure Plan. Part Two is to be used as a reference to guide interpretation and implementation of Part One.
- **Appendices** – Includes all specialist consultant reports and documentation used in the preparation of and to support the land use outcomes of the PKBEP Structure Plan.

1.3 Interpretations and Relationship with Town Planning Scheme No.2

1.3.1 Terms and Interpretation

Unless otherwise specified in this part, the words and expressions used in the PKBEP Structure Plan shall have the respective meanings given to them in the *City of Rockingham Town Planning Scheme No. 2* (TPS2) including any gazetted amendments.

1.3.2 Relationship of the Structure Plan with Town Planning Scheme No. 2.

The PKBEP Structure Plan has been prepared in accordance with Schedule 2, Part 4 of the *Planning and Development (Local Planning Schemes) Regulations 2015.* The subject land is zoned 'Port Kennedy Business Enterprise Zone' and as set out at sub-clause 4.9.3.2 of TPS2, a structure plan is required for the site.

The PKBEP Structure Plan Map outlines the zones and reserves intended to be applicable within the PKBEP Structure Plan area. A decision-maker for an application for development or subdivision approval in an area that is covered by a structure plan that has been approved by the WAPC is to have due regard to, but is not bound by the structure plan when deciding the application.

1.4 Structure Plan Operation

The date the PKBEP Structure Plan comes into effect is the date the structure plan is approved by the Western Australian Planning Commission (WAPC).

1.5 Staging

The development of the PKBEP Structure Plan will likely be implemented in multiple stages due to the significant size of the development area. Final development staging will also be dependent on a number of factors including market demand, servicing and infrastructure considerations.

Importantly, there is no requirement for specific staging of development. Provided that suitable road access and servicing infrastructure is included in any proposed development the staging of the development area will be market-led. It is anticipated that the first two stages of land release will occur along Port Kennedy Drive up to Ennis Avenue. The first stage of development is anticipated to include one dual lane roundabout on Port Kennedy Drive at the location of the new connecting subdivision road. This is to be funded and delivered as part of the development. The second stage of development is anticipated to include a second dual lane roundabout on Port Kennedy Drive at the location of the new connecting subdivision road being delivered in this stage. The Port Kennedy Drive and Ennis Avenue intersection will also require modification. The staging of these upgrade works are to be agreed with Main Roads WA (MRWA) and is anticipated to be prior to the creation of lots beyond Stage 1. Further information on the proposed staging is outlined within section 7.1 of the Explanatory Report.

1.6 Subdivision and Development Requirements

1.6.1 Subdivision Requirements

The PKBEP Structure Plan sets out the following key conditions to be met during the subdivision stages:

1. Subdivision shall generally be in accordance with the PKBEP Structure Plan and be approved by the WAPC.
2. Subsequent variations to the PKBEP Structure Plan may include minor adjustments to road configurations, open space boundaries and public path locations, provided that the variation does not change the intent or configuration of the PKBEP Structure Plan and is subject to the approval of the WAPC.
3. Developable lots should be connected to the following urban services: reticulated potable water; sewer; underground power; telecommunications; and reticulated gas supply.
4. A bushfire risk assessment/management plan in conjunction with the Department of Fire and Emergency Services and the City of Rockingham, shall be developed and must take account of long-term revegetation outcomes associated with the conservation lot.
5. An Urban Water Management Plan is to be prepared, to be consistent with the endorsed LWMS.
6. A Traffic Transport Impact Assessment shall provide technical specifications relating to the subdivision and development of the land.
7. A Landscape Management Plan shall detail the ongoing management and maintenance of the designated public open space area.
8. A Conservation Area Management Plan (CAMP) which outlines measures to enhance and protect the values of the Conservation Area.
9. A Fauna Relocation Management Plan to outline measures to identify, relocate and prevent harm to any native fauna remaining on the site during vegetation clearing.
10. A Dewatering Management Plan to outline how environmental values will be protected during any required dewatering.

1.6.2 Road and Intersection Upgrades

The Transport Impact Assessment indicates that a number of road and intersection upgrades will be required in order to accommodate new industrial development within the structure plan area. The WAPC may impose conditions of subdivision approval related to the required upgrades.

In this regard, the upgrade of Port Kennedy Drive and the construction of new intersections required to provide direct access to the structure plan area will need to be undertaken at the developer's cost.

Further, the existing intersection between Ennis Avenue and Port Kennedy Drive will also need to be modified to the specifications of Main Roads WA and these works will need to be undertaken at the developer's cost, as development within the structure plan area brings forward the need to modify the intersection.

1.6.3 Local Development Plan/s

At the subdivision stage, the WAPC may impose a condition of approval requiring Local Development Plan/s (LDPs) to be prepared for:

- lots abutting, or separated from the northern boundary of the structure plan area by a local road reserve or pedestrian access way;
- lots abutting public open space or separated from public open space by a pedestrian access way; and/or
- lots abutting Port Kennedy Drive.

The LDPs may be required to address one or more of the following matters, (where relevant):

- built form and building height;
- setbacks, siting and orientation of buildings and their interface and activation to the street or public open space;
- vehicle access and egress control;
- car parking and preferred locations for reciprocal parking arrangements;
- landscaping; and
- Implementation of Crime Prevention Through Environmental Design principles.

1.6.4 Development Requirements

Development within the Structure Plan area is guided by the provisions listed in Town Planning Scheme No. 2 for the Port Kennedy Business Enterprise Zone (currently set out in clause 4.9). This includes provisions relating to form of development, planning control, land use control, parking, general development provisions and landscaping.

In considering applications for development approval in this zone the City of Rockingham may have regard to the following:

a) promotion of a high standard of building development, landscaping and working environment;

b) protection of the amenities of adjacent residential areas;

c) management of drainage systems and land use to promote groundwater conservation; and

d) safe movement of vehicular and pedestrian traffic in the area.

As per the provisions listed in Town Planning Scheme No. 2 for this zone, the Structure Plan Map also designates two distinct areas which have additional land use controls. These controls seek to reduce amenity impacts on surrounding roads and adjacent residential development and apply to:

- lots with frontage to Warnbro Sound Avenue, Port Kennedy Drive, Ennis Avenue or any adjacent parallel service road (hatched on the Structure Plan Map); and
- lots within 50 metres of the northern boundary of the Zone (broken black line on the Structure Plan Map).

1.6.5 Construction and Operational Emissions

Future development applications are obliged to comply with the “Land development sites and impacts on air quality: a guideline for the prevention of dust and smoke pollution from land development sites in Western Australia”, prepared by the Department of Water and Environment Regulation.

Future development applications will need to ensure light being emitted or reflected from the land is not to create a nuisance to neighbouring properties. A Construction Management Plan will be required to ensure dust and noise mitigation measures are put in place.

1.6.6 Local Drainage

The proposed drainage network, as defined by the Local Water Management Strategy (LWMS), is outlined in Section 5 of this report. The location and nature of drainage infrastructure shall be provided in accordance with the LWMS, and a UWMP shall be provided at the subdivision stage. The LWMS identifies and describes a range of design elements and management measures being considered for the Project. The principal objective of this LWMS is to achieve better urban water management outcomes by designing a development that manages the total water cycle in a sustainable manner and meets objectives for water sensitive urban design. This includes consideration of water conservation and efficiency (water use), water quantity management (groundwater levels and surface water flows), water quality management (groundwater and surface water quality) and disease vector and nuisance insect management.

1.6.7 Management of Conservation Lot and Local Open Space

The notionally shown conservation lot will ultimately be reserved Parks and Recreation Reserve under the Metropolitan Region Scheme (MRS) and converted to a reserve under the *Land Administration Act 1997*. It is proposed that ultimately the conservation lot will be managed by the Department of Biodiversity, Conservation and Attractions (DBCA) in accordance with the *Rockingham Lakes Regional Park Management Plan*.

The conservation lot is to be ceded free of cost to the Crown at the time of subdivision (refer to existing WAPC conditional approval WAPC Ref:156342).

A Conservation Area Management Plan is also to be prepared for the conservation lot at the time of subdivision that sets out how the site's environmental assets are to be protected and managed. The plan is to include measures for rehabilitation of degraded areas monitoring of hydrology and vegetation health.

The LWMS identifies two areas proposed for drainage detention basins that will accommodate stormwater within open space reserves. They will be designed, constructed and ceded to the Crown and vested with the City of Rockingham as condition of subdivision approval, and reserved for the purpose of 'Local Reserve' by the City.

Legend

Structure Plan Boundary

MRS Reserves

Parks and Recreation

Local Reserves

Public Open Space and Drainage

Local Zones

Port Kennedy Enterprise Zone

Other

Local Distributor Road
25m Road Reserve

Local Access Road

Pedestrian Path

Dual Use Path

Principal Shared Path

Wetland

Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Part Two: Explanatory Section

2. Background

2.1 Introduction and purpose

The purpose of this report is to provide for the orderly and proper subdivision and development of Lot 17 and Lot 4 Port Kennedy Drive, Port Kennedy ('subject site'), for the purposes of Service Commercial, Office and Light Industry uses.

The PKBEP Structure Plan represents a design and land use response to the principles and objectives of State and Local Government policy and guidance, including Perth and Peel @ 3.5 Million.

The information contained in this section provides justification and support for the comprehensive and coordinated design response provided for the PKBEP Structure Plan.

2.1.1 Location

The subject site is located approximately 50 kilometres south of the Perth CBD and 12 kilometres south of Rockingham City centre. The subject site has frontages to Ennis Avenue to the east, Port Kennedy Drive to the south and Bakewell Drive to the west. It adjoins an existing residential area to the north and is located to the east of the existing Port Kennedy Business Enterprise area, which is located on the western side of Bakewell Drive.

Refer to Figure 1 – Location Plan

2.1.2 Legal description

The subject site comprises Lot 17 and Lot 4 Port Kennedy Drive, Port Kennedy. The land is legally described as set out in Table 1 below.

Refer to Figure 2 – Existing Lot Cadastre

Refer to Appendix A – Certificate of Titles and Sketches

Table 1 – Land Description

Lot No.	Diagram	Volume	Folio	Area (hectares)
17	65566	1663	339	42.617 ha
4	94300	2126	431	24.462 ha

source: googlemaps

Figure 1. Location Plan

Figure 2. Existing Lot Cadastre

2.1.3 Ownership

The site is owned by the Industrial Lands Development Authority, which is a business unit within DevelopmentWA. DevelopmentWA, through the Industrial Lands Development Authority unit takes a leading role in driving WA's economic development and jobs growth.

2.1.4 Area and land use

The subject site has a total area of 67.08 hectares and currently consists of native bushland with a number of tracks traversing the site. Activities occurring on the site include uncontrolled four-wheel driving and illegal dumping of rubbish. The surrounding land uses consist of light commercial and industrial land to the west, residential housing to the north and Rockingham Lakes Regional Park to the south and east including Bush Forever Site 356 and Lake Walyungup.

Historically, construction surrounding the site first commenced between 1979 and 1981 consisting of a road to the east of the site (Plate 1). Vegetation was cleared to the south of the eastern half of the site between 1983 and 1985 to construct a motorbike track.

The surrounding land uses consist of light commercial and industrial land to the west, residential housing to the north and Rockingham Lakes Regional Park to the south and east including Bush Forever Site 356 and Lake Walyungup. Historically, construction surrounding the site first commenced between 1979 and 1981 consisting of a road to the east of the site.

Refer to Figure 3 – Aerial Plan – Context (Source: Strategen JBS&G)

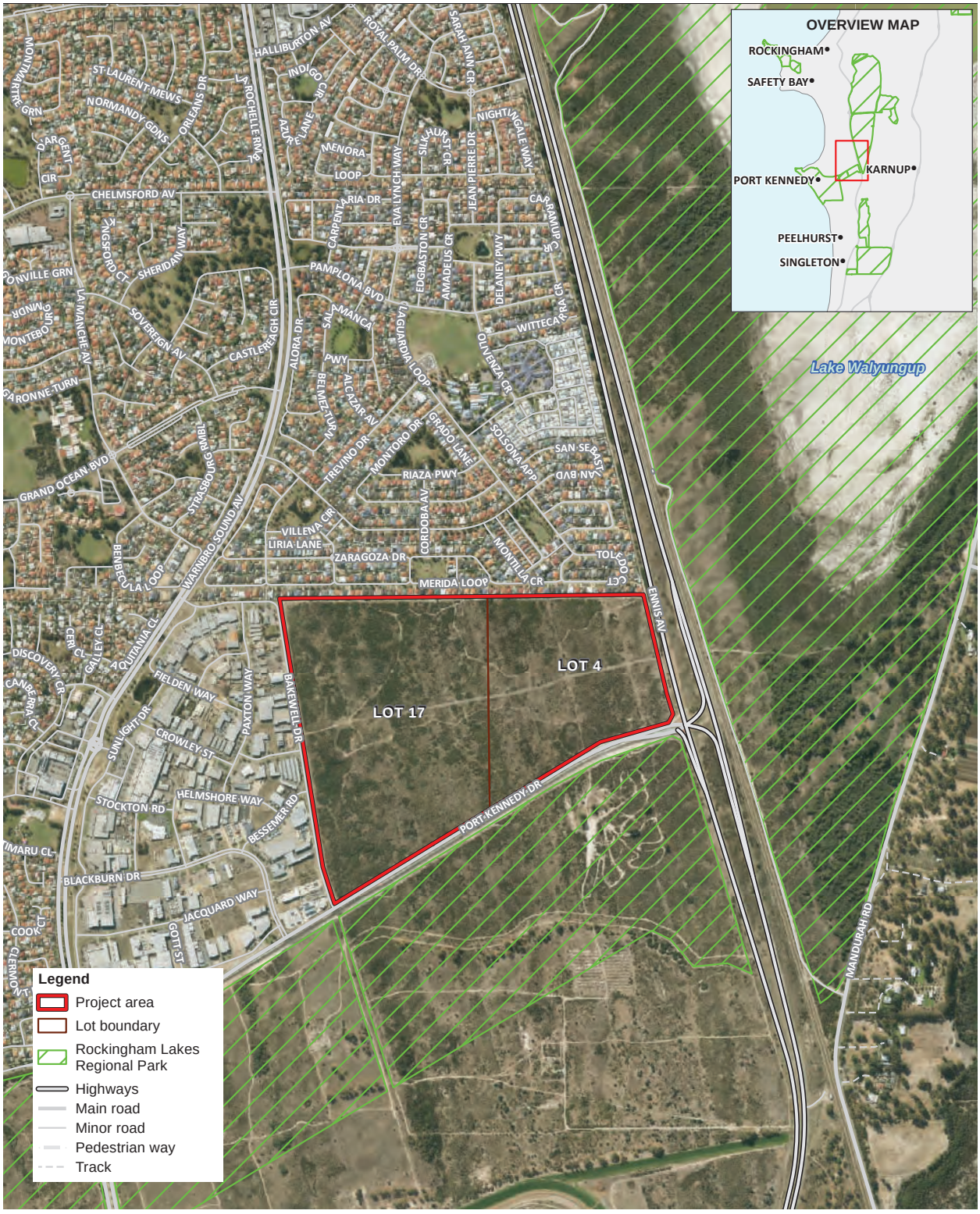


Figure 3. Aerial Plan – Context (Source: Strategen JBS&G)

Residential lots along northern boundary

View south-west to Bakewell Drive

View towards Bakewell Drive

View towards north-east

Existing dumping

2.2 Planning Framework

2.2.1 Zoning and Reservations

Under the provisions of the Metropolitan Region Scheme the subject site is zoned 'Industrial'. The subject site is zoned 'Port Kennedy Business Enterprise' under the City of Rockingham's Local Planning Scheme No.2 (LPS2). The objective under LPS2 is ***'to promote service commercial and office land uses within the area to service the demands of the locality and in recognition of the local government's regional responsibility to provide light industrial land within the region, encourage the development of light industrial land uses in an orderly and proper manner.' Regard is given to the following criteria:***

- promotion of a high standard of building development, landscaping and working environment;
- protection of the amenities of adjacent residential areas;
- management of drainage systems and landuse to promote groundwater conservation; and
- safe movement of vehicular and pedestrian traffic in the area.

Refer to Figure 4 – City of Rockingham LPS2

2.2.2 Planning Strategies

Perth and Peel @ 3.5 million

The Perth and Peel @ 3.5 Million framework (the framework) is an overarching suite of documents, which builds on the vision established under Directions 2031. It aims to achieve a more consolidated urban form to meet long–term housing needs and strengthen key activity centres and employment nodes as the Perth and Peel population grows to 3.5 million. The framework provides strategic guidance to government agencies and local governments on land use, land supply, land development, environmental protection, infrastructure investment and the delivery of physical and community/social infrastructure for the Perth and Peel regions. The suite of documents also includes four subregional planning frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions. The four sub-regional planning frameworks detail where future homes and employment should be located, and where important environmental assets should be avoided and protected.

The subject site is situated within the South Metropolitan Peel Planning Framework (sub-regional framework). It is identified within the framework as an industrial area, consistent with the current MRS zoning of the site.

Refer to Figure 5 – South Metropolitan Peel Planning Framework (sub-regional framework)

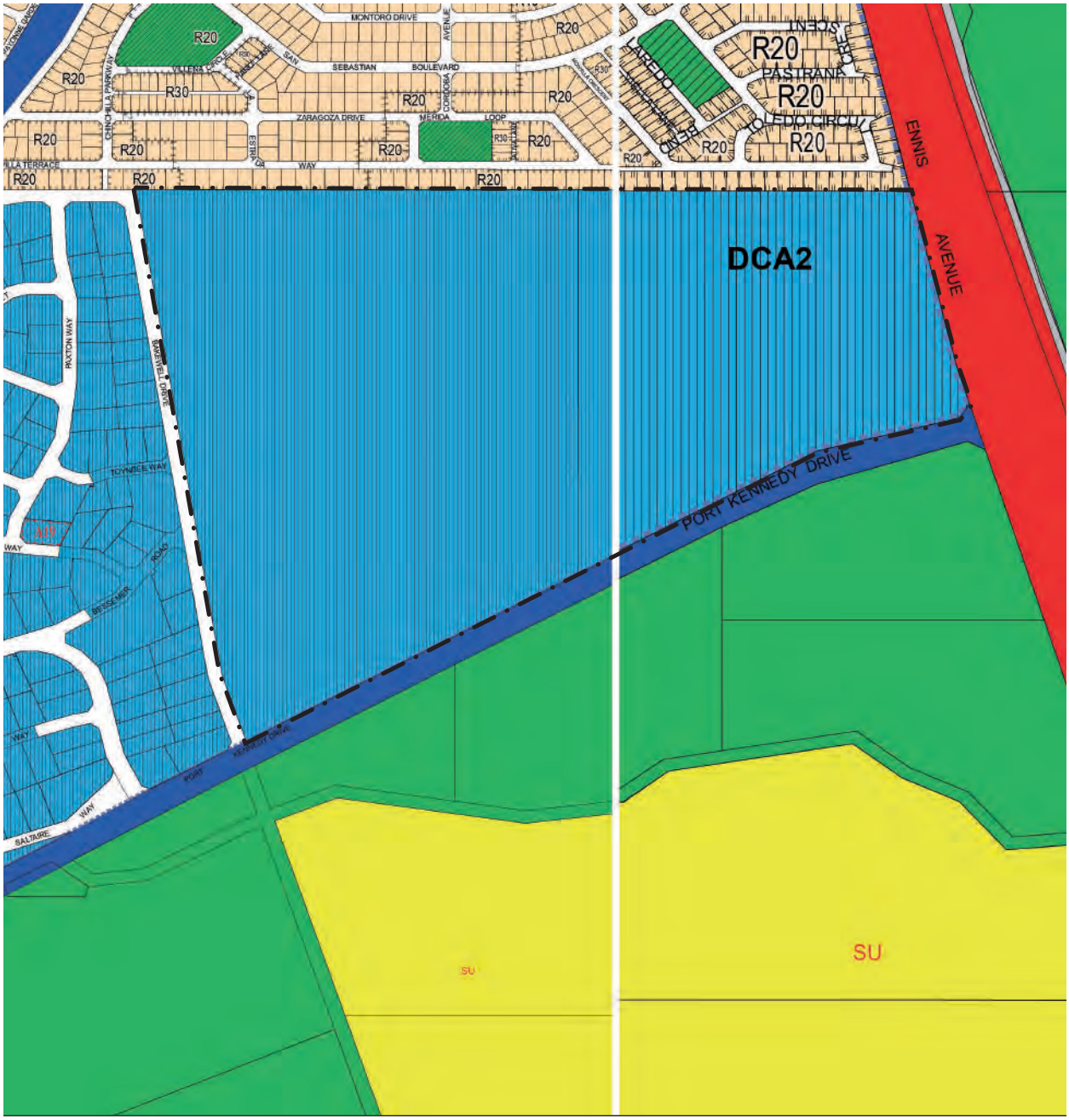


Figure 4. City of Rockingham LPS2

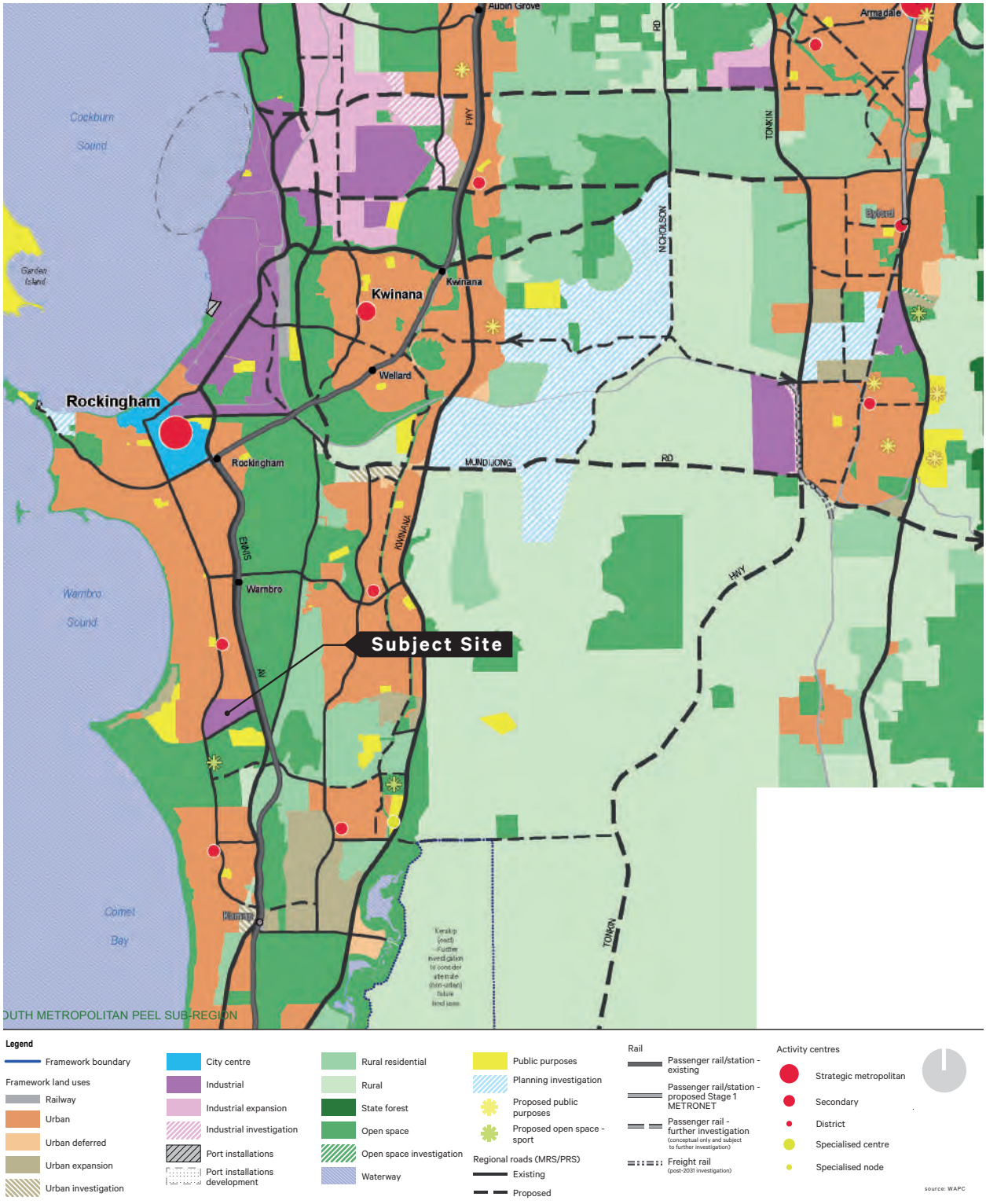


Figure 5. South Metropolitan Peel Planning Framework (sub-regional framework)

The sub-regional framework provides 10 principles for urban consolidation which include the following relevant principles:

6. Industrial Centres - Promote the current and proposed supply and/or development of industrial centres as key employment nodes and prevent incompatible residential encroachment on these areas.

9. Green Network - Preserve, enhance and consolidate the green network of parks, rivers, recreation areas, facilities for active open space, conservation and biodiversity areas, and areas with a high level of tree canopy coverage, considered important for the health and wellbeing of the community.

10. Protection - Avoid, protect and mitigate environmental attributes and promote development that contributes to maintaining air quality and minimises risks of inundation from sea-level rise, flooding or storm surge events and that minimises the risks of bushfire damage.

The key objective for the economy and employment under the sub-regional framework is:

To promote employment opportunities and increase the number of people who live and work within the sub-region, with a focus on attracting strategic economic and employment land uses within the strategic metropolitan centres and key industrial centres, while maximising use of existing and proposed infrastructure.

It is noted that the sub-regional framework suggests that there will be significant additional demand for industrial land in the sub-region and that the utilisation of undeveloped land forms a key part in meeting this future demand. The PKBEP Structure Plan directly responds to and is consistent with this approach.

The key objective for the environment and landscape under the sub-regional framework is:

To preserve and enhance the environmental and landscape values of the sub-region for future generations to enjoy

The sub-regional framework suggests that one of the challenges for the environment and landscape in the sub-region us to retain or create a 'sense of place' by maintaining key individual landscape characteristics and vistas in areas that are subject to large scale change. The PKBEP Structure Plan will achieve this through the conservation and enhancement of existing landscape values in the proposed conservation lot as well as the requirement for tree lined streets in the future subdivision and development of the subject site.

The PKBEP Structure Plan is entirely consistent with the framework and sub-regional framework and will contribute to the achievement of objectives identified in the sub0regional framework with respect to employment opportunities, availability of land for development, the protection of environmental values and the protection and enhancement of landscape values.

City of Rockingham Local Planning Strategy

The City is currently in the process of preparing a Local Planning Strategy (LPS) to guide the growth and development of the City for the next 20 years and beyond. Its intention is to build on the Council and community's shared vision of Rockingham as one of the safest, most liveable and sustainable cities in Australia.

In November 2023, the WAPC granted certification to advertise the draft LPS and it is currently anticipated advertising will form part of a community consultation program which will commence in February 2024.

2.2.3 Planning Policies

State Planning Policy 3.0 Urban Growth and Settlement

State Planning Policy 3.0 Urban Growth and Settlement (SPP3.0) sets out the principles and considerations which apply to planning for urban growth and settlement in Western Australia. The objectives of SPP3.0 are to:

- *To promote a sustainable and well planned pattern of settlement across the State, with sufficient and suitable land to provide for a wide variety of housing, employment, recreation facilities and open space.*
- *To build on existing communities with established local and regional economies, concentrate investment in the improvement of services and infrastructure and enhance the quality of life in those communities.*
- *To manage the growth and development of urban areas in response to the social and economic needs of the community and in recognition of relevant climatic, environmental, heritage and community values and constraints.*
- *To promote the development of a sustainable and liveable neighbourhood form which reduces energy, water and travel demand whilst ensuring safe and convenient access to employment and services by all modes, provides choice and affordability of housing and creates an identifiable sense of place for each community.*
- *To coordinate new development with the efficient, economic and timely provision of infrastructure and services.*

The PKBEP Structure Plan is consistent with SPP3.0 in that it seeks to deliver new land for a range of light industry, service industry, service commercial bulky goods showroom and office uses on a site which is planned to deliver such land under the MRS, Perth and Peel @ 3.5 Million framework and sub-regional framework. This contributes to a strong and diversified economic base for the area, providing access to jobs and employment.

The PKBEP also seeks to protect and enhance environmental values and biodiversity, which is achieved on the subject site through the proposed conservation lot.

State Planning Policy 3.6 Infrastructure Contributions

Development contributions to support the provision of infrastructure to enable the orderly development of an area are an essential part of the planning system. Land developers are responsible for the provision of standard infrastructure, including water supply, sewerage and drainage, roads and power, and for some community infrastructure, including public open space and primary school sites which are necessary for the development. These contributions can be by way of land, works or payments towards the provision of infrastructure. Requirements for developer contributions are imposed by way of conditions on subdivision or development, or in areas of fragmented ownership by development schemes or development contribution arrangements under local government planning schemes.

State Planning Policy 3.6 Infrastructure Contributions (SPP3.6) sets out the principles and considerations applying to infrastructure contributions for the provision of infrastructure required to accommodate new development. The objectives of the policy are to:

- *to facilitate the efficient and effective provision of infrastructure and facilities that are essential to meet the demands arising from population growth and development;*
- *to provide a system for the coordinated delivery of infrastructure necessary to facilitate new urban growth opportunities to achieve compact, consolidated towns and cities;*
- *to provide clarity on the acceptable methods of collecting and coordinating contributions for infrastructure;*
- *to establish a system for apportioning, collecting and spending contributions for infrastructure that is transparent, equitable, accountable and consistent; and*
- *to guide an efficient dispute resolution and arbitration process.*

Contributions are for the initial capital requirements only and not for ongoing maintenance and/or operating costs of the infrastructure.

The subject site is located within the City's Development Contribution Plan No.2 area. However, this Development Contribution Plan only requires the payment of contributions when a subdivision or development that includes dwellings occurs. It is not relevant to the development of the subject site.

Infrastructure contributions can include constructing infrastructure at the developer's cost that is to be transferred to the relevant government agency on completion (i.e. in kind contributions).

For the Port Kennedy Structure Plan area, infrastructure contributions will include:

- two dual lane roundabouts on Port Kennedy Drive, to be constructed at the location of the new connecting subdivision roads to provide direct access to the structure plan area; and
- upgrades to the Port Kennedy Drive and Ennis Avenue intersection. These works are to be undertaken to the specifications of Main Roads WA at the developer's cost on the basis that the development within the structure plan area brings forward the need to modify this intersection.

The provision of infrastructure to the site is reasonably expected to be conditioned upon the subsequent subdivision applications.

State Planning Policy 3.7 Planning in Bushfire Prone Areas

The subject site is identified within a 'bushfire prone area' on the state-wide Map of Bush Fire Prone Areas as prepared by the Office of Bushfire Risk Management (OBRM 2021). The principal objective of SPP 3.7 is to facilitate effective risk-based planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.

Following development of the PKBEP Structure Plan area, existing vegetation that is located on the subject site will be mostly cleared (with the exception of the Conservation Lot and centrally located wetland), which will result in a contraction of the identified bushfire prone areas as they impact the site.

To manage the risks associated with both the staging of the subdivision and with vegetation surrounding the PKBEP Structure Plan area and to address the requirements of SPP3.7, a Bushfire Management Plan has been prepared for the subject site (refer to section 2.6.6). Further discussion on the proposed bushfire planning for the PKBEP Structure Plan area and the manner in which this addresses the requirements of SPP3.7 is provided under the Site Conditions and Constraints section below.

State Planning Policy 4.1 Industrial Interface

State Planning Policy 4.1 Industrial Interface (SPP4.1) came into effect in July 2022. The purpose of SPP4.1 is to protect industry and infrastructure from the encroachment of incompatible land uses. It also seeks to prevent land use conflict between industry/infrastructure facilities and sensitive land uses.

The intention of SPP4.1 is to prevent land use conflict at higher levels of the planning framework, so that consideration of land use conflict is not deferred solely to the subdivision and/or development planning stages, where mitigation options are more limited.

Notably the subject site does not necessitate a statutory buffer under SPP4.1 as the site is not:

- Strategic Industrial Area;
- Infrastructure facility of State significance which generates off-site impacts; or
- A site or facility of State significance which generates off-site impacts.

SPP4.1 states that structure planning should address land use conflict, in addition to other standard structure planning requirements, and coordinate the development of compatible land uses in buffers and at the interface between industry/infrastructure facilities and sensitive zones.

Whilst no hazardous, noxious or general industry uses will be permitted on the site under the land use controls of LPS2 (as all are not permitted, 'X' uses in the Port Kennedy Business Enterprise Zone), the PKBEP Structure Plan carefully considers the interface between the site and the residential land to the north and employs land use controls to this effect, as set out at Section 1.6.4 of the PKBEP Structure Plan.

Importantly the PKBEP Structure Plan is also consistent with SPP4.1 on the basis that SPP4.1 promotes the use of light industry, service commercial and commercial zoned land as a compatible interface to residential zoned land.

Government Sewerage Policy (2019)

The Government Sewerage Policy (Sewerage Policy) establishes the Western Australian Government's position on the provision of reticulated sewerage in the State for the rezoning, structure planning, subdivision and development of land.

Whilst there have been improvements in technology associated with onsite sewage treatment systems, reticulated sewerage remains the most reliable, efficient and environmentally acceptable means of sewage disposal.

In recognition of the risks associated with their installation, operation and maintenance, on-site sewage disposal systems servicing individual lots are not considered as an appropriate alternative to reticulated sewerage for most subdivision and development.

The subject site is mapped as being within 1km of a significant wetland, which means that the site is considered to be within a sewerage sensitive area under the Sewerage Policy.

2.3 Development Control Policy 4.1 Industrial Subdivision

Development Control Policy 4.1 (DCP 4.1) provides guidance on the matters considered by the WAPC when determining applications for industrial subdivision throughout the State. These include such matters as the design and shape of industrial lots, road layout, servicing and open space requirements. Future subdivision applications will be assessed against the provisions of DCP 4.1.

2.4 Environmental Background

The site was rezoned to Industrial in the MRS as part of Major Amendment No. 938/33 in 1994. The Amendment was referred to the Environmental Protection Authority (EPA) by the former Department of Planning and Urban Development (now called the Department of Planning, Lands and Heritage) in 1993. The EPA considered that the Amendment had potential for significant impacts on a number of environmental assets.

The Minister for the Environment approved the Amendment on 11 October 1994 (Ministerial Statement No. 368) on the basis that:

- Land in and around Lark Hill (which is south of the subject site) be secured and managed variously for conservation purposes or recreational and conservation purposes; and
- A number of other linkages and integration requirements (none of which impacted on the subject site).

The 1994 ministerial approval anticipated development of the entirety of the subject site. In this regard the State negotiated a considerable offset pac development lot (49.1522 ha). The WAPC approved the subdivision application (WAPC Reference: 156342) on 6 July 2018. The subdivision has not yet been acted upon.

Refer to Figure 6 – Wetlands Mapping (Strategen JBS&G)

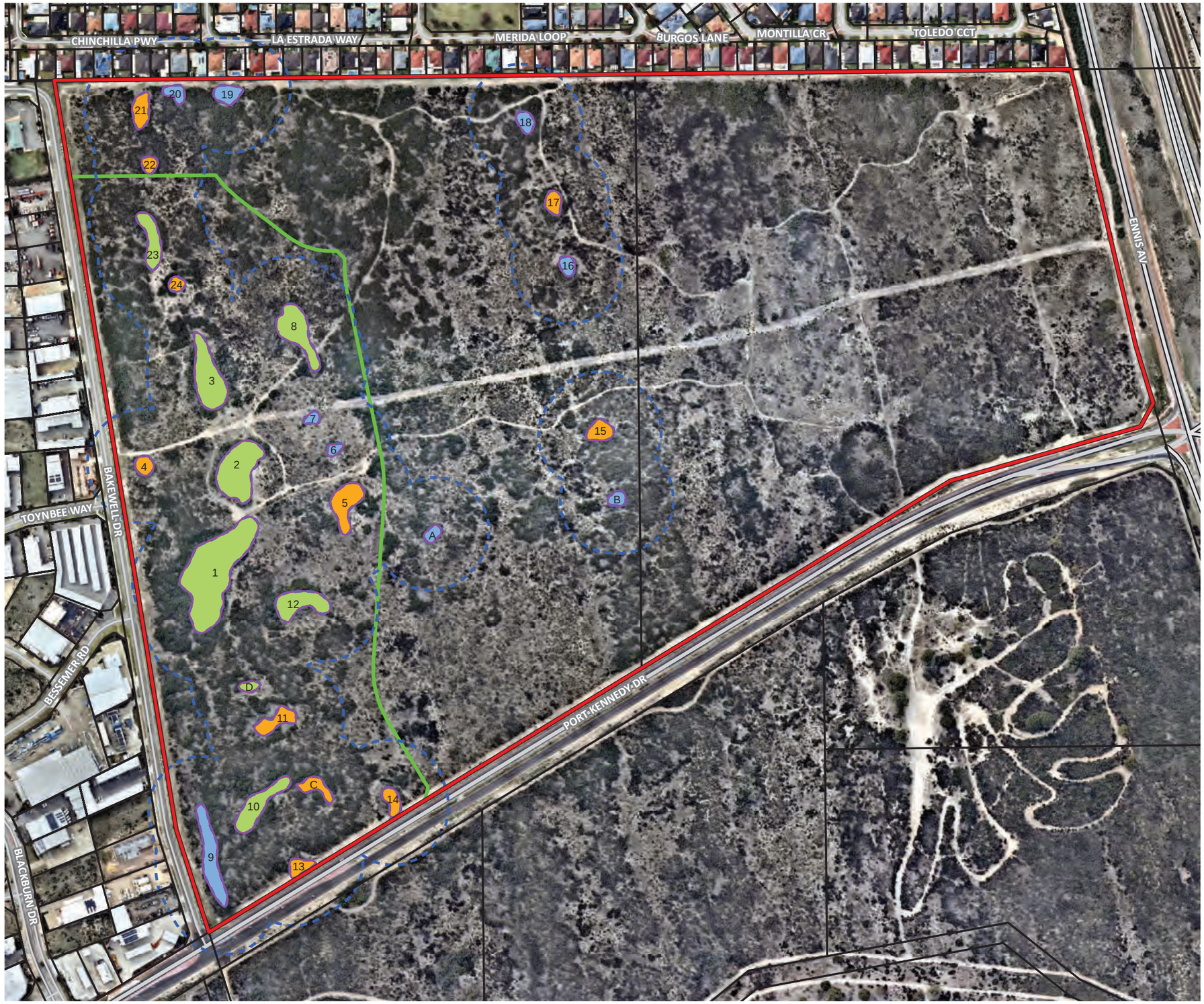


Figure 6. Wetlands Mapping (Strategen JBS&G)

2.5 Pre-Lodgement Stakeholder Consultation

The Project Team has undertaken pre-lodgement consultation with the following agencies prior to lodgement of the Structure Plan:

Table 2: Pre-lodgement consultation

	Consultation (Yes/No)	Date of Consultation	Contact person and position in agency	Form of consultation (phone call, email, letter)	Summary of outcome
City of Rockingham	Yes	18 September 2020 onwards	Brett Ashby, Tristan Fernandes	Various	Debrief on draft concept structure plan and provided debrief on project teams investigations undertaken.
Department of Biodiversity Conservation and Attractions	Yes	5 May 2020 onwards	Val English – Species and communities branch, Michael Coote, Catherine Prideaux	Phone call	Confirmation that mapping of TEC and wetlands was considered accurate. Approach to sewer line under Conservation Lot area.
Main Roads WA	Yes	15 February 2021	Various	Meeting and emails	Future operation/upgrade/ assessment of the intersection on Ennis Avenue and Port Kennedy Drive. RAV route assessment of the Structure Plan. Possibility of reducing the pavement width at bends in the proposed road network whilst still remaining RAV compliant.
Water Corporation	Yes	January – February 2021	Wayne Smith	Email	Water and sewer concept plans for review, with sewer crossing under Conservation Lot considered acceptable.
Western Power	Yes	Ongoing	Jade Wong	Letter	Power Feasibility Study provided.

2.6 Opportunities and Challenges

The PKBEP represents an opportunity to create a unique employment hub in this region, whilst integrating and enhancing the sites environmental values. The following section maps out the opportunities and challenges considered as part of the design solution for the structure plan.

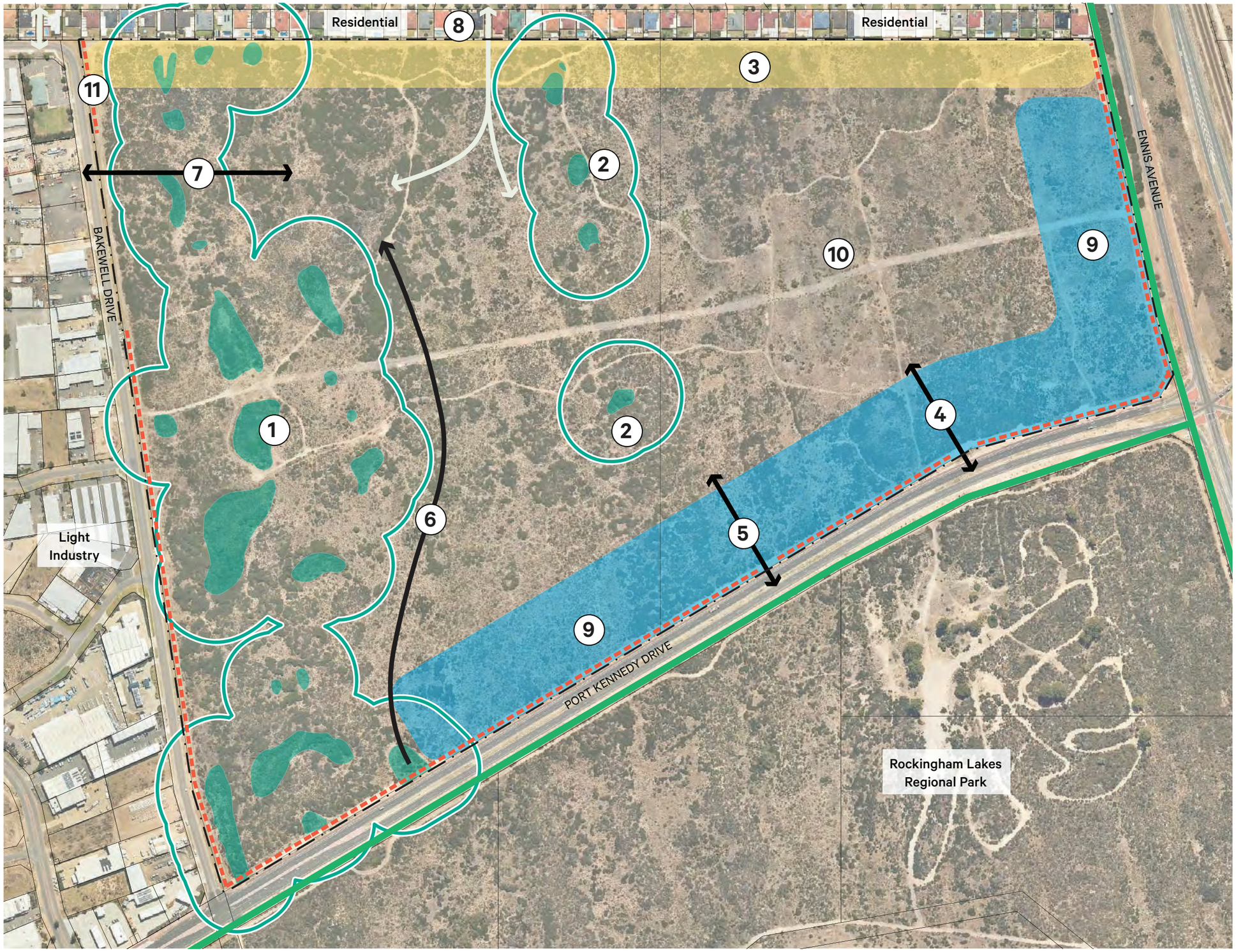
Refer to Figure 7 – Opportunities and Challenges

2.6.1 Contributing to the City of Rockingham's Employment Land Supply

The project will provide a coordinated approach to light industrial lot delivery. This opportunity is consistent with the intention of the 'Port Kennedy Business Enterprise Zone' as outlined in the City of Rockingham's LPS2, and is also consistent with the WAPC's wider strategic planning context, both of which state there is a shortage in the supply of lots for industrial development. The PKBEP provides an opportunity to contribute to the future light industrial land supply needs of the south west corridor and facilitate local employment generation. The approved structure plan shall provide DevelopmentWA and the City of Rockingham with a critical base plan which shall inform the subsequent incremental subdivision of the site in order to meet market demand.

2.6.2 Protection and Enhancement of Key Environmental Features

The site has remained undeveloped since its rezoning to 'Industrial' under the Metropolitan Region Scheme in 1994 and has been used as an illegal dumping ground for a range of materials. There is an opportunity to protect and enhance these key environmental assets as part of the design and management strategy for the site, whilst providing local amenity to the future employees of this business park and the local residential community, through the use of nature trails and dual use path networks, interpretation boards, the integration and relocation of grass trees and the preservation of significant wetlands.



LEGEND

- Precinct boundary
- City of Rockingham Greening Plan Local Green Corridor
- Potential vehicular access points
- Existing public acess way
- Restricted vehicular access to surrounding roads
- Identified wetlands and 50m buffers
- Potential commercial exposure opportunities
- Residential / light industrial interface

1. Geomorphic Wetlands - Western Edge of Site: Conservation Category and Resource Enhancement and associated 50m buffers. TEC19 Floristic Community exists in this location. Opportunity to protect and enhance these key environmental assets, whilst providing local amenity to the future employees of the business park and the local residential community.
2. Low to medium environmental value wetland mapping located outside Conservation Area.
3. Residential Interface: To consider appropriate lots to accommodate low impact light industrial land uses to preserve the amenity of adjoining residential area (in terms of odour, dust, sound and light emissions). Site development (including setback requirements) as per City of Rockingham TPS No.2 requirements (building setbacks 1.0 x the maximum height of the proposed structure, provide and maintain a vegetation buffer).
4. Full access distributor road.
5. Potential central boulevard vehicular access point.
6. Alignment of vehicular access point and road reserve to the north to provide an interface to the extent of the wetland buffers.
7. Potential east-west road to provide direct connectivity to the existing Port Kennedy Business Park development east of Bakewell Drive.
8. Opportunity to provide pedestrian access between the business park, the wetlands and the residential estate.
9. Commercial exposure opportunities to Port Kennedy Drive and Ennis Avenue, making the business park a more desirable location for potential businesses.
10. The site has remained undeveloped since its rezoning to 'Industrial' under the MRS in 1984. It has been used as an illegal dumping ground for a range of materials. The development of this remaining portion of the Port Kennedy Business Park represents an untapped opportunity for innovative industrial development in this region, meeting local industrial land needs, generating local employment, and integrating environmental solutions.

Figure 7. Opportunities and Challenges

2.6.3 Local Amenity – Creating a Sense of Place

Whilst some of the land will be set aside to protect the wetlands and vegetation communities, this also presents an opportunity to increase local amenity, by providing potential passive recreational space in some parts of the earmarked reserve, whilst also providing a unique visual outlook for future businesses/ community facilities overlooking the reserve. This opportunity should be realised by maximising appropriate lot layouts to achieve views and provide good pedestrian linkages to the reserves. This unique setting should be seen as a benefit for potential businesses wishing to locate within the PKBEP.

2.6.4 Connectivity

A number of opportunities present themselves for providing good vehicular access to Port Kennedy Drive. These include two north-south alignments onto Port Kennedy Drive.

In addition, the development of the PKBEP would open up the site to provide pedestrian links between the business park, the wetlands and the residential estate to the north through an existing pedestrian access way.

2.6.5 Commercial Exposure

The site benefits from fronting both Ennis Avenue and Port Kennedy Drive – both of which attract significant passing traffic. The PKEBP shall maximise this opportunity by providing a suitable interface to these roads by orientating new lots towards these frontages, facilitating good commercial exposure opportunities.

2.6.6 Protection of Environmental Features

The site contains a number of Conservation Category and Resource Enhancement Category wetlands, some of which are associated with the TEC 19 – Sedgelands in Holocene dune swales of the southern Swan Coastal Plain. These wetlands are predominantly located in the western part of the site. Currently, these environmental assets are threatened by unauthorised access to the site, including rubbish dumping and off-road vehicle use. The environmental values have been considered in the design of the structure plan and ongoing management solutions. The structure plan has been designed to ensure that significant assets are retained and enhanced, and that the environmental features are preserved through:

- The retention of approximately 29% of the site as a Conservation Area, including 4.6 ha (93%) of TEC19 and 1.4 ha (85-95%) of Conservation Category wetlands;
- Enhancement and rehabilitation of the Conservation Area to meet DBCA standards;
- Appropriate fencing of the site will allow for pedestrian (but not vehicle) access on formalised and dedicated paths;
- Permanent removal of waste dumped on the site; and
- Implementation of the Conservation Area Management Plan (CAMP).The draft CAMP outlines measures to enhance and protect the values of the Conservation Area.

2.6.7 Commercial Viability

Achieving a sufficient amount of developable land for the new business hub will be the key to the success and viability of the PKBEP. This means carefully balancing the environmental aspirations of the site with the commercial realities of delivering a sufficient amount of serviced land for light industrial and commercial purposes. The structure plan adopts a consolidated approach to the regeneration of the wetlands – i.e. focus on the wetlands which are deemed not to be completely degraded or in a poor condition, thereby unlocking some of the site's land for development purposes.

2.6.8 Interfacing

The development of the PKBEP will need to appropriately address how the light industrial areas will interface with the residential land to the north. Consideration will need to be given in relation to visual buffers between these two land uses, and how individual lot design and site development parameters along this common boundary can minimise land use conflict through setback requirements, landscaping, and operational placement on lots.

2.7 Site Conditions

2.7.1 Topography

The site contains low dunal ridges and swales, with an elevation ranging between 5-12m Australian Height Datum (AHD).

2.7.2 Geomorphology, Geology and Soils

The site is located on the Quindalup South System which consists of coastal dunes of the Swan Coastal Plain with calcareous deep sands and yellow sands of aeolian origin over sedimentary rocks. There are two soil units located on the site, described as:

- Quindalup South Qf2 Phase (211Qu_Qf2) consists of relict foredunes and gently undulating beach ridge plains on quaternary deposits in the coast between Rockingham and Dunsborough with deep uniform calcareous sands.
- Quindalup South Qf2a Phase (211Qu_Qf2a) consists of more prominent relict foredune ridges than occurring within unit 211Qu_Qf2, with deep uniform calcareous sands.

The majority of the site consists of the Quindalup South Qf2 Phase. Areas of Quindalup South Qf2a Phase are located in the eastern and north-eastern parts of the site and also in the central western and south-western areas. Douglas Partners (2011) conducted a Preliminary Geotechnical Investigation on the site in 2011. The Investigation was to assess the sub-surface soil and groundwater conditions. One location (BH28) contained uncontrolled sand filling to a depth of 0.2m. All test pit locations contained topsoil consisting of brown silty sand mostly to depths between 0.05m and 0.15m. Encountered at all the test pits below the topsoil was medium dense, brown and light yellow-brown sand. At locations TP6, TP8, TP9, TP19, TP22 and TP26 very low strength lithified sand layers were encountered. Test pit BH27 was the only location that contained organic sand consisting of loose, dark grey sand with low plasticity fines from 1.1m to 1.5m depth.

2.7.3 Acid Sulfate Soils

The subject site is mapped as having a Low Risk of ASS occurring within 3m of the natural soil surface.

2.7.4 Contaminated Sites

There are no reported Department of Environment and Regulation contaminated sites occurring on or adjacent to the site. The site is not known to have previously supported development; however, there has been illegal dumping of waste occurring around paths and tracks. This practice carries the potential risk of site contamination. A walkover inspection indicated that materials such as tyres, fridges, tins of paint/chemicals and building materials had been dumped on the site. The potential for the illegal dumping to represent a risk of contamination is likely to require investigation at subsequent development stages.

2.7.5 Groundwater and Surface Water

Pre-development groundwater monitoring was undertaken at the site over an 18 month period between October 2009 and April 2011. This showed winter maximum groundwater levels ranging from 2.64 m AHD (southeast corner of the site) to 4.25 m AHD (northwest corner of the site). Depth to maximum groundwater level below natural surface at the bores varied from 1.7 to 4.3 m. Bores located on the eastern end of the site consistently displayed the greatest depths to water whilst the western end had lower depth to water.

To check for potential changes over time, further groundwater monitoring was undertaken between July and November 2022. A subset of the bores was monitored, including redrilling of a former bore. Averaged over all bores, there was a difference of 0.075m in height, including those above and below the former maximum levels recorded. As 2022 was generally an above average rainfall year with high groundwater readings, the levels are considered suitable in confirming the previous Average Annual Maximum Groundwater Level (AAMGL).

Depth to groundwater over the whole site is estimated to range from approximately 0 m in winter in depressions in the western part of the site to 9 m at high points in the south- eastern corner of the site (At the bores, summer minimum groundwater levels ranged from 1.72 m AHD (southeast corner of the site) to 2.93 m AHD (northwest corner of the site). Observed seasonal groundwater variations were in the range of 0.3 m to 0.62 m across the site, which is typical of the Swan Coastal Plan.

Throughout the year, groundwater was recorded as flowing in a south-easterly direction across the site, towards Lake Walyungup. This flow direction is consistent with the Perth Groundwater Atlas which shows groundwater flow in the vicinity of the site flowing east to north easterly.

Standing water has been observed in three of the wetlands over the winter period. These bodies of water are considered to be ephemeral expressions of groundwater levels. These wetlands are all located in the Conservation Area. Lake Walyungup is permanent and is located to the east of the site. The lake is recharged mainly through groundwater flow in the superficial aquifer. A DoW surface water monitoring site is located at Lake Walyungup. Water levels in Lake Walyungup have slowly declined since monitoring began in 1927 and levels were below the datum in May 2011. Surface water is not expected to flow off the site in the 1% AEP event due to the high permeability of the local sands. For the same reason, water is considered unlikely to enter the wetlands on site via surface runoff in events up to the 1% AEP event.

2.7.6 Bushfire hazard

The Structure Plan area is located adjacent to bushland to the south, west and to the east. The site is separated from vegetation to the east by Ennis Avenue and the railway. The bushland to the south forms part of the Rockingham Lakes Regional Park. Because of this risk, a Bushfire Management Plan (BMP) has been prepared for the site (included in Appendix B). The BMP, prepared by Element Advisory, provides an assessment of the general bushfire management strategies to be considered at the structure planning stage, including:

- Site assessment including vegetation classification and slope analysis within the 150m assessment area of the proposed development, in accordance with Australian Standard 3959-2018 Construction of buildings in bushfire prone areas (AS3959-2018);
- Consideration of bushfire hazards that will exist post development and whether there are any temporary or permanent hazards that need to be considered;
- Assessment against the bushfire protection criteria of the Guidelines and demonstrate how subsequent planning stages can achieve compliance;
- Recommended mitigation measures to reduce the risk of bushfire from within the subject site; and
- Recommended roles and responsibilities associated with implementing the requirements of this BMP.

The document takes into account the requirements associated with the conservation lot and the public open space and drainage reserves. The environmental values associated with the subject site do not preclude compliance with the bushfire protection criteria of the Guidelines or any additional bushfire mitigation measures recommended as part of the BMP. The Structure Plan considers the bushfire hazards that will exist on-site post development and responds through the use of perimeter roads and Pedestrian Access Ways (PAWs) to achieve the compliant separation distances..

If clearing of the subject site for future development is undertaken on a staged basis, clearing in advance will need to occur to ensure future development is subject to an acceptable level of bushfire risk (BAL-29 or below). This will be achieved by ensuring each stage subject to construction is surrounded by a 22m wide low threat buffer which is managed in accordance with the City's Fire Control Notice to meet the definition of low threat under Clause 2.2.3.2 (f) of AS3959-2018. Once the buffers are created, they will need to be maintained on an ongoing basis until such time that the buffer area is developed as part of the next development stage.

If the construction of public roads is undertaken on a staged basis, vehicular access arrangements will need to ensure that all occupants are provided with at least two access routes for all stages. This can be achieved via construction of access in advance of the stages or through provision of a temporary emergency access way until two formal public access roads are available.

The retention of vegetation within the conservation lot will result in permanent bushfire hazards post development. The proposed road reserves and PAWs provide permanent separation between bushfire hazards and future subdivided lots to achieve a radiant heat flux of 29kW/m2 (BAL-29) or below, in accordance with SPP 3.7.

Prior to issuances of titles, the public road reserve bordering the conservation lot and the PAWs shall be cleared and made trafficable to provide permanent separation between bushfire hazards on the conservation lot and the development areas. This will also provide perimeter access for fire services should the retained bushfire hazard be subject to a bushfire.

All landscaping proposed on the subject site shall be managed to a minimum fuel condition in accordance with Clause 2.2.3.2 (f) of AS3959-2018. This excludes areas within the POS reserves which are intended to be revegetated and have been classified accordingly.

Low threat vegetation includes managed landscaping, reticulated lawns and gardens, maintained public reserves and parklands, sporting fields and natures strips. Management may include regular clearing of vegetation, removal of weeds, removal of dead plant material, tree pruning and mowing of grass to reduce the fuel load surrounding the proposed development.

Landscaping plans prepared for development on individual lots shall ensure future landscaping meets the definition of low treat vegetation to avoid the introduction of additional bushfire hazards.

On the basis of the information contained in the BMP, Element Advisory considers the bushfire hazards both within and adjacent to the project area and the associated bushfire risks are readily manageable through standard, acceptable solution management responses.

Refer to Figure 8 – BAL Contour Map - Overlaid Onto Concept Subdivision (element)

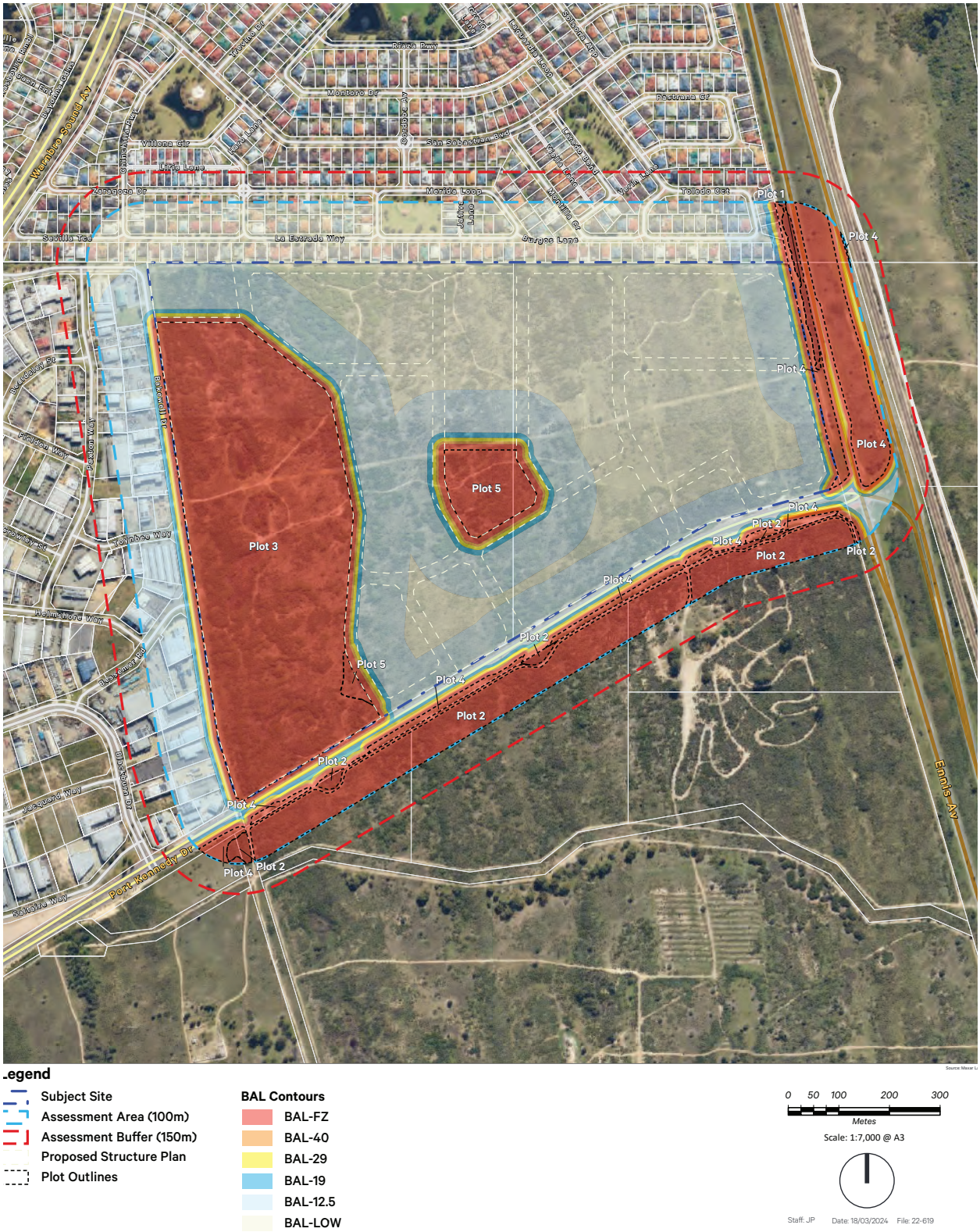


Figure 8. BAL Contour Map - Overlaid Onto Concept Subdivision (Element Advisory)

2.8 Biodiversity and Natural Area Assets

In 1996, the EPA published the Wetlands of the Swan Coastal Plain Volume 2, Wetland mapping, classification and evaluation which identified geomorphic wetlands in the Perth area and set categories that identified the levels of protection for those wetlands based on their environmental values. This work identified a series of wetlands on the site as being of 'conservation' and 'resource enhancement' categories. Subsequently in 2004, the site was assessed by the Department of Conservation and Land Management (CALM) for the presence of the Threatened Ecological Community (TEC) TEC19 (equivalent to Floristic Community Type [FCT]19 – sedgelands in Holocene dune swales of the southern Swan Coastal Plain).

Since this time, DevelopmentWA has undertaken several environmental assessments on the site, focussing on wetlands, vegetation condition and type and fauna habitat. The Environmental Impact Assessment prepared by PGV provides further details regarding the site including a summary and analysis of the work undertaken by both the agencies and DevelopmentWA.

Refer to Appendix C – Environmental Assessment Report

2.8.1 Flora and Fauna

A level 2 flora and vegetation spring survey of the study lots was conducted by RPS BBG in 2006 to confirm the presence or absence of the conservation listed species, define the vegetation units present, define wetland areas, map vegetation condition and locate any Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC). The survey identified a total of 118 species, of which 64 were introduced flora, from 47 families over the 67 ha surveyed. No Declared Rare Flora or Priority species were recorded during the RPS BBG survey, nor were any species listed under the EPBC Act recorded. The majority of the remnant vegetation type within the subject site is widespread and not considered to be regionally significant. It is also noted that the site does not form part of a Bush Forever site.

Refer to Figure 9 – Vegetation Communities (Strategen JBS&G)

Vegetation is generally in Good to Excellent condition, with areas of vegetation in Degraded condition in some wetlands, and Completely Degraded condition along tracks. It is also noted that the subject site has been subject to a number of degrading processes including recreational 4-wheel driving, trail biking and dumping of litter and heavy rubbish, which has resulted in concentrated areas of degradation and heavy weed invasion in a number of areas.

2.8.2 Threatened Ecological Community (TEC) 19

In 2006, the DPAW undertook a site assessment for the purpose of mapping the extent of TEC19 – 'Sedgelands in Holocene dune swales of the southern Swan Coastal Plain'. This assessment mapped the vegetation community, noted associated soil types and defined the community boundary. DPAW mapping of TEC19 at the site was undertaken by a combination of on-ground survey, aerial photo interpretation and general consideration of flora species. Seventeen instances of TEC19 were mapped by DPAW at the site in 2006. Maintenance of water level and quality are considered critical for this TEC.

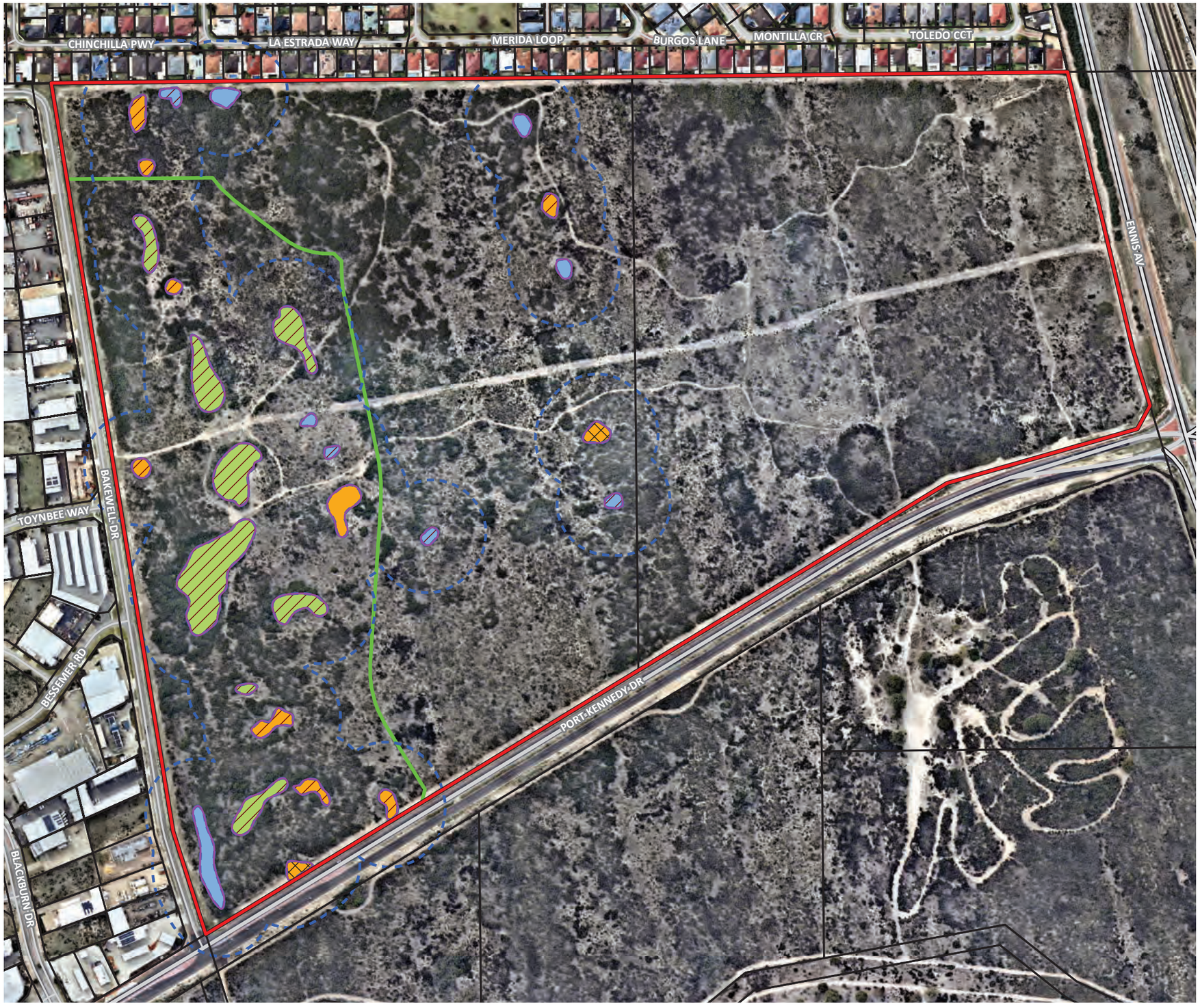


Figure 9. Vegetation Communities (Strategen JBS&G)

2.8.3 Wetlands

Wetlands are predominantly located along the western boundary of the site which have been identified by the State Government as being significant and more specifically as being 'Conservation Category' and 'Resource Enhancement' management categories under the geomorphic wetland series mapping administered by the Department of Parks and Wildlife (DPAW). The structure plan allocates a significant proportion of the site for conservation purposes. Approximately 19.3ha (29%) of the subject site will incorporate the majority of the wetlands and examples of TEC19. More than 90% of the TEC19 and 90% of the area of the Conservation Category Wetlands will be retained. The protection of this area has already begun by the WAPC's conditional approval for a dedicated Conservation Lot. This is being created for conservation purposes (subdivision approval Ref: 156342, 6 July 2018). Once the subdivision is enacted by DevelopmentWA it will establish Lot 1 (conservation) and Lot 2 (Port Kennedy Business Park Zone).

Lot 2 contains four wetlands as mapped by the Geomorphic Wetlands of the Swan Coastal Plain Database (National Map, 2020). These are:

- Conservation Dampland 6259 Point Becher Wetland
- Conservation Dampland 6473 Point Becher Wetland
- Conservation Dampland 6474 Point Becher Wetland
- Resource Enhancement Dampland 14638 Point Becher Wetland

Refer to Figure 6 on earlier page – Wetlands Mapping (Strategen JBS&G)

Several studies have shown that the mapped wetlands do not align with the location of wetlands on the ground. PGV Environmental undertook a wetland vegetation assessment and a wetland boundary assessment to resolve the differences in the two previous wetland studies and to assess the vegetation within the proposed conservation area. Eleven wetlands (wetlands 14, 15, 16, 17,18, 19, 20, 21, 22, A and B) were mapped on the site. The wetland mapping did not match the mapping in the Geomorphic Wetlands of the Swan Coastal Plain Database but aligned closely with the TEC 19 boundaries provided by DBCA (V. English) The environmental value of each wetland was assessed by PGV Environmental according to its size, condition, and vegetation types. Seven of the eleven wetlands were rated as having a Low value due to the small size, poor condition, and low diversity of vegetation types. Several of the Low rated wetlands were considered transitional wetlands/drylands. The remaining four wetlands were rated as having a Medium environmental value. The wetlands on the site are not part of the Becher Point Wetlands site which is listed as a Ramsar site (Wetlands of International Importance). However, the wetlands in the Conservation Area to the west of the development site are proposed to be managed by DBCA and added to the Rockingham Regional Lakes. As such they may be added to the Becher Point Wetlands Ramsar listing and managed accordingly.

2.8.4 Conservation Strategy – Wetlands and Vegetation

The notionally shown Conservation Area will be fenced and rehabilitated. The land will be managed by the DBCA following rehabilitation. The program of fencing and rehabilitation will act as an offset against the loss of other vegetated areas on the site. A preliminary Conservation Area Management Plan has been prepared for review by the City of Rockingham and the DBCA.

This is considered to be a positive outcome in terms of balancing the retention and rehabilitation of Environmentally Sensitive Assets with the need for a new business park in the Port Kennedy area.

2.9 Heritage

A search of the Department of Aboriginal Affairs (DAA) Aboriginal Heritage Inquiry System revealed that no registered sites are identified within area.

A search of the Heritage Council of Western Australia's Places Database revealed that no matches were found within the area.

3. Design Response

The PKBEP Structure Plan has been prepared to provide a logical and robust design framework for its future subdivision and subsequent site development. This section outlines the key elements which have been considered as part of this design response, being:

- Permitted land uses (Scheme restrictions);
- Positive design interface solutions to sensitive land uses;
- Suitable interfacing of the Conservation Area;
- Regeneration and enhancement of environmental features;
- Integration of drainage and landscaping solutions;
- Incorporating permeable movement networks; and
- Efficient infrastructure networks.

Refer to Figure 10 – Structure Plan

3.1 Land Use

Land use permissibility within the PKBEP is to be in accordance with the Port Kennedy Business Enterprise zone and Table 1 of the City of Rockingham's LPS2. Future land uses for the subject site shall be in keeping with the LPS2 objective:

> *'To promote service commercial and office land uses within the area to service the demands of the locality and in recognition of the Council's regional responsibility to provide light industrial land within the region, encourage the development of light industrial land uses in an orderly and proper manner.'*

Land use restrictions currently apply under LPS2 (clause 4.9.4.2) for lots/development located within 50m of the northern boundary. The Structure Plan design respects these provisions.

3.2 Form of Development

Future site development and the built form detail shall be in accordance with the provisions listed under clause 4.9 of the City of Rockingham's LPS2. This includes the specific consideration of future development applications against the following objectives:

1. Promotion of a high standard of building development, landscaping and working environment;
2. Protection of the amenities of adjacent residential areas;
3. Management of drainage systems and land use to promote groundwater conservation; and
4. Safe movement of vehicular and pedestrian traffic in the area.

Whilst the Structure Plan is not intended to address objective 1, this documentation does include the framework to implement future detailed landscaping design to create a high standard of amenity for the business and local residential community through the inclusion of the Conservation Area and central wetland retention.

Objective 2 is addressed by the placement of small lot product (low impact operators) along the northern periphery of the site. Objective 3 is considered as part of the Local Water Management Strategy (LWMS) works, whilst objective 4 is addressed through the road network design and the pedestrian accessibility provided through the site and into the St Michelle residential estate.

Refer to Figure 11 – Concept Subdivision Plan

The Concept Subdivision Plan shows how the development cells could potentially be subdivided into small to medium sized lot product with the opportunity to create a superlot, subject to meeting relevant traffic and site operated requirements.

Figure 10. Structure Plan

Figure 11. Concept Subdivision Plan

3.3 Interface to Residential Area

Consideration has been given to the interface between the residential area to the north and the future commercial land uses along the common boundary. Individual lot design and site development parameters along this common boundary (as per the City of Rockingham's LPS2 provisions) will minimise land use conflict through its setback controls, landscaping buffer provisions, and the future operational placement on lots at the development application stage.

The Structure Plan predetermines smaller-scale operations that can physically be accommodated within the lots. The City's LPS2 will play an important role to ensure certain undesirable land uses (by way of noise, light spill, risk and hazard, dust and odour emissions) are prevented from occurring along this common boundary through land use approvals and compliance. The Landscape Masterplan prepared for the Structure Plan integrates a 5m wide vegetated planting area to provide a visual buffer to the new road. This screening area will consist of native trees and shrub plantings.

This area is to be planted with low threat landscaping which will be maintained in accordance with BMP requirements so as to not create a bushfire hazard in this area.

The proposed road system is also structured in such a way that it will facilitate ease of access, mitigate adverse impacts on the amenity of adjoining lots and assist in ensuring the safe movement of vehicular and pedestrian traffic.

Refer to Figure 12 – Cross section – Landscape buffer planting and spatial setback of light industrial businesses (Plan e)

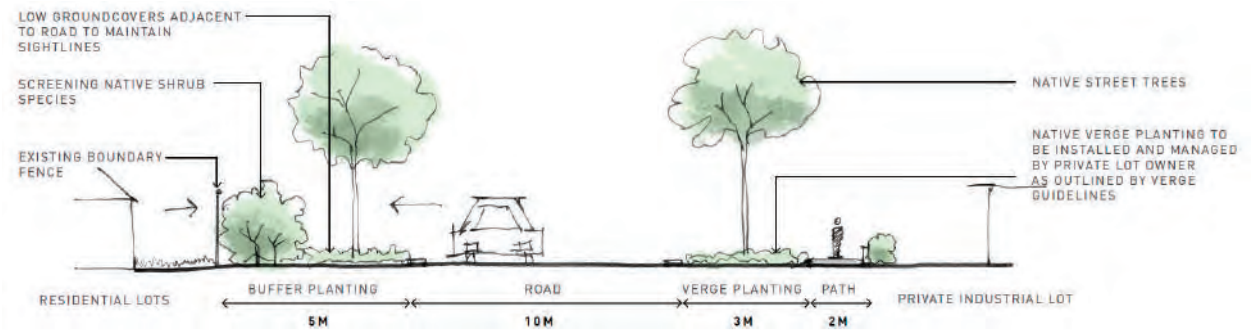


Figure 12. Cross section – Landscape buffer planting and spatial setback of light industrial businesses (Plan e)

3.4 Landscaping

There is no requirement for public open space areas within industrial areas. Despite this, it is acknowledged that there is a potential opportunity to utilise some peripheral areas of the central wetland area for general amenity purposes. This may include seating areas and interconnected pathways. These natural areas will provide visual amenity for workers within the PKBEP. In addition, it is envisaged that quality landscaped streetscapes will be also be incorporated to enhance the local landscape, creating a unique setting. A conceptual landscaping plan including a street tree masterplan has been prepared. The Street Tree Masterplan will assist in ensuring consistency and legibility throughout streets within the site.

As part of this landscape design, it is recognised that urban tree canopy creation is an important consideration by the City for all new developments. DevelopmentWA will work with the City to ensure the detailed landscaping provisions for the PKBEP align with the City's Greening Plan.

Refer to Figure 13 – Landscape Masterplan (Plan e)

Refer to Figure 14 – Street Tree Masterplan (Plan e)

Refer to Appendix D – Landscape Masterplan

LEGEND

01 ENTRY STATEMENT TO ESTATE WITH SIGNAGE WALL

02 EXISTING PEDESTRIAN ACCESS WAY

03 ENTRY TO BUSHLAND TRACK NETWORK INCLUDING EDUCATIONAL SIGNAGE AND ARTWORK/ INTERPRETATIVE ELEMENT (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

04 RETAINED VEGETATION IN EXISTING CONSERVATION AREA CEDED TO DBCA

05 OPEN MESH FENCE TO CONSERVATION AREA FOR VISUAL PERMEABILITY

06 *GRAVEL PATHWAYS ALONG EXISTING BUSH TRACKS

07 SEATING ON DECKING AT LOOKOUT POINTS WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19A- HOLOCENE SEDGELANDS (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

08 SCREENING NATIVE TREE AND SHRUB PLANTING ALONG BOUNDARY FENCE TO RESIDENCES

09 NEW *GRAVEL PATHWAY CONNECTION

10 VEGETATED SWALE WITH ENDEMIC WETLAND PLANTING AND MELALEUCA TREES WITH REFERENCE TO ADJACENT BUSHLAND SPECIES

11 PEDESTRIAN FOOTPATH NETWORK

12 STORMWATER MANAGEMENT INFRASTRUCTURE (INFILTRATION OR BIORETENTION) IN ROADSIDE TO BE PROVIDED AS PER THE INDICATIVE LOCATIONS SHOWN ON THE CONCEPT DRAINAGE PLAN (BY OTHERS)

13 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS

14 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)- SIGNAGE ENDORSED BY DBCA DESIGN STUDIO

15 *GRAVEL PATHWAYS TO TEC 19B- (HOLOCENE WOODLANDS) WITH REVEGETATION INCLUDING TREE PLANTING THROUGHOUT

16 ARTWORK/ INTERPRETIVE ELEMENT TO STREET CORNER AND DECKING OVER DRAINAGE BASIN

17 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS

18 VEGETATED DRAINAGE SWALE ALONG MEDIAN STRIP TO PORT KENNEDY DRIVE

19 VEGETATED DRAINAGE SWALE ALONG PORT KENNEDY DRIVE WITH BUFFER TREE AND SHRUB PLANTING. RETAIN EXISTING 3M WIDE BIKE PATH.

20 RETAIN EXISTING VERGE TREATMENT/ SWALES TO SOUTH SIDE OF PORT KENNEDY DRIVE

21 STREETSIDE PARKING ADJACENT TO CONSERVATION AREA INTERSPERSED WITH VERGE PLANTINGS - TOTAL 8 NO. PARKING BAYS

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

Figure 13. Landscape Masterplan (Plan e)

EUCALYPTUS LEUCOXYLON 'ROSEA'

EUCALYPTUS UTILIS

MELALEUCA RHAPHIOPHYLLA

AGONIS FLEXUOSA

EUCALYPTUS TORQUATA

EUCALYPTUS VICTRIX

EUCALYPTUS GOMPHOCEPHALA

Figure 14. Street Tree Masterplan (Plan e)

3.5 Regeneration and Enhancement of Environmental Features

The Structure Plan proposes a consolidated and focused approach to the regeneration of the wetlands by protecting and enhancing one substantial area containing a chain of wetlands, rather than multiple segregated areas across the site. The proposed notionally shown Conservation Area represents approximately 29% of the total site. This area will be rehabilitated to an appropriate standard before being handed over to the DBCA for conservation. Most of the Conservation Area will be fenced to prevent dumping and off- road vehicle access, although some pedestrian access will be allowed at key focal points. The interface with proposed Lot 1 (Conservation Area) has a road separating the conservation area from the development along the eastern side and a pedestrian path along the northern side separating lots from the development to meet the requirements of DBCA. The hard interface will assist in managing weeds and also provide additional setback for fire management purposes.

The central wetland identified by PGV Environmental as wetland No.15 and containing a small area of TEC19b will also be retained with a management buffer of 50m as Public Open Space. The core area of the wetland will be managed for conservation purposes. Some public facilities such as seating and tables may be included around the central core area.

3.6 Integrated Drainage

A Local Water Management Strategy (LWMS) has been prepared for the site. The LWMS outlines how the proposed development will address water use and management at the local planning level and details specific water management measures and strategies to be implemented to manage the water cycle in a sustainable manner. The site will be developed in a water sensitive manner, using a modular drainage approach that manages events up to the 1% Annual Exceedance Probability (AEP) rainfall event within the lots, drainage reserves, POS and road reserves. Through a series of bioretention gardens and infiltration systems in road reserves, linear open planted swales, below ground infiltration systems and at source disposal to basins for larger events. This approach minimises the need for Public Open Space (POS) for drainage purposes and infiltrates water as high in the site as possible, in line with the principles of water sensitive urban design. Urban Water Management Plan/s (UWMPs) will be required to support subdivision applications in due course.

3.7 Movement

The Structure Plan incorporates a permeable modified grid road network across the site. This includes three key north-south road alignments and two east-west alignments to achieve more regular lot shapes. The road alignment against the proposed Conservation Area located within the western sector of the site is more irregular in form in order to follow the environmental features of the site.

The proposed east-west road has been located carefully to minimise the impact on the conservation area. It should also be noted that Main Roads WA advised that it would not support any further connections onto Ennis Avenue. The Structure Plan has therefore not included any provision for access onto Ennis Avenue.

Access to Port Kennedy Drive has also been limited to only two points due to this road being classified as a District Distributor B Road and identified in the MRS as an Other Regional Road.

The Structure Plan also integrates new pedestrian pathway way connections through to the existing Pedestrian Access Way which links through to the residential area to the north.

4. Movement Network

4.1 Proposed Road Network

Two new road network connections are proposed to the Structure Plan area. These are located centrally to the site and are approximately evenly spaced along the developable Port Kennedy Drive frontage:

- Port Kennedy Drive, western – new dual lane roundabout;
- Port Kennedy Drive, eastern end – new dual lane roundabout.

The proposed dual lane roundabouts ensures right turn movements into and out of the development can be accommodated without excessive delays and long queue lengths within the development under the future scenario with traffic growth along Port Kennedy Drive.

The eastern connection is located approximately 270m to the west of the Ennis Avenue and Port Kennedy Drive signalised intersection. MRWA preferred practice is that intersection proximity is typically determined on the basis of at least 5 seconds of travel time between an intersection and the start of the auxiliary lanes for the downstream intersection. In this instance there are no auxiliary lanes as it is a roundabout although depending on the detailed design there may be a requirement for pre-deflection (circa 100m in length). Based on 80-90km/h, 5 seconds of travel time equates to a distance of 110-125m which can be provided prior to pre-deflection if needed i.e. 125m+100m = 225m <270m. Alternatively, from a design perspective, distance on the approach to the roundabout from the signalised intersection would need to take into account manoeuvring distances i.e. changing lanes. Based on 80-90km/h this equates to 130-146m which can be provided prior to pre-deflection if needed i.e. 146m+100m = 246m <270m which is still less than the 270m provided. Using both methods it is considered that the spacing of approximately 270m is adequate. It should be noted that the average speed of vehicles entering Port Kennedy Drive from the signals will in fact be less than the posted speed limit of 80km/hr hence these distances are considered to be robust. The same approach can be adopted for the spacing of the roundabouts which are also 270m apart. This distance is considered to be robust as again the average speed between the roundabouts would be less than 80km/h as vehicles would not exit or enter the roundabout at 80km/h. Notably, the 85th percentile speed recorded along Port Kennedy Drive, west of Ennis Avenue (SLK 1.08) is 66.7km/hr somewhat lower than 80km/h-90km/hr adopted.

The Structure Plan is estimated to generate in the order of 19,501 vehicle trips per weekday with approximately 1,229 and 2,106 vehicle trips during the am and pm peak hours respectively.

Refer to Appendix D – Traffic Assessment

4.2 Road Hierarchy

The proposed road network incorporates a main east-west road that facilitates access to/from the two north-south connections to Port Kennedy Drive as well as the local access road network. The new internal west-east road along the northern boundary of the subject site has been segmented into two lengths to reduce straight sections of road that may be conducive to speeding.

A vehicular connection to Bakewell Drive is not provided to avoid the potential for rat running through the Business Park from Warnbro Sound Avenue to Port Kennedy Drive.

It is proposed that the Structure Plan accommodate RAV 4 vehicles i.e. B-Double (27.5m). RAV access will not be permitted along the west-east road on the northern boundary of the site abutting the residential properties. The proposed 10m pavement will accommodate the RAV 4 vehicles with the exception of intersections or right angle bends where the swept paths of these vehicles will require some road widenings and larger than normal truncations to suit. Detailed design as part of the subdivisional works should confirm these requirements.

There are a number of right angle bends incorporated within the Structure Plan. Bends can assist with reducing the speed limit however they can also result in drivers “cutting the corner” which can increase crash risk. Based on the low

volume of traffic on the internal road network and the subsequent design speed, the bends are likely to be considered "low risk". Good practice would be to include road widening to separate vehicle movements. To ensure that the road network is RAV 4 compliant these bends will need to be designed accordingly with the RAV 4 vehicle being the checking vehicle. Truncations (larger than typical) on the corner lots are likely to be required to provide adequate sight distance between opposing vehicles approaching the bend as well as for potential driveways located around bends.

The ultimate design will need to demonstrate that the road reserve is adequate to accommodate swept paths of the design vehicle (RAV 4) at intersections and bends. The proposed road hierarchy for the Structure Plan is shown in Figure 15.

4.3 Road Access Restrictions

The Structure Plan factors in no direct access from new lots onto Port Kennedy Drive. All access will be via the new internal roads. Individual access to lots developed will need to be considered at the subdivisional stage to ensure each lot can be serviced in accordance with Australian Standards and guidelines.

Traffic volumes are at their highest along the southern portion of two new connections to Port Kennedy Drive. Access to properties along these southern sections, particularly in close proximity to the proposed Port Kennedy roundabouts should be limited to left in and left out.

Alternatively, where possible access should be provided on the side roads that carry lower traffic volumes. Ideally larger lots that naturally limit the number of accesses required would be preferable along the southern sections of these two Port Kennedy Drive road connections.

Ultimately, approvals for driveway access would form part of individual development applications with consideration to standards including proximity to intersections and the specific trip generation to/from that property.

Refer to Figure 15 – Proposed Road Hierarchy (Porters)

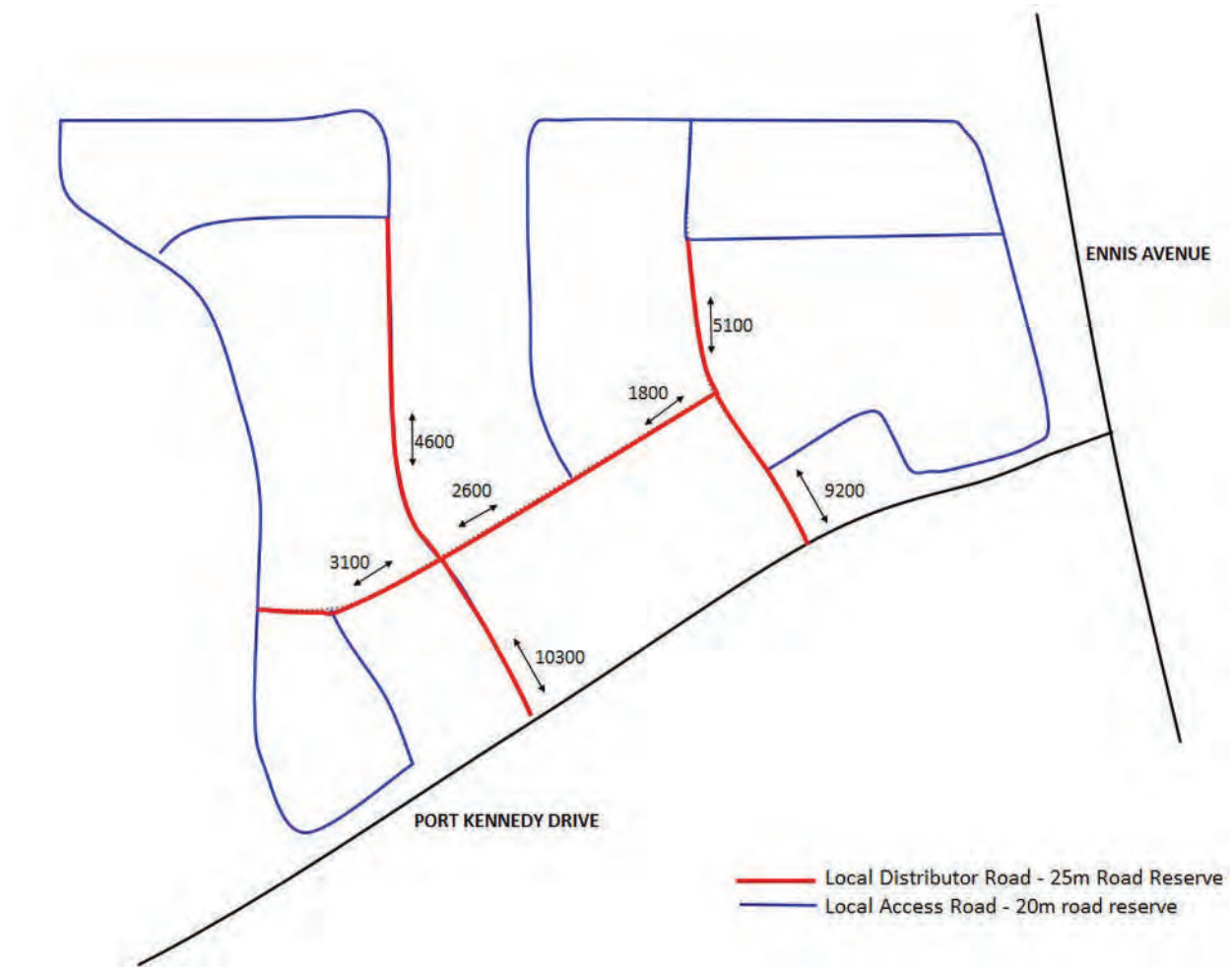


Figure 15. Proposed Road Hierarchy (Porters)

4.4 Port Kennedy Drive Upgrades

Port Kennedy Drive between Warnbro Sound Avenue and Ennis Avenue has been recently (early 2020) upgraded to a 4 lane dual carriageway standard from a 2 lane single carriageway standard. The City of Rockingham have advised that there are no other road network upgrades within the vicinity of the subject site.

The SIDRA analysis both without and with the development indicates that the signalised intersection of Port Kennedy Drive and Ennis Avenue will need to be upgraded to accommodate general growth in traffic on the adjacent road network from the broader development of the local area even without the development traffic but similarly would also require upgrading due to the development traffic. It is acknowledged that the timing for these improvements will likely be required to be earlier with the addition of the development traffic.

The identified modifications works to the signalised intersection comprised of the following:

- Double right turn from Ennis Avenue into Port Kennedy Drive in conjunction with give way control for the Ennis Avenue left turn into Port Kennedy Drive;
- Double right turn from Port Kennedy Drive into Ennis Avenue in conjunction with an appropriate merge treatment along Ennis Avenue southbound; and
- Auxiliary through lane to be provided on Ennis Avenue northbound – south approach.

With these proposed modifications with the 2036 base case traffic scenario (i.e. without development traffic), the SIDRA modelling indicated that the signalised intersection of Port Kennedy Drive and Ennis Avenue would operate at a DOS 0.870 and 0.813 during the am and pm peaks. The average intersection delay was approximately 27 seconds with the highest average delay incurred being 39 seconds.

With the addition of full development traffic in 2036, the SIDRA modelling indicated that the signalised intersection of Port Kennedy Drive and Ennis Avenue would operate at a DOS 0.891 and 0.875 during the am and pm peaks. The average intersection delay was approximately 35 seconds with the highest average delay incurred being 47 seconds. By comparison the 2026 analysis (at opening) with full development indicated that with these improvements the signalised intersection would operate with an average intersection delay of 29 seconds with the highest average delay incurred being 37 seconds.

Whilst the 2026 analysis (at opening) assumes that the Structure Plan will be fully developed the reality is that it will be progressive over a longer time period. Some indicative staging analysis suggests that adequate capacity can be provided for the earlier stages of development with fewer upgrades to the signalised intersection. For example, incorporating double right turns on both Port Kennedy Drive and Ennis Avenue (without the auxiliary Ennis Avenue northbound through lane) would likely be sufficient for Stages 1, 2 or approximately 60% of the Structure Plan at opening (2026) and for an additional 10 years (2036).

Main Roads WA are the controlling authority for Ennis Avenue and its intersection with Port Kennedy Drive. Main Roads WA approval of both the staged and final intersection layout to be adopted will be required. Main Roads will need to confirm the acceptance of the various operating conditions presented with respect to the stages and upgrade treatments for this signalised intersection.

4.5 Pedestrian and Cycle Networks

Whilst light industrial estates historically have tended not to include pedestrian and cycle networks, there is an identified opportunity to integrate some networks within the site, providing connectivity to the two existing Public Access Ways to the residential estate to the adjoining north, and connectivity to the preserved central wetland/POS area and the Conservation Area for localised amenity. The network of paths to be provided within the site will provide connectivity with the existing Principal Shared Path (PSP) along Ennis Avenue and the dual use path along Port Kennedy Drive, which are in accordance with the Department of Transport's Long Term Cycle Network. Connectivity between the recreational opportunities within the site and these existing paths have been considered as part of the Landscape Masterplan prepared by Plan-e and is shown in the Bicycle and Pedestrian Network Plan at Figure 16.

Refer to Figure 16 – Bicycle and Pedestrian Network Plan

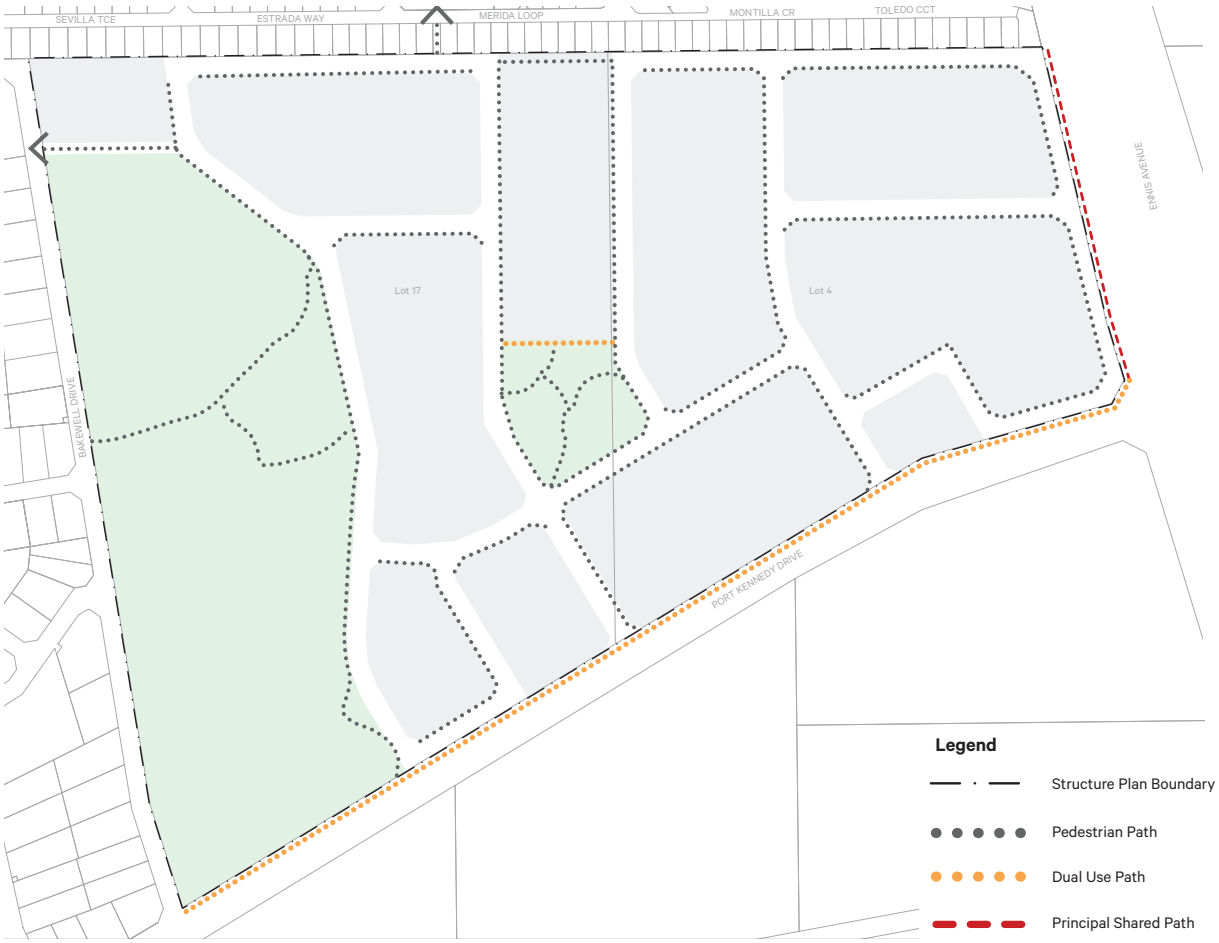


Figure 16. Bicycle and Pedestrian Network Plan

4.6 Public Transport Routes

No public transport routes are proposed within the Structure Plan. Liaison with the PTA indicates that there are no plans to provide a new service within the Structure Plan. Since the road network will be designed to cater for trucks it could readily accommodate bus routes if they were to be introduced in the future should the demand warrant services feasible.

4.7 Impact on Local Road Network

Port Kennedy Drive, west of Ennis Avenue, carries in the order of 11,850 vehicles per day. (AWT, 2020/21). Port Kennedy Drive has recently been upgraded to a four lane dual carriageway standard. Based on 3% growth per annum it is anticipated that traffic volumes along Port Kennedy Drive would increase to 13,700 vehicles per day by 2026 and to 18,500 vehicles per day by 2036.

The proposed development is anticipated to result in traffic volumes on Port Kennedy Drive increasing by approximately 11,600 vehicles per day near Ennis Avenue and 7,700 vehicles per day near Bakewell Drive at full development. In 2036, this would correspond to 30,200 vehicles per day on Port Kennedy Drive near Ennis Avenue and 26,300 vehicles per day near Bakewell Drive.

According to the Main Roads Functional Hierarchy Port Kennedy Drive is classified as a District Distributor B. This classification of road is typically expected to carry in excess of 6,000vpd based on its function. According to Liveable Neighbourhoods Port Kennedy Drive would be classified as an Integrator Arterial and would be anticipated to carry traffic volumes between 15,000vpd and 35,000vpd.

On this basis, there is sufficient spare capacity for the additional traffic generated by the proposed Structure Plan onto Port Kennedy Drive as well as proposed background traffic growth from the area in line with traffic volumes expected based on the road classification and function.

Warnbro Sound Avenue, north of Port Kennedy Drive, carries in the order of 15,000 vehicles per day. (AWT, 2021/22). Warnbro Sound Avenue is constructed to a four lane dual carriageway standard. Based on 2% growth per annum it is anticipated that traffic volumes along Port Kennedy Drive would increase to 16,300 vehicles per day by 2026 and to 20,000 vehicles per day by 2036.

The proposed development is anticipated to result in traffic volumes on Warnbro Sound Avenue increasing by approximately 5,800 vehicles per day north of Port Kennedy Drive and 1,700 vehicles per day south of Port Kennedy Drive at full development. In 2036, this would correspond to 25,800 vehicles per day on Port Kennedy Drive north of Port Kennedy Drive.

As a 4 lane dual carriageway road, Warnbro Sound Avenue is expected to carry similar volumes of traffic as Port Kennedy Drive. On this basis, there is sufficient spare capacity for the additional traffic generated by both local traffic growth and the proposed Structure Plan onto Warnbro Sound Avenue.

Two lots are located on Bakewell Drive comprising of 6,497m2. This represents approximately 1.8% of the total lot yield for the Structure Plan. On this basis these lots are estimated to generate in the order of 354 daily trips, 22 am peak hour trips and 38 pm peak hour trips. These additional trips are estimated to be distributed onto the Warnbro Sound Avenue/ Bakewell Drive intersection (40% i.e. 9/15 am/pm peak hour trips) and Port Kennedy Drive/Bakewell Drive intersection (60% i.e. 13/23 am/pm peak hour trips). It is noted that these additional volumes are less than those that would require further detailed traffic assessment and it is therefore anticipated that these volumes will have minimal impact on the existing operating conditions of these intersections.

5. Local Water Management

A Local Water Management Strategy (LWMS) has been prepared by Strategen JBS&G in support of this Structure Plan.

Refer to Appendix E – Local Water Management Strategy

The subject site contains a number of ephemeral wetlands and examples of a Threatened Ecological Community. As such, water management is important to maintain hydrological regimes and ensure that water quality on the site is managed. The LWMS outlines how the proposed development will address water use management at the local planning level and details specific water management measures and strategies to be implemented to manage the water cycle in a sustainable manner. The key guiding principles of the LWMS are to:

- facilitate implementation of sustainable best practice in urban water management;
- encourage environmentally responsible development;
- provide integration with planning processes and clarity for agencies involved with implementation;
- facilitate adaptive management responses to the monitored outcomes of development;
- minimise public risk; and
- maintain the total water cycle of the site.

5.1 Stormwater Management Strategy

One of the aims of stormwater management on the site is to maintain pre-development flows off the site. There is currently no flow off the site for events up to a 1% AEP rainfall event and no flow off the site will occur post-development. Water will therefore be infiltrated within the development. Stormwater in events up to the 1% AEP event will be retained within the lots drainage reserves, POS and the road reserves. There may also potentially be some discharge to the Conservation area in events above the 10% AEP, subject to detailed design and agreement from relevant parties including the City of Rockingham and Department of Biodiversity and Conservation and Attractions (DBCA).

The advantages of this concept are:

- maintaining the current surface water hydrology of the wetlands and TECs, where water does not enter these areas via surface runoff;
- a modular approach that allows flexibility, should the road layout need to be modified to address demand for a particular size of industrial lot.

Different management approaches have been investigated to manage the road stormwater runoff. The options include:

- at source disposal at low point via bioretention gardens and infiltration systems in road reserves adjacent to lots);
- at source disposal via linear open planted swale;
- at source disposal via below ground linear infiltration system; and
- at source disposal to open air basin for larger events (where other management systems are impractical or flow can be directed to dedicated drainage reserve and edges of the POS).

With these structures, it is anticipated that only minimal piped drainage will be required on the site. As the development is currently at the Structure Planning stage, combinations or alternative options may be used in each catchment. To assist with future detailed design, stormwater modelling has been undertaken for both vegetated linear swales and underground infiltration systems for each catchment that doesn't have a designated open basin. All open basins have also been modelled.

Ratios for bioretention gardens to capture and infiltrate the first 15mm of rainfall, as well as infiltration chamber sizing for larger events have also been determined based on different road lengths.

The analysis of these different options provides direction in determining the most suitable option for each area as part of detailed design. While the above systems have all been analysed and included as options, it is noted that the City's has a hierarchical preference for stormwater treatment in industrial areas. This hierarchy is as follows:

1. Linear swales on one side of the road, (with potential offsetting centreline to maximise verge space);
2. Pit and pipe system discharge to a linear swale; and
3. Pit and pipe system discharge to a linear swale with underground storage.

Option 2 and 3 also assumes the use of bioretention areas/treatment trains prior to pit capture.

At detailed design, this hierarchy is to be followed, in consultation with the City, to determine the optimal option for each drainage location. These best management practices (BMPs) are considered to provide simple, easy to maintain structures for stormwater management on the site.

The drainage system of Port Kennedy Drive will not be altered. No stormwater is to be discharged from the development area to any land reserved as Primary Regional Road under the Metropolitan Region Scheme. This will be outlined in detail as part of the UWMP.

Refer to Figure 17 – Concept Drainage Plan (JBS&G)

Legend

- Project area
- Conservation category wetland
- At source disposal within street
- Roadside disposal with possible discharge to conservation lot
- At source disposal leading to open aired basin for larger events
- Basin area and flood storage areas
- Lot layout boundary
- Cadastral boundary
- Lot layout
- Proposed kerb
- Proposed drainage
- Maximum groundwater level
- 50m environmental buffer
- Basin top
- Basin toe
- Footpath
- 6.9 Finished lot level
- Highway
- Major road
- Minor road

Figure 17. Concept Drainage Plan (JBS&G)

5.2 Minor storm event drainage system - 15mm and 10% AEP event

A minor storm event is considered to be an event up to and including the 10% AEP storm. The aim of the design for management of the minor storm events is to treat and infiltrate the first 15mm with infiltration of the entire 10% AEP stormwater. Treatment is through the use of vegetated areas prior to infiltration (biofiltration). In the 10% AEP event, the aim is to infiltrate stormwater without water covering the road pavement. As the design and infiltration systems for the minor storm events on the site are very similar, these are discussed together.

To provide flexibility in the final design, a range of drainage infiltration options have been modelled. Wherever possible, the treatment for the 63% AEP will be via vegetated systems such as bioretention gardens, vegetated swales and basins. These will treat the first 15mm of rainfall collected. In larger events, up to and including the 10% AEP, stormwater runoff will also make use of these structures plus other infiltration devices. In line with the City's guidelines (Planning Procedure No. 18), all soakwells are to have a minimum separation of 0.3m between the base of the soakwell and the AAMGL. All swales and basins are to have a minimum separation between their base and the AAMGL of 0.5m.

The drainage infiltration options include:

- bioretention gardens;
- swales;
- underground infiltration systems; and
- vegetated basins.

Isolated vegetated bioretention gardens and infiltration areas will be placed at the low points of the roads or terminal basin locations. Roads in the development will generally be kerbed, with kerb openings used to direct water into the bioretention gardens via a bubble up pit to prevent erosion.

The first 15mm of rainfall will runoff into the infiltration area of the bioretention garden which will then infiltrate through the base of the bioretention garden. The bioretention garden will be vegetated with native species to strip nutrients and particulates. Soil underneath and around the bioretention garden will be selected to have an elevated phosphorus retention index, such as Spearwood Sand. For this size event, the water levels will not be high enough to enter the soak well system associated with the bioretention garden, where these may be used.

The required volume of the infiltration area will be dependent upon the catchment area of the road reserve. As the road reserves will generally be 20m wide, the length of the road reserve for each catchment is the main variable to determine runoff volume for the critical event. The final requirements will be determined as part of detailed design and presented in the UWMP.

Bioretention gardens will have a minimum 0.5 m separation from the base of the vegetated infiltration area to the groundwater level. Bollards will be placed around the infiltration area of bioretention gardens to avoid cars parking in these areas.

In the 10% AEP event, the water will overtop the grate on top of the soak well within the bioretention area and flow via the distribution pipe into the interconnected soak wells which will be located in the road reserve on the other site of the road. The number of soak wells will again be dependent upon the length of the road reserve catchment.

Swales with local native vegetation suited to sporadic inundation are likely to be utilised in areas adjacent to the Conservation Area to minimise the impact of drainage infrastructure on the Conservation Area. They may also be used in as other catchments where they are determined to be the most suitable option at detailed design. The swales will be designed to retain the 1% AEP event within the road reserve unless agreement is reached as part of detailed design to allow some higher flows through to the conservation area in a controlled manner. Soil underneath the swales will be selected to have an elevated phosphorus retention index (>10), such as Spearwood Sand.

The swales may also have a buried, infiltration drain filled with limestone or other rock sized material to maximise infiltration rates and ensure that the swale drains quickly. Where used, the infiltration drain will be wrapped with geofabric to prevent sand and silt entering the infiltration drain. A high-level inlet will prevent the first 15mm from entering the infiltration drain associated with the swale ensuring that water is infiltrated through the biofilter. The use of these systems will be determined in consultation with the City at detailed design and subject to the best overall option for the location and City maintenance regimes.

Vegetation planted within the swales will be chosen to have root systems compatible with the infiltration system. This includes sedges, rushes, and small shrubs. The final design, including the potential requirement for an infiltration trench will be determined as part of the detailed design in consultation with the City. The design will consider the necessary maintenance regime for the City. Should the infiltration trench be included, the inclusion of geofabric around the structure will also be determined in consultation with the City.

The sides of the swale will be battered at a grade of 1 in 6 for safety. It has been proposed to make the road edge adjacent to the swales flush kerbed with bollards to prevent vehicle entry to the road reserve. Alternatively, they may be kerbed with designated rocked chutes. This detail will be confirmed with the City of Rockingham at the design stage.

Swales have been designed with a minimum 0.3 metre separation from the base of the vegetated infiltration area to the groundwater level.

The swales and bioretention gardens in the roads adjacent to the Conservation Area will be required to be managed to ensure the understorey and surface fuels remain in a low threat, minimal fuel condition in accordance with Clause 2.2.3.2 (f) of AS 3959 and Schedule 1 Guidelines for Planning in Bushfire Prone Areas (WAPC 2017). This will limit the surface fuel load allowed to occur in this area to less than 6 millimetres in thickness and maintained at 2 tonnes per hectare or vegetation that can be slashed prior to summer to reduce fire risk. Trees are allowed in the low fuel zone, provided the density is not adequate to constitute a fire risk. This will require lower branches removed to height of 2 metres above surface vegetation, canopy cover less than 15% and tree canopy at least 5 metres apart.

The use of swales for drainage management meets the objective of maintaining 63% AEP event volume and peak flow rates maintained at or below pre-development conditions for the 10% AEP, as there is no outflow from any system.

Where it may not be possible to utilise swales, underground infiltration systems may be used. To assist with determining where these may be the most suitable option at detailed design, all non-basin catchments have been analysed to determine the appropriate sizing for these systems. The modelling has assumed that the infiltration systems are 0.6m deep with straight sides. It is also assumed that there is 0.3m of rise from the top of the system to the gutter level. The sizing assumes all stormwater is contained within the infiltration system with no standing water on the road surface in the 10% AEP or 1% AEP to be conservative. As part of detailed design, these will be refined to suit the subcatchment feeding them, with the potential for some storage in the road in the 1% AEP. To be conservative, no upstream soakage in bioretention gardens is assumed.

The 1EY (Exceedances per Year) is generally 0.3 metres deep within the infiltration systems if there is no bioretention garden before the infiltration system.

Where suitable space is available, vegetated basins within designated reserves have been used to manage stormwater for all events up to and including the 1% AEP. They have been designed so that they completely contain the 10% AEP within the designed basin. In the 1% AEP, water may flood out into the land surrounding the basin within the reserve area, with the maximum depth of water in the basin, including surrounding standing water to be less than 1.2 metres deep.

Balance pipes may be used to allow water to flow between the different basins, depending on the exact catchment area that will feed each basin. The most suitable configuration to protect the wetland, keep all drainage infrastructure outside of the wetland buffer and allow for other passive uses will be determined in consultation with the City at detailed design. The current modelling highlights that there is suitable space available to achieve these outcomes within the available reserve area outside of the 50 metre buffer.

Any flooding of adjoining roads next to the basin has been designed to be less than 0.15 metres above the gutter, noting that it is likely that water will be completely contained within the reserve area due to the available space.

5.3 Major event drainage system - 1% AEP event

The 1% AEP event will generally be retained within the bioretention gardens, swales, infiltration systems and basins with potentially some minor flooding of adjoining roads to less than 0.2m.

Finished floor levels on lots will be designed to maintain a 0.3 m clearance from the relevant 1% AEP event flood level, to prevent flooding. Final levels of all roads and therefore flood levels lots and finished floor levels are to be determined at detailed design and set out in the UWMP. This meets the design guideline for flood management by managing events up to the 1% AEP event within the development area to match predevelopment flows. Detained stormwater will fully infiltrate within 96 hours of the rainfall event, in line with the design criteria for disease vector and nuisance insect management. Underground infiltration systems are designed to hold the entire 1% AEP, however, this may be refined at detailed design stage. As all flows are infiltrated on site, there are no post development flows off the site in the 1% AEP.

The current drainage concepts has been designed so that there is no need for stormwater runoff to enter the Conservation Area in events up to the 1% AEP event, to minimise impacts on wetlands and Threatened Ecological Communities. The flow paths within the Conservation Lot are to be vegetated with the plants to include a high portion of groundcover and low multi stemmed plants such as dryland sedges to assist with protecting the ground surface from sporadic occurrences of flowing water. The species choice and mix of plants is to be in accordance with the approved Conservation Area Management Plan.

Due to using plants to manage the flow into the Conservation Lot, the maintenance will be primarily of a plant management nature. Maintenance is also to review any potential erosion, with rectification should it occur. Should there be a need to sheet the flow over any trails within the Conservation Lot, the relevant portion of the pathway is to be protected with a suitable surface such as crushed stabilised stones.

It is noted that generally the Conservation area is slightly higher than the preliminary design level of the adjoining road, limiting the opportunity for flows to it. Any possible discharge options will be undertaken in negotiation with the relevant authorities, primarily DBCA and the City. It is noted that DBCA and DWER have provided support for flows above the 10% AEP being directed to the Conservation Lot, should final levels allow for it. The final agreement will be detailed in both the UWMP and the Conservation Lot Management Plan.

5.4 Water Quality Management

At the development scale, stormwater quality will be managed through use of vegetated rain gardens and swales for infiltration and amended soils. There are no plans for landscaping that requires fertilisers in the Conservation Area. These measures, and the use of appropriate swales and water pollution control BMPs at a lot level complies with the design principles of maintaining or improve groundwater and surface water quality and minimising the discharge of pollutants to shallow groundwater.

5.5 Water Conservation

Water conservation in developments will be managed at both a development and lot scale. At a development scale, the development is not proposing to include any irrigated POS, although limited irrigation may be required for establishment of swales and rain gardens. Irrigation during establishment is anticipated to be provided through the use of water tankers. The POS provided will consist of some small areas with drainage function. The drainage area has been allocated in the north-west corner of the site to manage road drainage from areas adjacent to the POS. The lack of irrigated POS significantly reduces the use of water at a development scale.

Water use at a lot scale depends on the type of industry established. While warehouses and retail showrooms may not require large volumes of potable water, some industries, such as commercial laundries, require large volumes of water. DevelopmentWA is proposing to utilise a mixture of design guidelines and incentives to ensure that the measures chosen to manage water use at a lot scale are flexible, to meet the needs of different types of business. These design guidelines and considerations have been based on DevelopmentWA design guidelines for the Element Precinct (Light Industry Precinct) in the East Rockingham Industrial Park (DevelopmentWA). Water conservation measures will be incorporated into the site design guidelines, which will include measures to require:

- water efficient tap fixtures and showers to be installed within the buildings;
- the use of low water use irrigation systems within the lot, such as trickle irrigation systems, with a programmable controller/timer system; and
- support of rainwater tanks connected to a suitable, seasonally independent water use, such as toilet flushing.

Consideration will be given to the following items at the subdivision stage:

- provision of waterwise and low fertiliser use landscaping packages, including advice on minimising fertiliser and water use in landscaping;
- rebates or provision of infrastructure for rainwater tanks such as tanks and pumps; and
- complimentary access to a nominated water conservation consultancy to assist with design and commissioning of rainwater and/or greywater recycling systems, up to a certain value.

These measures will assist industries present on the site to reduce their water use, while providing a high level of amenity and meets the design guidelines' objective to minimise the use of potable water where drinking water quality is not essential.

Industries that use more than 20,000 kL/year are required to submit a Water Efficiency Management Plan (WEMP) to the Water Corporation. It is considered unlikely that industries in the Light Industrial Park would require such large volumes of water.

Maintaining summer water levels in the wetlands is considered important for their long-term survival.

6. Servicing and Infrastructure

A Engineering Servicing Report for the PKBEP has been prepared by Porter Consulting Engineers. The report concludes that there are no major servicing impediments to developing the site and the service agencies have undertaken the necessary network planning to support the Structure Plan.

Refer to Appendix F – Engineering Servicing Report

6.1 Sewer

The subject site is within the Water Corporation sewer scheme area, but is not yet serviced. There are 300mm and 225mm diameter sewer mains constructed in the existing subdivision to the west.

Water Corporation will require a sewer to be extended from the existing in Bessemer Road and then advanced in an easterly direction throughout the subdivision. Consistent with this, a concept sewer layout has been prepared and is presented in Figure 18.

Refer to Figure 18 – Concept Sewer Layout (Porters)

The gravity sewer crosses under the Conservation Category Wetland (CCW) via trenchless techniques, before it branches out to service the estate. The subdivision sewers will be 225mm diameter and developed on a frontage basis. Standard chambers and property connections are required.

The north western corner of the site is serviced via a separate sewer. This reduces fill requirements and allow the seamless tie in with the existing Bakewell Drive. Approval in principle has been provided by the Water Corporation for this layout.

6.2 Water

The Water Corporation will require all lots to be serviced with water, compliant with industrial subdivision standards. A concept water main layout has been prepared with a new DN200 loop main extending from the existing 200mmm water main at the intersection of Blackburn Drive/ Port Kennedy Drive, through the estate and back to the 200mm main at the intersection Bakewell Drive / Paxton Way. All other water mains are DN150. Approval in principle has been provided by the Water Corporation for this layout.

6.3 Power

A Western Power Feasibility Study (MF010087) in summary indicates:

- 7MVA (7000kVA) expected capacity based on minimum usable land.
- there is spare capacity in the network equaling 2MVA (2000kVA) or 2-3x 630kVA transformers.
- More than 2MVA requires a new HV feeder to be installed from the Waikiki zone substation (approx. 4.5km).

Current Western Power mapping (Forecast of Remaining Capacity 2026) suggests the area has 15-20MVA spare capacity. Further discussions with Western Power are recommended to verify what reinforcing works have been completed since the 2011 study and what impact this has on their previous advice. It is recommended this happens at detailed design stage.

A high and low voltage underground network will be established to service the estate. Street lighting is required and will be installed compliant with governing standards. Alternate lighting arrangements could be considered however are subject to approval by the City of Rockingham.

Figure 18. Concept Sewer Layout (Porters)

The development of new technology in the power industry has presented opportunities to mitigate consumer costs. Innovations that could be utilised within this development include:

- Solar Power Supply with battery support across strata lots.
- Solar Hot Water System.
- Heat Transfer Hot Water System (Low Power).
- Wind Pods (Wind Power).

These initiatives will be further explored by DevelopmentWA as the project progresses to the subdivision stages.

6.4 Telecommunications

There are NBN telecommunication networks in the surrounding suburbs to the north and west which can be extended into the subject site at the subdivision stage of development.

6.5 Earthworks

Due to the regular occurrence of dune ridges, the site will be earth worked in full to create generally level lots. Based on ground water levels, drainage requirements and sewer servicing, filling will be required. An indicative bulk earthwork re-contouring plan based on the combination of drainage and sewer requirements is shown in Figure 19.

Refer to Figure 19 – Concept Earthworks Plan

The soils and climatic conditions are such that dust may be an issue during construction. The Contractor will prepare and obtain approvals for a dust management plan, this will nominate strict control measures to mitigate dust blow off during each stage. It is expected these controls will include on site storage of construction water, regular stabilisation, dust fencing and staging their construction activities.

Figure 19. Concept Earthworks Plan

7. Implementation and Conclusions

7.1 Staging

As set out in Part 1 of this document, the development of the PKBEP Structure Plan will likely be implemented in multiple stages due to the significant size of the development area. Final development staging will also be dependent on a number of factors including market demand, servicing and infrastructure considerations.

Refer to Figure 20 – Indicative Staging Plan

Provided that suitable road access and servicing infrastructure is included in any proposed development the staging of the development area will be market-led. It is anticipated that the first two stages of land release will occur along Port Kennedy Drive up to Ennis Avenue.

7.2 Subdivision and Development Requirements

The following actions have been identified as part of future works to support the subsequent subdivision and development of the subject site:

- **Bushfire:** A bushfire risk assessment/management plan in conjunction with the Department of Fire and Emergency Services and the City of Rockingham, shall be developed and must take account of long-term revegetation outcomes associated with the Conservation Area lot.
- **Water Management:** To ensure that the quantity and quality of water is maintained to protect the receiving and surrounding environments, an Urban Water Management Plan (UWMP) will be prepared as part of the detailed subdivision design. The UWMP will include the following Water Sensitive Urban Design (WSUD) principles:
  - Provide protection to life and property from a 1 in 100 year flood event;
  - Manage stormwater to minimise run off as high in the catchment as possible;
  - Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features, regimes and processes and integrate these into the light industrial landscape;
  - Maximise water use efficiency and reduce potable water demand; and
  - Minimise pollutant inputs through implementation of appropriate non-structural source controls.
- **Traffic:** A Transport Impact Assessment shall provide technical specifications relating to the subdivision and development of the land.
- **Landscape Design:** A detailed landscape plan for the subject site shall be prepared prior to subdivision. This will include details regarding the business park's fencing strategy, plant types, proposed planting design adjacent to the residential interface, public open space, and street tree planting strategy. A landscape management plan shall also detail the ongoing management and maintenance of the designated public open space area.
- **Fauna Relocation Management Plan.**
- **Acid Sulfate Soils:** ASS investigations shall be undertaken prior to any dewatering works being undertaken near the western boundary of the site.
- **Earthworks:** Construction activities need to be managed to minimise the impact to the Conservation Area and adjoining residential areas during the bulk earthworks and construction phases. Impacts may include nuisance dust generation during bulk earthworks, vehicular activities, disturbance of acid sulphate soils and associated dewatering. These impacts are manageable through appropriate engineering design and good site management practices (Construction and Environmental Management Plan).
- **Potential Contamination:** Investigations of dumped material prior to subdivision to determine if any formal investigation (e.g. a PSI) is required on the site.

Figure 20. Indicative Staging Plan

- **Conservation Area Management Plan (CAMP):** A CAMP will be prepared in accordance with WAPC 156342. It will cover the following aspects prior to any construction works on the site:
  - Fencing the boundary of the Conservation Area;
  - Removal of rubbish;
  - Rehabilitating areas of degraded vegetation to a suitable standard that the Conservation
  - Public Open Space can be handed to City of Rockingham for management;
  - Retaining or creating appropriate access tracks for the public and fire management;
  - Closing and rehabilitating existing tracks where appropriate;
  - Installing signage for public awareness of environmental values;
  - Undertaking weed control;
  - Monitoring vegetation health; and
  - Implementation, monitoring, reporting and responsibility.

7.3 Concluding Comments

The PKBEP Structure Plan has been prepared to guide the future subdivision, development and conservation of 67 hectares of land at Lot 17 and Lot 4 Port Kennedy Drive, Port Kennedy. This will enable the coordinated subdivision and development of the site for the purposes of Service Commercial, Office and Light Industry uses. The Structure Plan is supported by the following key considerations:

- The subject site is appropriately zoned for the business park under the MRS and the City of Rockingham's LPS2.
- The development of the site will facilitate a diverse range of employment generating land uses in accordance with the objectives of LPS2.
- It will create a logical and permeable movement network throughout the site. Access and egress to and from the subject site and Port Kennedy Drive can achieved in a logical and safe manner.
- The framework will direct the orderly development of the site in an environmentally sensitive manner and protect and enhance its environmental assets. This includes contributing to the City's tree canopy objectives, reducing the urban heat island effect and improving urban amenity, aligning with the vision of the City of Rockingham's Greening Plan.
- The subject site can be serviced with reticulated water, sewer, power and NBN.
- The Structure Plan design will incorporate a notionally shown Conservation Area located on the western part of the site, which is approximately 18 hectares in area. This will protect a large proportion of the significant wetlands and TEC19 on the site. In addition, a further wetland will be retained centrally within the business estate as part of a dedicated Public Open Space local park. This will result in a total of 19 wetlands being protected under the PKEP Structure Plan. It is noted that historic environmental approvals allow for all vegetation and wetlands on the site to be cleared. The proposed retention of 19 wetlands in the PKBEP Structure Plan is considered a much better environmental outcome for the site.

8. Technical Appendices

A. Certificate of Titles and Sketches

WESTERN AUSTRALIA

REGISTER NUMBER
4/D94300

DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	**29/6/2016**

VOLUME	FOLIO
2126	**431**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 4 ON DIAGRAM 94300

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

WESTERN AUSTRALIAN LAND AUTHORITY OF LEVEL 6, 40 THE ESPLANADE, PERTH WA 6000
(T N366124) REGISTERED 28/6/2016

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	2126-431 (4/D94300)
PREVIOUS TITLE:	1245-450, 1245-452, 1254-453
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	CITY OF ROCKINGHAM
RESPONSIBLE AGENCY:	WESTERN AUSTRALIAN LAND AUTHORITY

WESTERN AUSTRALIA

REGISTER NUMBER
17/D65566

DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

VOLUME	FOLIO
1663	**339**

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 17 ON DIAGRAM 65566

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

INDUSTRIAL LANDS DEVELOPMENT AUTHORITY OF 12 SAINT GEORGE'S TERRACE, PERTH
(T C730028) REGISTERED 15/3/1984

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1663-339 (17/D65566)
PREVIOUS TITLE:	1245-452
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	CITY OF ROCKINGHAM
RESPONSIBLE AGENCY:	WESTERN AUSTRALIAN LAND AUTHORITY

B. Bushfire Management Plan

element.
the art and science of place

Bushfire Management Plan

Port Kennedy Industrial Estate Structure Plan
Lots 4 and 17 Port Kennedy Drive, Port Kennedy

March 2024 | 22-619

Document ID: 22-619			
Issue	Date	Status	Prepared by
			Name
1	18/03/24	Draft – Client Review	Dylan Wray – BPAD 44656
2	27/03/24	Final – Submission	Dylan Wray – BPAD 44656

Contents

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lots 4 and 17 Port Kennedy Drive, Port Kennedy

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 15 Month December Year 2022

Report author or reviewer: Dylan Wray

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☑ Level 3 practitioner ☐

If accredited please provide the following.

BPAD accreditation number: 44656 Accreditation expiry: Month March Year 2025

Bushfire management plan version number: 2

Bushfire management plan date: Day 27 Month March Year 2024

Client/business name: DevelopmentWA

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✔
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✔

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✔
Strategic planning proposal (including rezoning applications)	✔	
High risk land-use		✔
Vulnerable land-use		✔

None of the above ☐

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Structure Plan

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer 

Date 27/03/24

1. Proposal Details

1.1 Background

This Bushfire Management Plan (BMP) has been prepared by **element** on behalf of DevelopmentWA for the Port Kennedy Industrial Estate Structure Plan (the Structure Plan). The Structure Plan relates to Lot 4 and 17 Port Kennedy Drive, Port Kennedy (the subject site).

This BMP has been prepared in accordance with State *Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) and the *Guidelines to Planning in Bushfire Prone Areas* (the Guidelines) to accompany the Structure Plan to the City of Rockingham (the City) and the Western Australian Planning Commission (WAPC).

1.2 Purpose

The aim of this BMP is to assess bushfire hazards within the subject site and surrounding areas to ensure the threat posed by any identified hazards can be appropriately managed and mitigated. This document provides an assessment of the general bushfire management strategies to be considered at the structure planning stage, including:

- Site assessment including vegetation classification and slope analysis within the 150m assessment area of the proposed development, in accordance with *Australian Standard 3959-2018 Construction of buildings in bushfire prone areas* (AS3959-2018);
- Consideration of bushfire hazards that will exist post development and whether there are any temporary or permanent hazards that need to be considered;
- Assessment against the bushfire protection criteria of the Guidelines and demonstrate how subsequent planning stages can achieve compliance;
- Recommended mitigation measures to reduce the risk of bushfire from within the subject site; and
- Recommended roles and responsibilities associated with implementing the requirements of this BMP.

1.3 Proposal Description

The subject site will be developed by DevelopmentWA to deliver the planned Port Kennedy Industrial Estate. The Structure Plan establishes the guiding framework to enable the future subdivision and development of the subject sites for industrial purposes.

The Structure Plan includes the following elements:

- Port Kennedy Enterprise Zone which contemplates future industrial development;
- Conservation Lot which retains existing vegetation;
- Public Open Space (POS) and drainage reserves; and
- Public road reserves and pedestrian access ways (PAWs).

Refer to Appendix 1 – Structure Plan

1.4 Site Description

The subject site comprises of approximately 67 hectares and is bound by Ennis Avenue to the east, Port Kennedy Drive to the south, Bakewell Drive to the west and existing residential development to the north, as detailed in Figure 1.

Figure 1 – Location Plan

1.5 Map of Bushfire prone Areas

The entire subject site is designated as bushfire prone on the Office of Bushfire Risk Management (OBRM) Map of Bushfire Prone Areas, as detailed in Figure 2. The designation of an area as bushfire prone reflects the potential for bushfire attack and acts as a mechanism to initiate further considerations through the planning approval process.

1.6 Previous Assessments

Strategen JBS&G previously prepared the BMP to accompany the Structure Plan however this is considered outdated given it was prepared against the previous versions of the Guidelines (V1.3).

element prepared a BMP to accompany the recently approved subdivision application for the subject site. This BMP has been prepared using the assessment outcomes of the previous subdivision BMP.

Figure 2 – Map of Bush Fire Prone Areas

1.7 Bushfire History

The subject site is susceptible to bushfires which was evident through a fire which threatened residential properties directly to the north of the subject site. Evidence of burn scar from the December 2022 bushfire is shown in Figure 3.

The majority of the fuel loads on the subject site will be cleared which will reduce the potential for further bushfires within the area. Furthermore, the bushfire mitigation measures contained within this BMP will ensure future development appropriately responds to the identified risk.

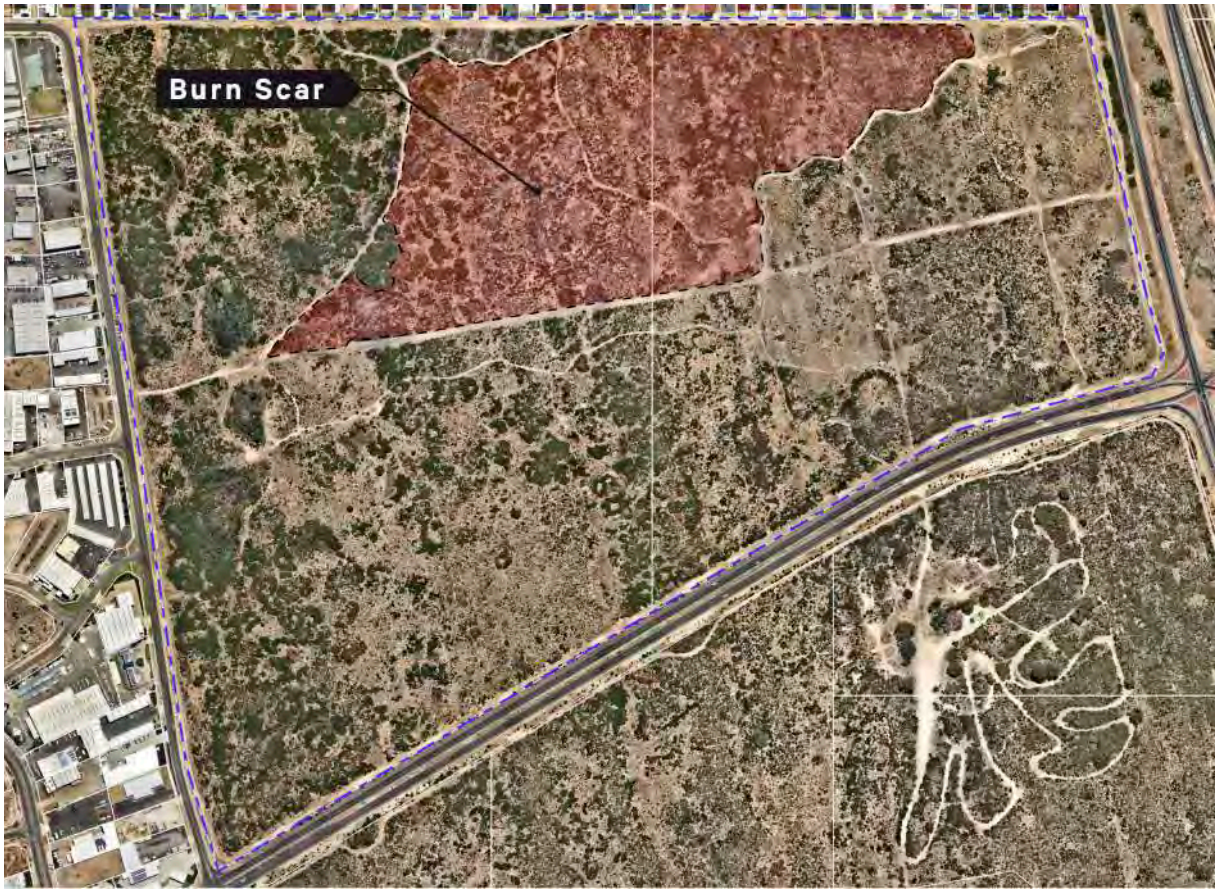


Figure 3 – Extent of Recent Bushfire (29 December 2022)

2. Environmental Considerations

2.1 Native Vegetation – Modification and Clearing

Policy Objective 5.4 of SPP 3.7 recognises the need to consider bushfire risk measures alongside environmental, biodiversity and conservation values. This BMP considers the environmental values specific to the subject site that may require consideration through protection, retention, or revegetation.

Table 2.1 provides a summary of the relevant environment considerations obtained from public databases and the previous Environmental Assessment Report (PGV Environmental, 2020).

Table 2.1 – Summary of Potential Environmental Considerations

Environmental Features	Dataset	Applicable?	Comments
Conservation Category Wetland and Buffer	DBCA-019	Yes	Conservation status geomorphic wetlands of the Swan Coastal Plain are mapped as occurring within and adjacent to the subject site.
RAMSAR Wetlands	DBCA-010	No	N/A
Threatened and Priority Flora	DBCA-036	No	No threatened or priority flora have been recorded through previous environmental assessments.
Threatened Ecological Communities (TECs)	DBCA-038	Yes	The Sedgelands in Holocene Dune Swales TEC has been recorded on-site. Banksia Woodlands of the Swan Coastal Plain TEC and Tuart Woodlands TEC are both mapped as 'may occur' within and adjacent to the subject site.
Bush Forever Areas	DOP-071	Yes	Bush Forever Area 356 is mapped to the south and east of the subject site.
Environmentally Sensitive Areas	DWER-046	Yes	Land within and adjacent to the subject site area mapped as an environmentally sensitive area.
Swan Bioplan Regionally Significant Natural Areas	DWER-070	No	N/A
Native Vegetation Extent	DPIRD-005	Yes	The subject site contains native vegetation.

The subject site will require clearing to facilitate future industrial development, as contemplated by the Structure Plan. As identified in the Environmental Assessment Report (PGV Environmental, 2020), the site has previously been assessed by the Environmental Protection Authority (EPA) which determined the site as being suitable for industrial development. As such, any clearing of native vegetation associated with an approved subdivision is considered exempt from the requirement of a clearing permit given the site has been formally assessed by the EPA.

To assist with the protection of the environmental values associated with the western portion of the subject site, a conservation lot has been proposed. In addition, POS / drainage reserves have been proposed as a buffer around retained conservation category wetlands.

The environmental values associated with the subject site do not preclude compliance with the bushfire protection criteria of the Guidelines or any additional bushfire mitigation measures recommended as part of this BMP. The Structure Plan considers the bushfire hazards that will exist on-site post development and responds through the use of perimeter roads and PAWs to achieve the compliant separation distances.

2.2 Landscaping Plans / Revegetation

A landscape masterplan has been prepared by Plan E (2023) to guide future landscaping, revegetation and retention of existing remnant vegetation throughout the project area. A copy of the landscape masterplan is provided in Appendix 2.

Landscaping treatments associated with the Structure Plan include:

- Revegetation of existing native vegetation on-site within the central POS reserve;
- Revegetation of proposed drainage basin within both POS reserves;
- Establishment of low threat landscaping throughout the central POS reserves;
- Establishment of low threat landscaping within the road reserves and PAWs including verges and drainage swales; and
- Establishment of low threat landscaping along the northern boundary as a buffer to the adjoining residential development.

Areas proposed to be revegetated within the POS reserves have been considered in the bushfire assessment based on the worst-case post development scenario. All other landscaping that meets the definition of low threat has been excluded on the basis that it will be maintained in accordance with Clause 2.2.3.2 (f) of AS3959-2018.

It is also expected that individual industrial lots will require landscaping as part of future development. Individual landscaping plans will be prepared to accompany future development applications and will incorporate areas of low threat vegetation, where required.

Refer to Appendix 2 – Landscape Masterplan (Plan E)

3. Bushfire Assessment Results

3.1 Assessment Inputs

3.1.1 Site Assessment

A site visit was undertaken on the 15th December 2022 by a BPAD accredited practitioner with vegetation and effective slope classified in accordance Table 2.3 of AS3959-2018.

3.1.2 Vegetation Classifications

All vegetation within the assessment area has been classified in accordance with AS3959-2018 and the Visual Guide for Bushfire Risk Assessment in Western Australia (WAPC 2016).

The assessment has been based on the following post development assumptions:

- Classified vegetation located in the Port Kennedy Enterprise Zone, proposed road reserves and PAWs, as identified on the Structure Plan, can be cleared and managed in a low fuel state;
- Classified vegetation contained on the conservation lot, as identified on the Structure Plan, will remain unchanged and will continue to pose a bushfire risk post development;
- Areas of revegetation within the POS and drainage reserves, as identified on the Structure Plan, have been assessed based on the worst-case post development scenario being Class B Woodland;
- Classified vegetation contained on surrounding properties and within the road reserves will remain unchanged and will continue to pose a bushfire risk post development; and
- Low threat vegetation contained on surrounding private properties and within the adjoining road reserves will remain managed which is a continuation of existing management regimes.

Refer to Appendix 3 – Vegetation Assessment

3.1.3 Effective Slope

The effective slope under classified vegetation has been determined in accordance with AS3959-2018 through on-site observations with a rangefinder, cross checked with available contour data.

The subject site is characterised by frequent undulations with a worst-case slope of >0-5 degrees downslope. Accordingly, a conservative effective slope of >0-5 degrees has been applied for on-site classified vegetation that will exist post-development.

Land on adjacent sites to the south and east of the subject site are either flat or upslope and have been assigned an effective slope of flat / upslope in accordance with AS3959-2018.

3.1.4 Summary of Inputs

The assessment inputs described above have been summarised in Table 3.1 and visually represented in Figure 4 – Site Assessment Map.

Table 3.1 – Assessment Summary

Plot	Vegetation Classification	Effective Slope	Comments
Plot 1	Class D Scrub	Flat / Upslope	Large acacia shrubs with an average height greater than 2m and foliage cover greater than 30%. The small area of scrub vegetation only occurs within the Ennis Avenue road reserve to the east of the subject site.
Plot 2	Class C Shrubland	Flat / Upslope	Open low heaths of acacia shrubs found throughout the subject site and on the adjacent property to the south. The vegetation is characterised by an average height less than 2m with grassy understorey and foliage cover greater than 30%.
Plot 3	Class C Shrubland	Downslope 0-5°	
Plot 4	Class G Grassland	Flat / Upslope	Area of unmanaged grassland typically found in road reserves where there is no evidence of management regimes.
Plot 5	Class B Woodland (Revegetation)	Flat / Upslope	Drainage basins and areas of tree planting through the proposed POS reserves. These areas have been applied a worst-case classification of woodland on the basis that they will contain large native tree plantings.
Plot 6	Excluded – Clause 2.2.3.2 (e)	N/A	Non-vegetated areas including roads, buildings and access tracks.
Plot 7	Excluded – Clause 2.2.3.2 (f)	N/A	Area of low threat vegetation including residential gardens, landscaping and road reserves where there is evidence of management regimes.
Plot 8	Excluded – Clause 2.2.3.2 (e) & (f)	N/A	The development area (Port Kennedy Enterprise Zone), proposed road reserves and PAWs on the subject site which currently consists of Class C Shrubland. These areas will be cleared to facilitate the approved subdivision and future development.

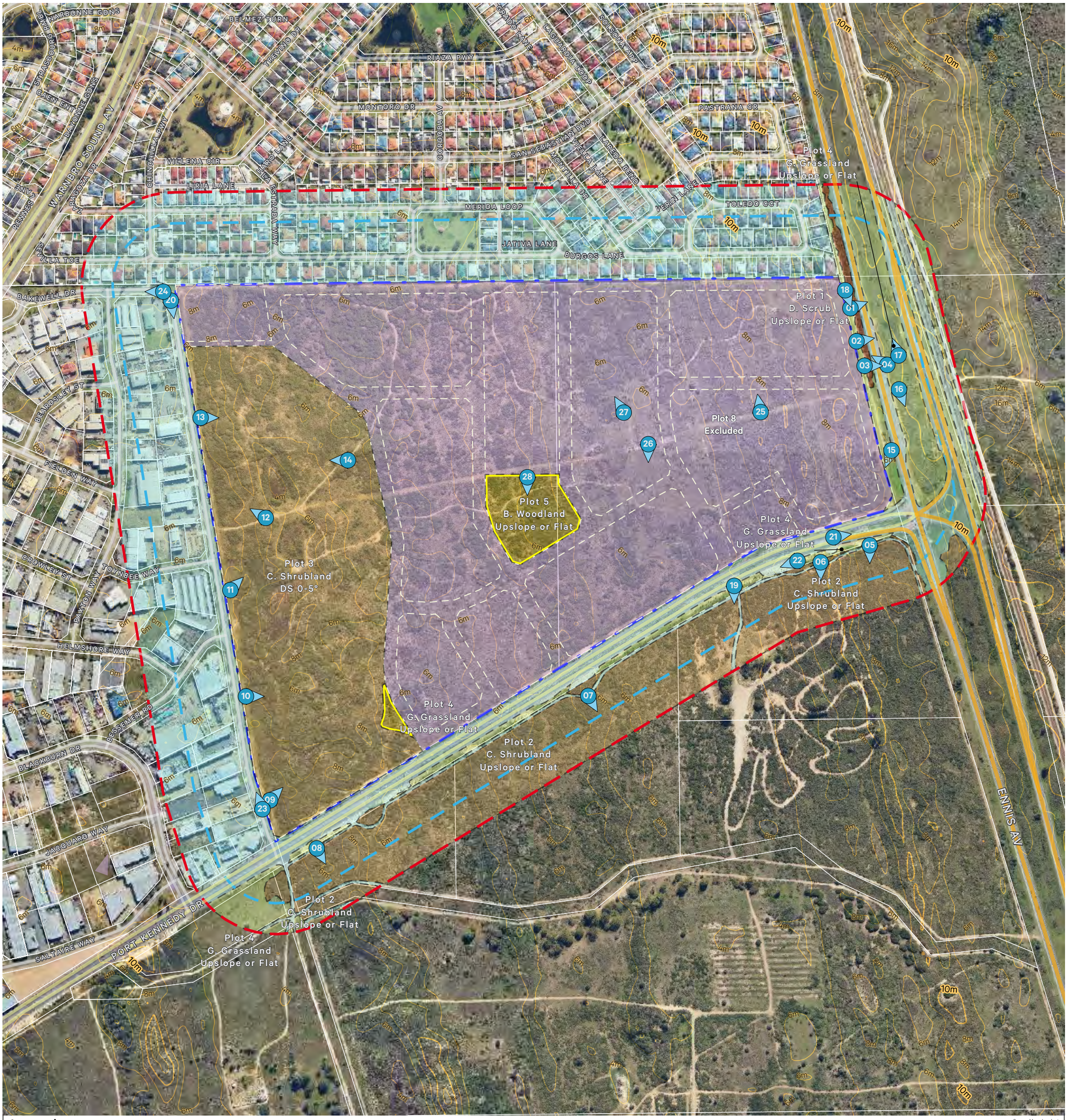


Figure 4 - Site Assessment Map

Port Kennedy Industrial Estate Structure Plan

Lots 4 and 17 Port Kennedy Drive, Port Kennedy

Assessment Date: 14/12/2022

Accreditation Details: BPAD 44656 (Level 2)

element.

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3.2 Assessment Outputs

The classified vegetation and effective slope identified in Table 3.1 has been used to determine the radiant heat impact across the subject site through the determination of the Bushfire Attack Level (BAL) in accordance with Method 1 of AS3959-2018. Table 3.2 provides an extract of the applicable separation distances from Table 2.5 of AS3959-2018.

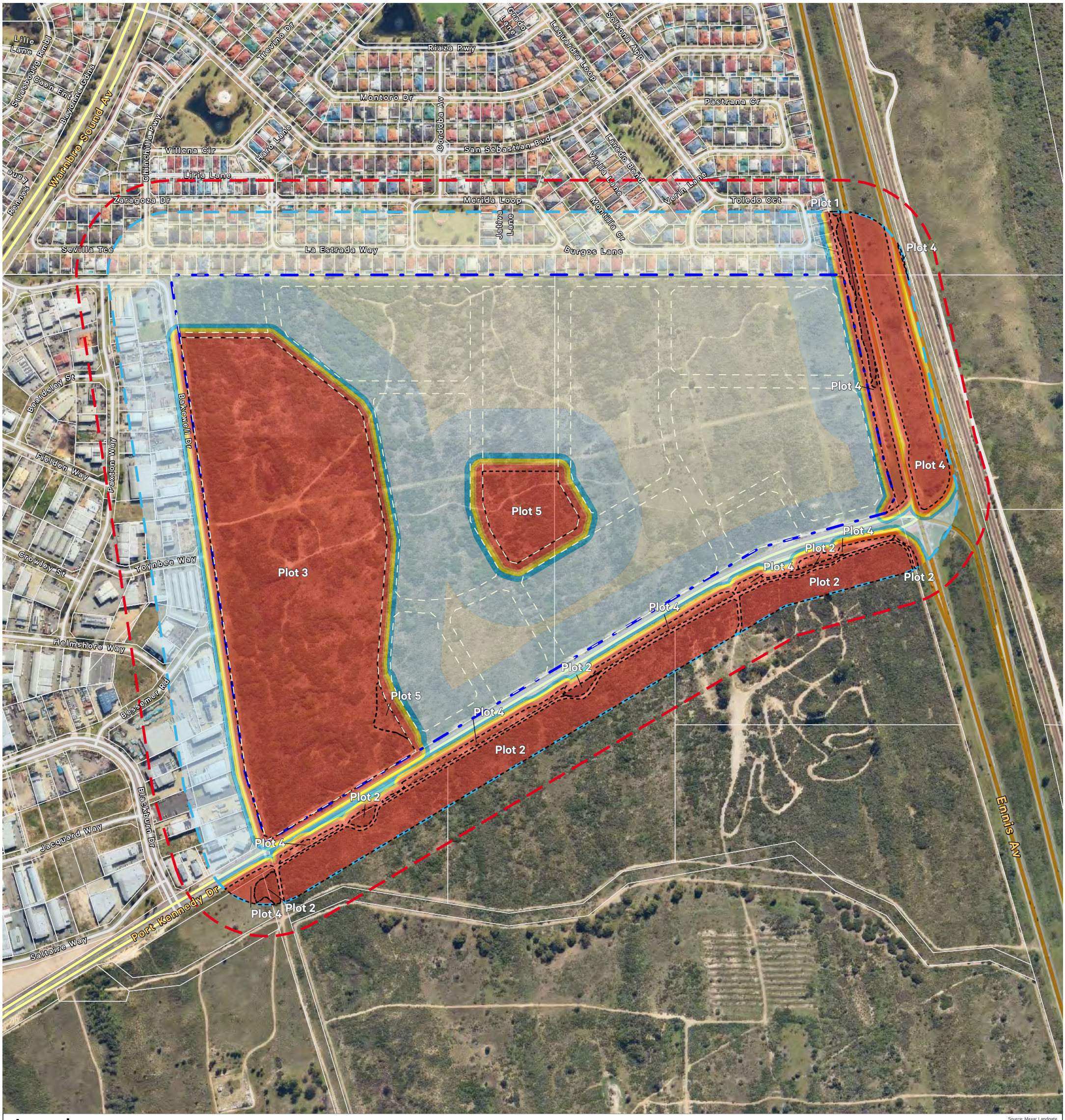
Table 3.2 – Vegetation Separation Distances (Table 2.5 of AS3959-2018)

Plot	Vegetation Classification	Effective Slope	BAL-FZ	BAL-40	BAL-29	BAL-19	BAL-12.5	BAL-LOW
Plot 1	Scrub	Flat / Upslope	<10	10-<13	13-<19	19-<27	27-<100	>100
Plot 2	Shrubland	Flat / Upslope	<7	7-<9	9-<13	13-<19	19-<100	>100
Plot 3	Shrubland	Downslope 0-5°	<7	7-<10	10-<15	15-<22	22-<100	>100
Plot 4	Grassland	Flat / Upslope	<6	6-<8	8-<12	12-<17	17-<50	>50
Plot 5	Woodland	Flat / Upslope	<10	10-<14	14-<20	20-<29	29-<100	>100

The Bushfire Attack Level (BAL) Contour Map in Figure 5 has been prepared for the assessment area based on the following post-development considerations following the completion of subdivisional works:

- The vegetation classifications and slope analysis in Table 3.1;
- AS3959-2018 separation distances in Table 3.2;
- The Port Kennedy Enterprise Zone, proposed road reserves and PAWs being managed in a low fuel state, in perpetuity;
- The conservation lot remaining unmanaged; and
- The POS / drainage reserves being revegetated to Class B Woodland.

The BAL Contour Map indicates that the Port Kennedy Enterprise Zone is capable of accommodating development in areas that achieve 29kW/m^2 (BAL-29) or below. There is an area assessed as BAL-FZ along the eastern boundary which is due to the adjoining Ennis Avenue verge being considered unmanaged at the time of the assessment. However, there is sufficient area on site to accommodate future development in an area assessed as 29kW/m^2 (BAL-29) or below.



Legend

- Subject Site
- Assessment Area (100m)
- Assessment Buffer (150m)
- Proposed Structure Plan
- Plot Outlines

BAL Contours

- BAL-FZ
- BAL-40
- BAL-29
- BAL-19
- BAL-12.5
- BAL-LOW

Source: Maxar Landgate

0 50 100 200 300

Metes

Scale: 1:7,000 @ A3

Staff: JP Date: 18/03/2024 File: 22-619

Figure 5 - BAL Contour Map

Port Kennedy Industrial Estate Structure Plan
Lots 4 and 17 Port Kennedy Drive, Port Kennedy

Assessment Date: 14/12/2022

Accreditation Details: BPAD 44656 (Level 2)

element.

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4. Identification of Bushfire Hazard Issues

4.1 Key Issues

SPP 3.7 and AS3959-2018 aim to minimise the likelihood of radiant heat exposure, flame contact and ember attack to habitable buildings. However, given the unpredictable nature of bushfires, it is not guaranteed that damage will not occur from bushfires or that the land use intensification will not increase the likelihood and risk of bushfire ignition.

From a bushfire hazard management and safety perspective, the key issues that are likely to require management and additional consideration at structure planning stage include:

- The subdivision layout ensures that future development can be located in areas that achieve a radiant heat flux of 29kW/m^2 (BAL-29) or below. This will be achieved by ensuring lots are sufficient in size to enable future development to be setback from areas of permanent vegetation or areas of revegetation.
- Future landscaping shall meet the definition of low threat in accordance with AS3959-2018. Should the landscaping result in additional fuel loads through lack of management or revegetation, a revised assessment may be required;
- The existing reticulated water supply servicing the adjacent industrial development to the west will require an extension to the subject site. The developer will need to ensure there is sufficient flow and pressure available to meet the demand of future industrial development. Street hydrants will also need to be provided in accordance with Water Corporation technical requirements;
- Access to the subject site will be provided from two (2) crossovers along Port Kennedy Drive. Should the release of lots be staged, a compliant access route that provides egress in two different directions shall be provided for all stages; and
- There is a history of bushfires within the immediate area which should be conveyed to future landowners through notification on titles.

It is acknowledged that the bushfire risk to the subject site posed by the identified bushfire hazards can be managed through standard application of the acceptable solutions of the bushfire protection criteria, as detailed in Section 5.1.

Additional bushfire mitigation measures have been recommended in response to the issues identified above to further improve the site response and resilience to a bushfire, as detailed in Section 5.2.

5. Bushfire Protection Criteria

5.1 Compliance Table

This BMP provides an outline of the mitigation strategies that will ensure the Structure Plan meets the bushfire protection criteria of the Guidelines. The bushfire protection criteria addressed as part of this BMP include:

- Element 1 – Location of the development;
- Element 2 – Siting and design of the development;
- Element 3 – Vehicle access; and
- Element 4 – Water supply.

The assessment in Table 5.1 has only considered the bushfire protection criteria relevant to the Structure Plan. Where there is insufficient information to demonstrate compliance, this BMP outlines how compliance will be achieved at subsequent planning stages.

Table 5.1 – Bushfire Protection Criteria

Bushfire Protection Criteria	Acceptable Solution	Compliance Comments
Element 1: Location	A1.1 Development Location The strategic planning proposal, subdivision and development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL–29 or below.	**Compliant** The BAL Contour Assessment (Figure 5) indicates that there are sufficient areas to allow future subdivided lots and habitable buildings to achieve a radiant heat flux of 29kW/m^2 (BAL-29) or below. This will be achieved through the clearing of the subject site, specifically the Port Kennedy Enterprise Zone, proposed road reserves and PAWs, as identified on the Structure Plan.
Element 2: Siting and Design	A2.1 Asset Protection Zone (APZ) Every habitable building is surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the following requirements: • Width: Measured from any external wall or supporting post or column of the proposed building, and of sufficient size to ensure the potential radiant heat impact of a bushfire does not exceed 29kW/m. (BAL-29) in all circumstances. • Location: the APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity. • Management: the APZ is managed in accordance with the requirements of Standards for Asset Protection Zones, as detailed in Appendix 4.	**Complaint** The BAL Contour Assessment (Figure 5) indicates that there is sufficient capacity to enable APZs to be provided around future habitable buildings to maintain a radiant heat flux of 29kW/m^2 (BAL-29) or below. The width of APZs will be determined at the development approval stage for individual developments once building locations have been defined. Any APZ will be subject to ongoing management regimes in accordance with the Standards for Asset Protection Zones (Appendix 4). Upon completion of the subdivisional works, future habitable buildings can be sited in areas that achieve a radiant heat flux of 29kW/m^2 (BAL-29) or below. As such, APZs are unlikely to be required based on the post-development assessment outcomes, as detailed in Figure 5.
Element 3: Vehicular Access	A3.1 Public Road Public roads are to meet the minimum technical requirements in Appendix 5. All proposed and existing public roads are to comply with the requirements of the Local Government Guidelines for Subdivisional Development (IPWEA Subdivision Guidelines), Liveable Neighbourhoods, Austroad Standards and/or any applicable standards for the local government area.	**Compliant** Port Kennedy Drive is an existing Distributor B public road constructed to a four lane dual carriageway standards between Ennis Avenue and Warnbro Sound. The existing public road network is deemed compliant with the relevant technical specifications. Future internal access roads associated with the proposed industrial subdivision will be designed to comply with the Guidelines and Development Control Policy 4.1 – Industrial Subdivisions, including minimum road reserve width of 20m and two lane single carriageway with a 10m wide pavement.

Bushfire Protection Criteria	Acceptable Solution	Compliance Comments
Element 3: Vehicular Access Cont.	A3.2a Multiple Access Routes Public road access is to be provided in two different directions to at least two different suitable destinations with an all-weather surface (two-way access).	**Compliant** The subject site will be serviced via two (2) entrance points along Port Kennedy Drive. These connections provide egress in two different directions to multiple suitable destinations, including: • Port Kennedy Drive (East) provides direct connection to existing built-up areas which are not designated as bushfire prone; and • Port Kennedy Drive (West) connects to Rockingham Road / Ennis Avenue which provide access to the Rockingham City Centre (north) or built-up areas (south).
	A3.2b Emergency Access Way (EAW) Where it is demonstrated that A3.2a cannot be achieved due to site constraints, or where an alternative design option does not exist, an EAW can be considered as an acceptable solution.	**Not Applicable** An EAW is not required given compliance with A3.2a has been achieved.
	A3.3 Through Roads All public roads should be through-roads. No-through roads should be avoided and can only be considered in certain scenarios.	**Compliant** All public roads will be through roads.
	A3.4a Perimeter Roads A perimeter road is a public road and should be provided for greenfield or infill development where 10 or more lots are being proposed (including as part of a staged subdivision).	**Compliant** Perimeter roads have been provided along the edge of the conservation lot to provide permanent separation between future subdivided lots and retained bushfire hazards.
	A3.4b Fire Service Access Routes Where proposed lots adjoin classified vegetation under AS3959, and a perimeter road is not required in accordance with A3.4a, a fire service access route can be considered as an acceptable solution to provide firefighter access, where access is not available, to the classified vegetation.	**Not Applicable** A fire service access route is noted required given perimeter roads have been provided.
	A3.5 Battle-Axe Access Legs Where it is demonstrated that a battle-axe cannot be avoided due to site constraints, it can be considered as an acceptable solution.	**Not Applicable** The proposed Structure Plan does not include battle-axe lots.

Bushfire Protection Criteria	Acceptable Solution	Compliance Comments
Element 3: Vehicular Access Cont.	A3.6 Private Driveways The private driveway is to meet all the following requirements: • Technical Specifications in Appendix 5; • Passing bays every 200 metres with a minimum length of 20 metres and a minimum additional trafficable width of two metres; and • Turn-around areas within 30 metres of the habitable building. Note, there are no technical requirements for private driveways less than 70m in length where the lot is serviced by reticulated water and access from a public road where the speed limit is less than 70km/h.	**Not Applicable** A3.6 is not applicable to Structure Plans and will be considered at development application stage. However, it is unlikely that there will be any technical requirements considering future private driveways are likely to be less than 70m in length, the site will be serviced by reticulated water and the speed limit of the internal road network will be less than 70km/h.
Element 4: Water	A4.1 Identification of Future Water Supply Evidence that a reticulated or sufficient non-reticulated water supply for bushfire fighting can be provided at the subdivision and/or development application stage, in accordance with the specifications of the relevant water supply authority or the requirements detailed in Appendix 6.	**Compliant** A new DN200 loop main extension from the existing 200mm water main at the intersection of Blackburn Drive and Port Kennedy Drive will service the future subdivided lots.
	A4.2 Provision of Water for Firefighting Purposes Where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority.	**Compliant** Future subdivided lots will be serviced by a reticulated water supply. Street hydrants will be required in accordance with Water Corporations technical specifications, including one (1) street hydrant every 100m (Appendix 6).

5.2 Additional Management Strategies

The following additional bushfire management strategies have been recommended to inform ongoing planning stages and increase the level of bushfire risk mitigation and resilience across the subject site. The responsibilities and timeframes for the below recommendations are provided in Section 6.

5.2.1 Future Approval Considerations

Following endorsement of the Structure Plan and the creation of lots in accordance with the approved subdivision, a development application will be required for future industrial development. This BMP and the predicted BAL ratings (see Figure 5) can be used to demonstrate compliance with SPP3.7 for future development unless it meets the definition of a high-risk land use, as detailed in Section 5.2.6.

Alternatively, a separate site-specific BMP can be prepared to accompany subsequent development applications to ensure future development aligns with the assessment outcomes of this BMP.

5.2.2 Staging Buffers

If clearing of the subject site for future development is undertaken on a staged basis, clearing in advance will need to occur to ensure future development is subject to an acceptable level of bushfire risk (BAL-29 or below). This will be achieved by ensuring each stage subject to construction is surrounded by a 22m wide low threat buffer which is managed in accordance with the City's Fire Control Notice to meet the definition of low threat under Clause 2.2.3.2 (f) of AS3959-2018. Once the buffers are created, they will need to be maintained on an ongoing basis until such time that the buffer area is developed as part of the next development stage.

5.2.3 Staging Vehicle Access

If the construction of public roads is undertaken on a staged basis, vehicular access arrangements will need to ensure that all occupants are provided with at least two access routes for all stages. This can be achieved via construction of access in advance of the stages or through provision of a temporary emergency access way until two formal public access roads are available.

5.2.1 Permanent Bushfire Hazards

The retention of vegetation within the conservation lot will result in permanent bushfire hazards post development. The proposed road reserves and PAWs provide permanent separation between bushfire hazards and future subdivided lots to achieve a radiant heat flux of 29kW/m^2 (BAL-29) or below, in accordance with SPP 3.7.

Prior to issuances of titles, the public road reserve bordering the conservation lot and the PAWs shall be cleared and made trafficable to provide permanent separation between bushfire hazards on the conservation lot and the development areas. This will also provide perimeter access for fire services should the retained bushfire hazard be subject to a bushfire.

5.2.2 On-Site Landscaping

All landscaping proposed on the subject site shall be managed to a minimum fuel condition in accordance with Clause 2.2.3.2 (f) of AS3959-2018. This excludes areas within the POS reserves which are intended to be revegetated and have been classified accordingly.

Low threat vegetation includes managed landscaping, reticulated lawns and gardens, maintained public reserves and parklands, sporting fields and natures strips. Management may include regular clearing of vegetation, removal of weeds, removal of dead plant material, tree pruning and mowing of grass to reduce the fuel load surrounding the proposed development.

Landscaping plans prepared for development on individual lots shall ensure future landscaping meets the definition of low treat vegetation to avoid the introduction of additional bushfire hazards.

Refer to Appendix 2 – Landscape Masterplan (PlanE)

5.2.1 Verge Management

Management of verges within the road reserves will be the responsibility of future landowners / occupiers, as encouraged through the City's Verge Development Guidelines. Any landscaping of verges will need to include appropriate plant selection and maintenance to avoid the introduction of unnecessary fuel loads and reduce the spread of bushfire.

5.2.2 High-Risk Land Uses

The proposed industrial estate may include high-risk land uses such as services stations, landfill sites, bulk storage of hazardous materials, fuel depots, certain heavy industries, power generating land uses, sawmills and any other land use deemed by the decision-maker.

In accordance with Policy Measure 6.6 of SPP3.7, a high-risk land use proposed in a designated bushfire prone area must be located in areas of BAL-29 or below with the development application to be accompanied by a Bushfire Risk Management Plan (BRMP).

5.2.3 Fire Hazard Compliance Notice

The City of Rockingham Fire Control Notice provides a structure for managing bushfire throughout the local government area. The Fire Control Notice is issued under Section 33 of the *Bush Fires Act 1954* which authorises the City to enforce bushfire preparation works such as fuel reduction and firebreaks.

The landowner or occupier will be responsible for ensuring ongoing compliance with the Fire Control Notice as provided in Appendix 7.

Refer to Appendix 7 – City of Rockingham Fire Control Notice

5.2.4 Public Education and Preparedness

The City of Rockingham provides fire and emergency advice to landowners which is available on their website:

https://rockingham.wa.gov.au/your-services/fire-and-emergencies

Additional information and resources can also be sourced from the Department of Fire and Emergency Services (DFES) website. This includes educational programs and safety guidelines to assist landowners with preparing for and surviving bushfire events.

In the event of a bushfire, specific advice and recommendations will be given to landowners from DFES, emergency services personnel and/ or the City of Rockingham.

6. Responsibilities

6.1 Implementation and Management Actions

This BMP has been prepared as a strategic guide to demonstrate how future subdivision and development can achieve compliance with the general objectives of SPP 3.7 and the bushfire protection criteria of the Guidelines. The developer will be responsible for the implementing the requirements of this BMP through subsequent planning stages, in consultation with the City and the Water Corporation.

Table 6.1 – Developer

Responsibilities	Stage
Ensure the BAL Ratings contained within Figure 5 of the BMP are still accurate at the time titles are created. If site conditions have changed, a revised BMP / BAL Assessment will be required at subdivision clearance stage.	Prior to Titles.
Construct public roads to the relevant standards outlined in the BMP including minimum trafficable width of 10m. Road reserves shall be designed and maintained to achieve low threat in accordance with Clause 2.2.3.2(f) of AS3959-2018.	Prior to Titles.
Construct PAWs to a minimum width of 10m. The PAWs shall be designed and maintained to achieve low threat in accordance with Clause 2.2.3.2 of AS3959-2018.	Prior to Titles.
Remove or modify vegetation on the subject site to meet the definition of low threat in accordance with Clause 2.2.3.2(f) of AS3959-2018 unless vegetation is proposed to be retained or revegetated.	Prior to Titles.
Ensure the proposed landscaping is designed and implemented to achieve a low threat standard in accordance with Clause 2.2.3.2(f) of AS3959-2018, with the exception of areas identified for retention or revegetation.	Prior to Titles.
Reticulated water supply and hydrants are to be installed as per Water Corporation requirements, unless agreed otherwise.	Prior to Titles.
Ensure all stages of the development comply with the bushfire protection criteria. Where development is undertaken on a staged basis, the provision of temporary staging buffers and vehicular access arrangements for multiple access routes will be required.	Prior to titles for each stage.
Ensure development applications comply with SPP 3.7 and the bushfire protection criteria of the Guidelines. This may require a site specific BMP to be prepared where the development achieves a rating of BAL-12.5 or above.	Development Application.
Ensure development applications for high-risk land uses are accompanied by a Bushfire Risk Management Plan.	Development Application.
Ensure ongoing compliance with the City of Rockingham Fire Control Notice.	Ongoing.

Table 6.2 – Local Government

Responsibilities	Stage
Monitor compliance with the Fire Control Notice enforced under Section 33 of the Bush Fires Act 1954.	Ongoing.
Maintain and repair public roads, when deemed required, to ensure access to the subject site is always available.	Ongoing.

Table 6.3 – Water Corporation

Responsibilities	Stage
Maintain and repair the reticulated water network and street hydrants, when required.	Ongoing.

7. References

Office of Bushfire Risk Management (OBRM) Map of Bush Fire Prone Areas, accessed January 2023, https://maps.slip.wa.gov.au/landgate/bushfireprone/

City of Rockingham, Fire Control Notice, accessed January 2023, https://rockingham.wa.gov.au/forms-and-publications/your-services/fire-and-bush/fire-control-notice-2022-2023

City of Rockingham, Fire and Emergencies, accessed January 2023, https://rockingham.wa.gov.au/your-services/fire-and-emergencies

Porter Consulting Engineers (2023). Traffic Impact Assessment.

PVG Environmental (2020). Environmental Assessment Report.

Standards Australia. AS 3959: 2018 Construction of buildings in bushfire-prone areas. Australian Standard published 14 November 2018.

Western Australian Planning Commission (WAPC, 2015) State Planning Policy 3.7 Planning in Bushfire Prone Areas. Western Australian Planning Commission.

Western Australian Planning Commission (WAPC, 2016) Visual guide for bushfire risk assessment in Western Australia. Western Australian Planning Commission.

Western Australian Planning Commission (WAPC) (2021) Guidelines for Planning in Bushfire Prone Areas Version 1.4. Western Australian Planning Commission.

Appendix 1 – Structure Plan

Legend

- Structure Plan Boundary

MRS Reserves

- Parks and Recreation

Local Reserves

- Public Open Space and Drainage

Local Zones

- Port Kennedy Enterprise Zone

Other

- Local Distributor Road 25m Road Reserve
- Local Access Road
- Pedestrian Path
- Dual Use Path
- Principal Shared Path
- Wetland
- Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1
- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Lot 4 and 17 Port Kennedy Drive, Port Kennedy

Date: 8 Feb 2024 Scale: 1:4000 @ A3 1:2000 @ A1 File: **717-278 ST-1** Staff: MR GW Checked: MR

0 40 80m

element.

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Appendix 2 – Landscape Plan

TEC RATING:

- HIGH QUALITY
- MEDIUM QUALITY
- LOW QUALITY

LEGEND

01 ENTRY STATEMENT TO ESTATE WITH SIGNAGE WALL

02 EXISTING PEDESTRIAN ACCESS WAY

03 ENTRY TO BUSHLAND TRACK NETWORK INCLUDING EDUCATIONAL SIGNAGE AND ARTWORK/ INTERPRETATIVE ELEMENT (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

04 RETAINED VEGETATION IN EXISTING CONSERVATION AREA CEDED TO DBCA

05 OPEN MESH FENCE TO CONSERVATION AREA FOR VISUAL PERMEABILITY

06 *GRAVEL PATHWAYS ALONG EXISTING BUSH TRACKS

07 SEATING ON DECKING AT LOOKOUT POINTS WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19A- HOLOCENE SEDGELANDS (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

08 SCREENING NATIVE TREE AND SHRUB PLANTING ALONG BOUNDARY FENCE TO RESIDENCES

09 NEW *GRAVEL PATHWAY CONNECTION

10 VEGETATED SWALE WITH ENDEMIC WETLAND PLANTING AND MELALEUCA TREES WITH REFERENCE TO ADJACENT BUSHLAND SPECIES

11 PEDESTRIAN FOOTPATH NETWORK

12 STORMWATER MANAGEMENT INFRASTRUCTURE (INFILTRATION OR BIORETENTION) IN ROADSIDE TO BE PROVIDED AS PER THE INDICATIVE LOCATIONS SHOWN ON THE CONCEPT DRAINAGE PLAN (BY OTHERS)

13 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS

14 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)- SIGNAGE ENDORSED BY DBCA DESIGN STUDIO

15 *GRAVEL PATHWAYS TO TEC 19B- (HOLOCENE WOODLANDS) WITH REVEGETATION INCLUDING TREE PLANTING THROUGHOUT

16 ARTWORK/ INTERPRETIVE ELEMENT TO STREET CORNER AND DECKING OVER DRAINAGE BASIN

17 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS

18 VEGETATED DRAINAGE SWALE ALONG MEDIAN STRIP TO PORT KENNEDY DRIVE

19 VEGETATED DRAINAGE SWALE ALONG PORT KENNEDY DRIVE WITH BUFFER TREE AND SHRUB PLANTING. RETAIN EXISTING 3M WIDE BIKE PATH.

20 RETAIN EXISTING VERGE TREATMENT/ SWALES TO SOUTH SIDE OF PORT KENNEDY DRIVE

21 STREETSIDE PARKING ADJACENT TO CONSERVATION AREA INTERSPERSED WITH VERGE PLANTINGS - TOTAL 8 NO. PARKING BAYS

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

CONCEPT MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.101 REV N

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

STREET TREE PLANTING

EUCALYPTUS LEUCOXYLON 'ROSEA'

EUCALYPTUS UTILIS

MELALEUCA RHAPHIOPHYLLA

AGONIS FLEXUOSA

EUCALYPTUS TORQUATA

EUCALYPTUS VICTRIX

EUCALYPTUS GOMPHOCEPHALA

ENTERPRISE PARK, PORT KENNEDY

STREET TREE MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.102

REV F

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

LEGEND

01 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS -NON-IRRIGATED

02 PROTECT AND RETAIN EXISTING REMMANT VEGETATION CORE TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)

03 REVEGETATION AREA WITHIN 50M BUFFER ZONE, RETAINING REMNANT VEGETATION AND WITH NEW LOCALLY NATIVE TREE & SHRUB PLANTINGS. TEMPORARY IRRIGATION TO NEW PLANTINGS AND WEED MANAGEMENT THROUGHOUT

04 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO LOCAL ECOLOGY/ BOTANY OF THE AREA (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

05 INFORMAL *GRAVEL PATHWAYS THROUGH REGETATION AREA FOR BUSH WALKING

06 STREET TREES & LOW NATIVE GROUNDCOVER PLANTINGS TO VERGE- NON-IRRIGATED

09 ARTWORK/ INTERPRETIVE SHADE ELEMENT TO STREET CORNER WITH INFORMAL SEATING AND/OR TABLES WITH DECKING OVER DRAINAGE BASIN

10 SHORT BOARDWALK ELEMENT OVER DRAINAGE BASIN

11 SMALL LOOKOUT OVER DRAINAGE BASIN

12 CONCRETE FOOTPATHS

13 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS- NON-IRRIGATED

14 LANDSCAPE BATTER & ROCKWORK TO MEET EXISTING LEVELS

15 STORMWATER MANAGEMENT INFRASTRUCTURE THAT INCLUDES SUITABLE ENDEMIC VEGETATION

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

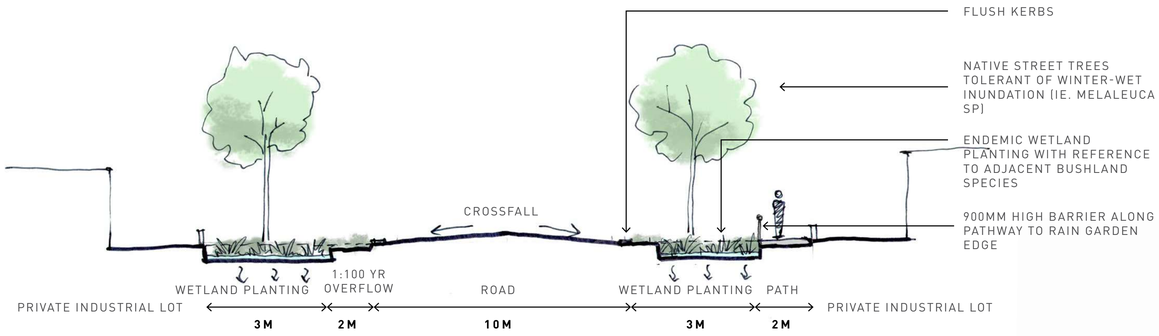
PRELIMINARY CONCEPT PLAN - POS 01
JULY 2024

JOB NO. 2011201
1:2500 @ A1

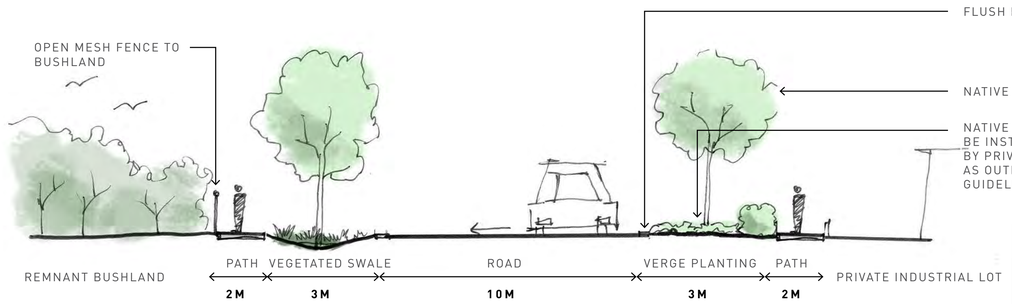
C1.103 REV D

0 25 50 100 150 250m

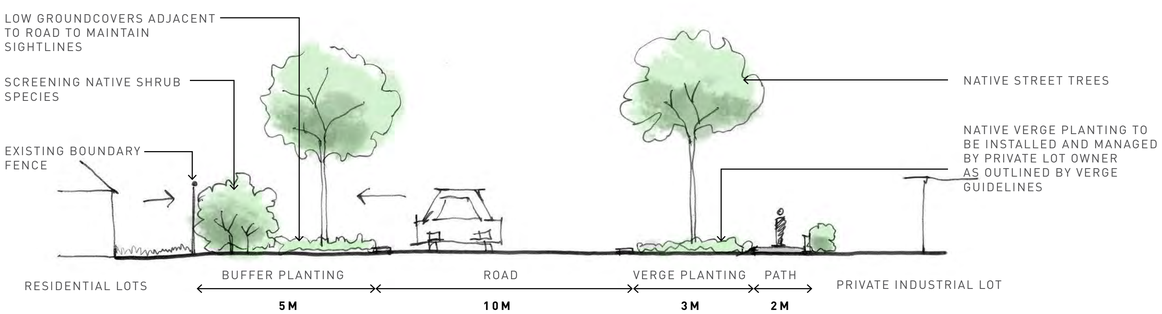
PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au



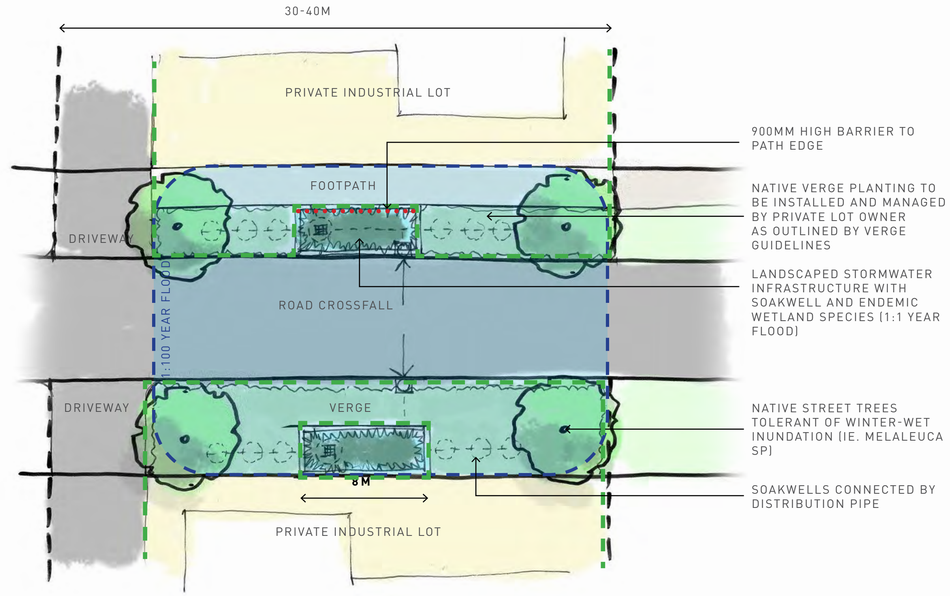
TYPICAL STREET SECTION- RAIN GARDENS



TYPICAL STREET SECTION- CONSERVATION AREA BOUNDARY



TYPICAL STREET SECTION - BUFFER TO RESIDENTIAL LOTS



TYPICAL STREET PLAN - STORMWATER INFRASTRUCTURE

ENTERPRISE PARK, PORT KENNEDY

TYPICAL SECTIONS
JULY 2024

JOB NO. 2011201
NTS

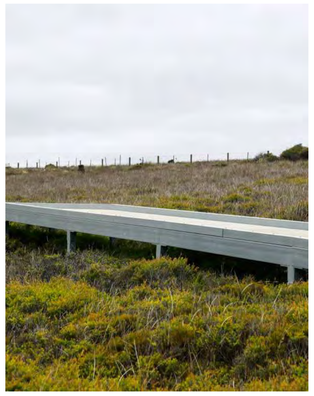
C2.101

REV E

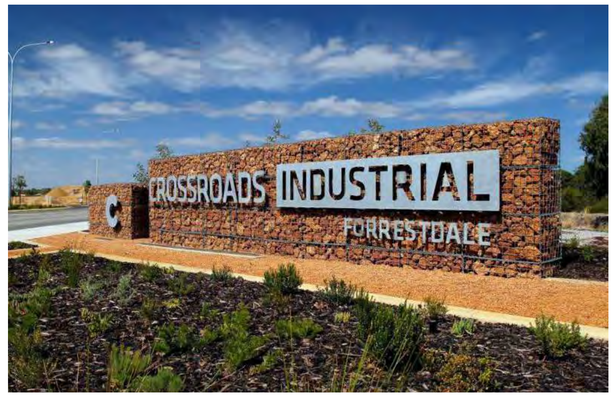
PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

FRP LOW IMPACT AND DURABLE BOARDWALK

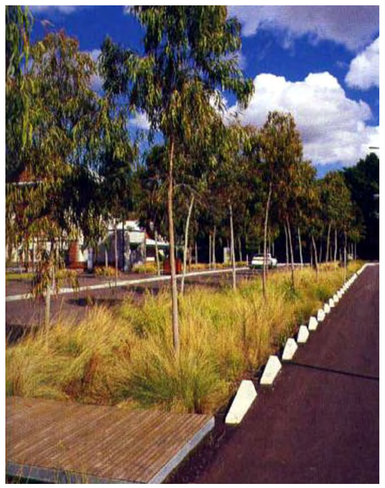
PERMASTRUCT COMPOSITE BOARDWALK



EXISTING REMNANT VEGETATION



TURF AND SHADE TREES IN AMENITY SPACE



RAIN GARDENS

VEGETATED SWALES AND FLUSH KERBING

ENTERPRISE PARK, PORT KENNEDY

CONCEPT IMAGERY
JULY 2024

JOB NO. 2011201 C3.101 REV A

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STREET TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


EUCALYPTUS UTILIS


MELALEUCA RHAPHIOPHYLLA


EUCALYPTUS TORQUATA


EUCALYPTUS VICTRIX


EUCALYPTUS LEUCOXYLON 'ROSEA'

POS/ REVEGETATION TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


MELALEUCA RHAPHIOPHYLLA


MELALEUCA LANCEOLATA


CALLITRIS PRESEII


BANKSIA LITTORALIS


BANKSIA ATTENUATA

FEATURE PLANTING


XANTHORRHOEA PREISEII


ANIGOZANTHOS MANGLESEII


LEUCOPHYTA BROWNII


SCAEVOLA 'MAUVE CARPET'


KENNEDIA PROSTRATA


CONOSTYLIS CANDICANS


PIMELEA FERRUGINEA

STREET VERGES


HEMIANDRA PUNGENS


EREMOPHILA GLABRA PROSTRATE


SCAEVOLA CRASSIFOLIA PROSTRATE


DIANELLA 'LITTLE JESS'


WESTRINGIA 'MUNDI'


GREVILLEA CRITHMIFOLIA PROSTRATE


MELALEUCA 'LITTLE PENTA'

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

JOB NO. 2011201 C3.102 REV C

PLAN E
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DRAINAGE SWALES/ RAINGARDENS


MACHAERINA JUNCEA


MACHAERINA ARTICULATA


FICINIA NODOSA


LEPIDOSPERMA LONGITUDINALE


CENTELLA ASIATICA


LOBELIA ANCEPS


ISOLEPIS CERNUA

POS/ REVEGETATION PLANTING


FICINIA NODOSA


OLEARIA AXILLARIS


GREVILLEA CRITHMIFOLIA


GUICHENOLTIA LEDIFOLIA


HARDENBERGIA COMPTONIANA


HAKEA PROSTRATA


MELALEUCA TERETIFOLIA


MELALEUCA SYSTENA


KENNEDIA PROSTRATA


MYOPORUM INSULARE


RHAGODIA BACCATA


ACACIA PULCHELLA


*ACACIA BENTHAMII


*JACKSONIA SERICEA

*RARE/PRIORITY FLORA

LARGE SHRUBS/ SCREEN PLANTING


CALOTHAMNUS QUADRIFIDUS


BANKSIA SESSILIS


ACACIA ROSTELLIFERA


DODONAEA HACKETTIANA


TEMPLETONIA RETUSA


MELALEUCA HUEGELLII


MELALEUCA SYSTENA

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

JOB NO. 2011201 C3.103 REV B

PLAN E
LANDSCAPE ARCHITECTS
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Appendix 3 – Vegetation Assessment

APPENDIX 3 – VEGETATION ASSESSMENT

<table>
<tr><th colspan="2">PLOT 1</th></tr>
<tr><td>Classification: Class D Scrub</td><td>Effective Slope: Flat / Upslope</td></tr>
<tr><td>Pre-Development Description:
Large acacia shrubs with an average height greater than 2m and foliage cover greater than 30%. The small area of scrub vegetation only occurs within the Ennis Avenue road reserve to the east of the subject site.</td><td>Post Development Description:
The vegetation will remain unchanged.</td></tr>
<tr><td>Photo ID: 01</td><td>Photo ID: 02</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photo ID: 03</td><td>Photo ID: 04</td></tr>
<tr><td> 
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</td></tr>
</table>

APPENDIX 3 – VEGETATION ASSESSMENT

<table>
<tr><th colspan="2">PLOT 2</th></tr>
<tr><td>Classification: Class C Shrubland</td><td>Effective Slope: Flat / Upslope</td></tr>
<tr><td>Pre-Development Description:

Open low heaths of acacia shrubs found on the adjacent property to the south of the subject site. The vegetation is characterised by an average height less than 2m with grassy understorey and foliage cover greater than 30%.</td><td>Post Development Description:

The vegetation will remain unchanged.</td></tr>
<tr><td>Photo ID: 05</td><td>Photo ID: 06</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photo ID: 07</td><td>Photo ID: 08</td></tr>
<tr><td> 
</td><td> 
</td></tr>
</table>

APPENDIX 3 – VEGETATION ASSESSMENT

PLOT 3	
Classification: Class C Shrubland	**Effective Slope: Downslope 0 – 5°**
Pre-Development Description: Open low heaths of acacia shrubs found on the subject site within the proposed conservation lot and POS. The vegetation is characterised by an average height less than 2m with grassy understorey and foliage cover greater than 30%.	**Post Development Description:** This plot of vegetation has been proposed to be retained or revegetated.
Photo ID: 09	**Photo ID: 10**
	
Photo ID: 11	**Photo ID: 12**
	

APPENDIX 3 – VEGETATION ASSESSMENT

PLOT 3	
Classification: Class C Shrubland	**Effective Slope: Downslope 0 – 5°**
Pre-Development Description: Open low heaths of acacia shrubs found on the subject site within the proposed conservation lot and POS. The vegetation is characterised by an average height less than 2m with grassy understorey and foliage cover greater than 30%.	**Post Development Description:** This plot of vegetation has been proposed to be retained or revegetated.
Photo ID: 13	**Photo ID: 14**
	

APPENDIX 3 – VEGETATION ASSESSMENT

PLOT 4	
Classification: Class G Grassland	**Effective Slope: Flat / Upslope**
Pre-Development Description: Area of unmanaged grassland typically found in road reserves where there is no evidence of management regimes.	**Post Development Description:** The vegetation will remain unchanged.
Photo ID: 15	**Photo ID: 16**
	
Photo ID: 17	**Photo ID: 18**
	

APPENDIX 3 – VEGETATION ASSESSMENT

PLOT 5	
Classification: Exempt	**Reason: Clause 2.2.3.2 (e) – Non-Vegetated**
Pre-Development Description: Non-vegetated areas surrounding the subject site consisting of roads, buildings and access tracks. These areas have been excluded in accordance with Clause 2.2.3.2 (e) of AS3959-2018.	**Post Development Description:** N/A
Photo ID: 19	**Photo ID: 20**
	

APPENDIX 3 – VEGETATION ASSESSMENT

<table>
<tr><th colspan="2">PLOT 6</th></tr>
<tr><td>Classification: Exempt</td><td>Reason: Clause 2.2.3.2 (f) – Low Threat</td></tr>
<tr><td>Pre-Development Description:

Area of low threat vegetation including residential gardens, landscaping and road reserves where there is evidence of management regimes. These areas have been excluded in accordance with Clause 2.2.3.2 (f) of AS3959-2018.</td><td>Post Development Description:

N/A</td></tr>
<tr><td>Photo ID: 21</td><td>Photo ID: 22</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photo ID: 23</td><td>Photo ID: 24</td></tr>
<tr><td> 
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</td></tr>
</table>

APPENDIX 3 – VEGETATION ASSESSMENT

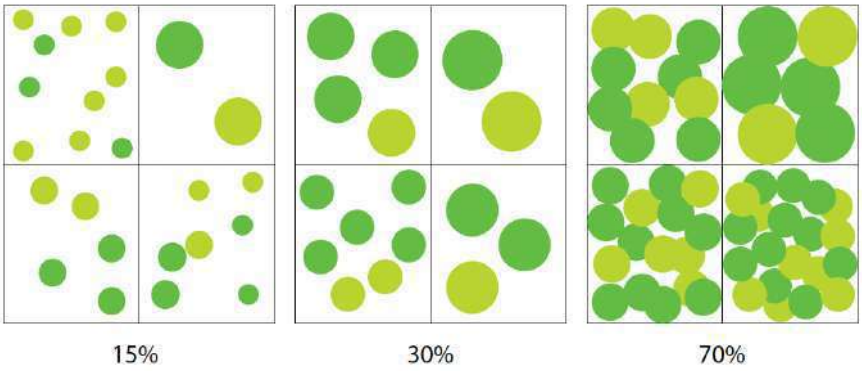
<table>
<tr><th colspan="2">PLOT 7</th></tr>
<tr><td>Classification: Exempt (to be cleared)</td><td>Reason: Clause 2.2.3.2 (f) – Low Threat</td></tr>
<tr><td>Pre-Development Description:

Open low heaths of acacia shrubs found on the subject site which is proposed to be developed. The vegetation is characterised by an average height less than 2m with grassy understorey and foliage cover greater than 30%.</td><td>Post Development Description:

The vegetation will be cleared to facilitate the proposed development.</td></tr>
<tr><td>Photo ID: 25</td><td>Photo ID: 26</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photo ID: 27</td><td>Photo ID: 28</td></tr>
<tr><td> 
</td><td> 
</td></tr>
</table>

Appendix 4 – Standards for Asset Protection Zones

APPENDIX 4 – STANDARD FOR ASSET PROTECTION ZONE

Object	APZ Requirements
Fences within the APZ	• Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	• Should be managed and removed on a regular basis to maintain a low threat state. • Should be maintained at <2 tonnes per hectare (on average). • Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees (>6 metres in height)	• Trunks at maturity should be a minimum distance of six metres from all elevations of the building. • Branches at maturity should not touch or overhang a building or powerline. • Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. • Canopy cover within the APZ should be <15 per cent of the total APZ area, as detailed below. • Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ.  15% 30% 70%
Shrub and scrub (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees.	• Should not be located under trees or within three metres of buildings. • Should not be planted in clumps >5 square metres in area. • Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	• Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. • Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.
Grass	• Grass should be maintained at a height of 100 millimetres or less, at all times. • Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.
Defendable space	• Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	• Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. • The pressure relief valve should point away from the house. • No flammable material within six metres from the front of the valve. • Must sit on a firm, level and non-combustible base and be secured to a solid structure.

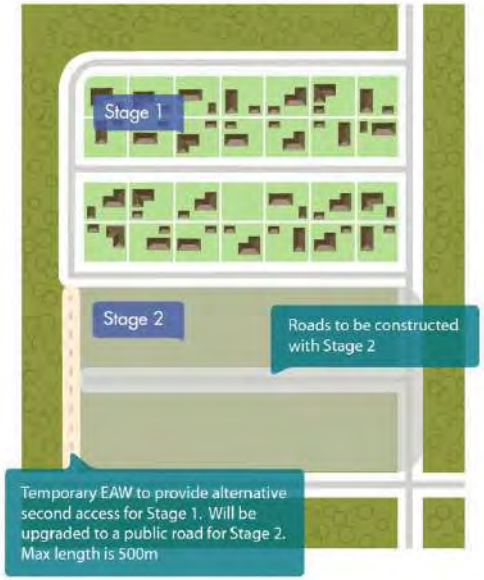
Note: Plant flammability, landscaping design and maintenance should be considered – Refer to explanatory notes of the Guidelines.

Appendix 5 – Access Technical Requirements

APPENDIX 5 – VEHICULAR ACCESS TECHNICAL REQUIREMENTS

TECHNICAL REQUIREMENTS	1. Public Road	2. Emergency Access Way	3. Fire Service Access Rout	4. Battle-Axe and Private Driveways
Minimum trafficable surface	In accordance with A3.1	6m	6m	4m
Horizontal clearance	N/A	6m	6m	6m
Vertical clearance	4.5m			
Minimum weight capacity	15 tonnes			
Maximum grade unsealed road	As per the Subdivision Guidelines.	1:10 (10%)		
Maximum grade sealed road		1:7 (14.3%)		
Maximum average grade sealed road		1:10 (10%)		
Minimum inner radius of road curves		8.5m		

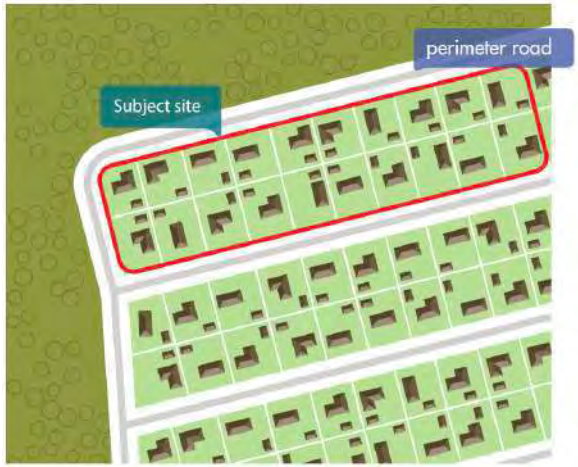
Example of a Public Road



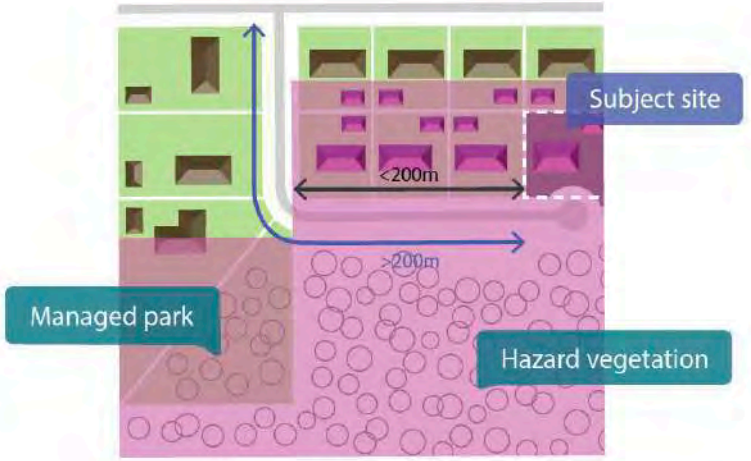
Example of Emergency Access Way

Example of Fire Service Access Way

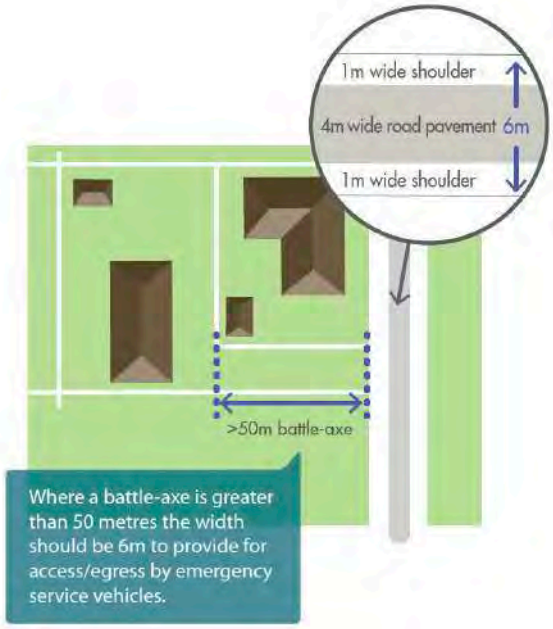
APPENDIX 5 – VEHICULAR ACCESS TECHNICAL REQUIREMENTS



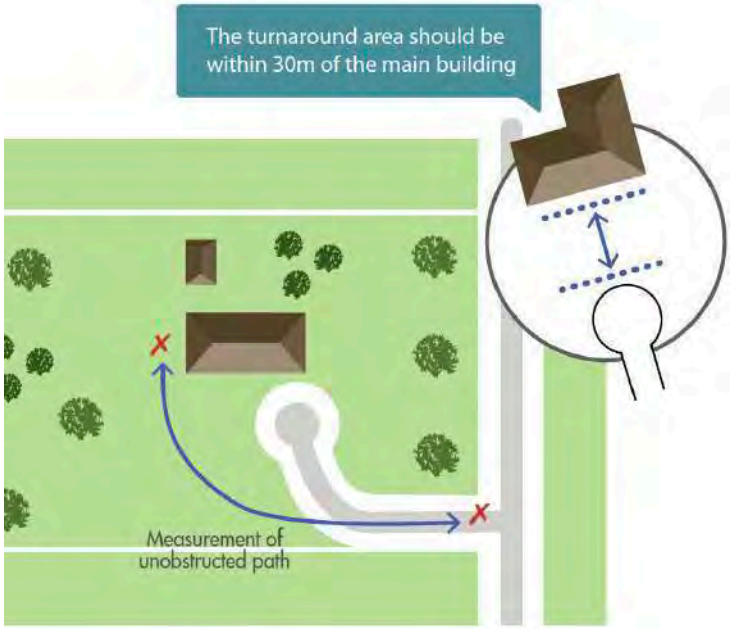
Example of a Perimeter Road



Example of a Cul-de-sac

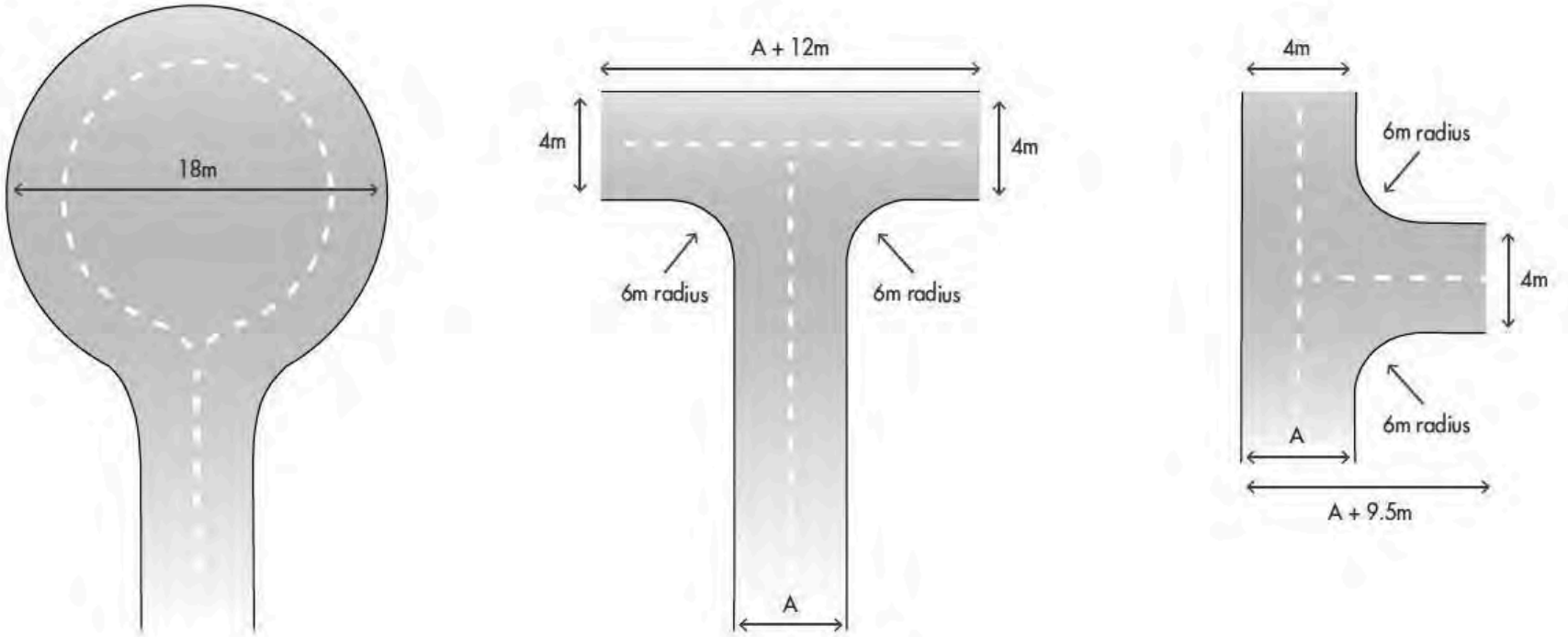


Example of a Battle-Axe Access Leg



Example of a Private Driveway

APPENDIX 5 – VEHICULAR ACCESS TECHNICAL REQUIREMENTS



Example of Turn Around Areas

Appendix 6 – Water Supply Requirements

APPENDIX 6 – WATER TECHNICAL REQUIREMENTS

Hydrant Requirements (Water Corp Design Standard 63)

Hydrants shall be screw-down hydrant with built-in isolation valve and installed only on DN100 or larger pipes. Hydrants shall be located:

- so that the maximum distance between a hydrant and the rear of a building envelope, (or in the absence of a building envelope the rear of the lot) shall be 120m and the hydrants shall be no more than 200m apart;
- a maximum of 100m spacing in Industrial and Commercial areas;
- hydrant spacing in rural residential areas where minimum site areas per dwelling is 10,000m^2 (1ha), a maximum 400m hydrant spacing be applied. If area is further subdivided to land parcels less than 1ha, then the residential standard (200m) is to be applied;
- centrally along the frontage of a lot to avoid being under driveways;
- where appropriate at the truncation of road junctions or intersections so that they can serve more than one street and can be readily located;
- on both sides of the major roads at staggered intervals where there are mains on both sides of the road;
- at major intersections on dual multi-lane roads, where two hydrants are to be sited on diagonally opposite corners;
- hydrants should be located at least 20m from traffic calming devices i.e. median slow points or chokers, chicanes, mini traffic circles, and intersection ‘pop-outs’ to ensure traffic is not impeded;
- in a position not less than 10m from any high voltage main electrical distribution equipment such as transformers and distribution boards (AS 2419.1-2005).
- hydrants with washout bends shall be used only in cul-de-sac situations.

Appendix 7 – Fire Control Notice

Fire Control Notice 2022 - 2023

Your property must comply on 1 December 2022 and be maintained through to 31 May 2023

First and final notice to owners and/or occupiers of all land within the City of Rockingham

Penalty of up to $5,000 for non-compliance

rockingham.wa.gov.au

city of Rockingham
where the coast comes to life

As a measure to assist in the control of bushfires and pursuant to the powers contained in ***Section 33 of the Bush Fires Act 1954***, you have a legal requirement to carry out fire prevention works on your property. Your property must comply on 1 December 2022 and be maintained through to 31 May 2023.

*"Take notice that pursuant to **Section 33 (4) of the Bush Fires Act 1954**, where the owner and/or occupier of the land fails or neglects to comply with the requisitions of this Notice within the specified times, the City of Rockingham may by its officers and with such servants, workmen and contractors, vehicles and machinery as the officers deem fit, enter upon the land and carry out the requisitions of this Notice which have not been complied with and pursuant to **Section 33 (5) of the Bush Fires Act 1954**, the amount of any costs and expenses incurred may be recovered from you as the owner and/or occupier of the land."*

Compliance inspections will commence on 1 December 2022. Failure to comply with the City's Fire Control Notice may result in a penalty of up to $5,000, with additional contractor and administration costs to carry out fire prevention works on your property.

All land with an area of 4047 m² or more (more than one acre)

Owners/Occupiers of developed and vacant land are required to:

- install and maintain mineral earth firebreaks as per firebreak specifications
- ensure driveways and access ways to all buildings are maintained at a minimum of three (3) metres in width and a vertical clearance height of four (4) metres, with all over hanging vegetation trimmed back to clear access.

All land with an area of less than 4047 m² (less than one acre)

Owners/Occupiers of vacant land are required to:

- remove accumulated fuel such as leaf litter, twigs, dead bush and dead trees capable of carrying a running fire
- have the entire vacant land clear of weed or long grasses by slashing, mowing or other means to a height no greater than 50 mm and maintained in this state.

Owners/Occupiers of developed land are required to:

- ensure driveways and access ways to all buildings are maintained at a minimum of three (3) metres in width and a vertical clearance height of four (4) metres, with all over hanging vegetation trimmed back to clear access.

C. Environmental Assessment Report

PORT KENNEDY BUSINESS PARK

ENVIRONMENTAL ASSESSMENT REPORT

Prepared for:	DevelopmentWA
Report Date:	16 December 2020
Version:	1
Report No.	2020-556

pgv ENVIRONMENTAL

CONTENTS

LIST OF ATTACHMENTS

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Plates

Figures

Appendices

1 INTRODUCTION

1.1 Location

DevelopmentWA is proposing to develop a business park on Lots 4 and 17 Port Kennedy Drive, Port Kennedy (the site). The site is located in the City of Rockingham, approximately 55km south of the Perth Central Business District and 10km from the Rockingham city centre (Figure1). The site is bordered by Ennis Avenue to the east, Port Kennedy Drive to the south, Bakewell Drive to the west and residential housing to the north (Figure 2).

The site is zoned 'Industrial' under the Metropolitan Regional Scheme (MRS) and 'Port Kennedy Business Enterprise' under the City of Rockingham Town Planning Scheme No. 2. The site is currently undeveloped and contains native vegetation.

1.2 Background

1.2.1 State Environmental Approval

The site was rezoned to Industrial in the MRS as part of Major Amendment No. 938/33 in 1994. The Amendment included the following land use changes:

- Creation of a Rapid Transport Reserve for the Perth-Mandurah rail;
- Rezoning of the north-west corner of System 6 Area M103 for Public Purposes;
- Rezoning of the south-west portion of System 6 Area M103 west of Ennis Avenue for Urban and Industrial uses (includes the site); and
- Widening of Safety Bay Road between Ennis Avenue and Mandurah Road.

The Amendment was referred to the Environmental Protection Authority (EPA) by the Department of Planning and Urban Development (now called the Department of Planning, Lands and Heritage) in 1993. The EPA considered that the Amendment had potential for significant impacts on System 6 Areas M103 and M104, and on several lakes and wetlands and their vegetation. As a result, the EPA set the level of assessment as a Public Environmental Review (PER).

The assessment of scheme amendments under Section 38 of the *Environmental Protection Act 1986* (EP Act) was allowable in 1994 as that pre-dates the 1996 amendment to the EP Act which introduced Section 48A that required all schemes and scheme amendments to be referred to the EPA.

The Minister for the Environment approved the Amendment on 11 October 1994 (Ministerial Statement No. 368) (Appendix 1). Condition 4-2 of the approval states that:

Condition 4-2 The Proponent may allow the development of the area west of Ennis Avenue which is currently within System 6 Area M103 subject to the following requirements:

1. *Land owned by the State Planning Commission generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue and between Port Kennedy Drive and*

Secret Harbour and east of the area subject to the Port Kennedy Development Act to be secured and managed for conservation purposes;

2. *Land owned by the State Planning Commission reserved under the Metropolitan Region Scheme for Public Purposes generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue, south of Port Kennedy Drive and west of Ennis Avenue and Mandurah Road to be secured and managed for recreational and conservation purposes;*
3. *A linkage to be provided between the greater part of System 6 Area M103 east of Ennis Avenue through to the coast at Port Kennedy, consistent with recommendations made for System 6 Area M106; and*
4. *Integration of the management of the area referred to in requirements 1, 2 and 3 above with the management of the Port Kennedy conservation area and the greater area of System* Six Area M103.

The 1994 ministerial approval (MS 368) anticipates development of the entire site. The State negotiated a considerable offset package for the protection of conservation significant land south of Port Kennedy Drive to allow the industrial and urban development north of Port Kennedy Drive

1.2.2 Post Approval Environmental Studies

Following the 1994 approval to develop the site for industrial purposes additional environmental investigations have occurred on the site. The most relevant studies are summarised below.

In 1996 the Wetlands of the Swan Coastal Plain Volume 2b mapped for the first time thirteen wetlands on the site. The wetlands included nine Conservation Category wetlands, two Resource Enhancement Category wetlands and two that had a management category of 'not applicable'. Since that publication, further wetland investigations have identified additional wetlands on the site. Currently 22 wetlands are recognised as occurring on the site. Most of the wetlands are located on the western side of Lot 17 while several occur on the eastern side. No wetlands are known to occur on Lot 4.

Since that publication, further wetland investigations have identified additional wetlands on the site. Currently 28 wetlands are recognised on the site (RPS BBG, 2005; Strategen, 2011; PGV Environmental, 2016; PGV Environmental, 2017). Most of the wetlands are located on the western side of Lot 17 with five wetlands mapped on the eastern side. No wetlands are known to occur on Lot 4.

In 2004, the (then) Department of Conservation and Land Management surveyed the site for the presence of the Threatened Ecological Community FCT 19 '*Sedgelands in Holocene Dune Swales*'. A total of 17 occurrences of FCT 19 were recorded.

PGV Environmental (2016) mapped 22 occurrences of FCT 19, of which the majority occur on the western side of Lot 17. All locations of FCT 19 occur within wetlands, however not all wetlands on the site contain FCT 19.

1.3 Super Lot Subdivision 156342

To assist in the protection of the environmental values associated with the western portion of the site (Part Lot 17), DevelopmentWA created two super lots. The western superlot was created for conservation purposes and the remainder of the site (Part Lot 17 and Lot 4) was consolidated into

one lot which will be developed in the future for general industrial purposes in accordance with its zoning under the MRS. The Western Australian Planning Commission (WAPC) approved the subdivision application 156342 on 6 July 2018 (Appendix 2). The subdivision when enacted by DevelopmentWA will establish Lot 1 (conservation) and Lot 2 (General Industry). For the purpose of this report, proposed Lot 2 will be referred to as the 'site'.

1.4 Scope of Work

This Environmental Assessment Report (EAR) has been prepared to facilitate the subdivision of the site and identify strategies to manage the environmental impact of developing the site for General Industry purposes.

The EAR addresses the following key environmental factors:

- Geology and Soils;
- Hydrology;
- Wetlands;
- Vegetation and Flora;
- Fauna; and
- Heritage.

The environmental factors have been validated and refined through:

- Review of environmental studies relating to the site; and
- Undertaking a desktop assessment.

2 EXISTING ENVIRONMENT

2.1 Land Use

The site currently consists of native bushland with a number of tracks traversing the site (Plate 3). Activities occurring on the site include uncontrolled four-wheel driving and illegal dumping of rubbish. The surrounding land uses consist of light commercial and industrial land to the west, residential housing to the north and Rockingham Lakes Regional Park to the south and east including Bush Forever Site 356 and Lake Walyungup.

Historically, construction surrounding the site first commenced between 1979 and 1981 consisting of a road to the east of the site (Plate 1). Vegetation was cleared to the south of the eastern half of the site between 1983 and 1985 (Landgate, 2014a) to construct a motorbike track. The track is still present and can be seen in Plate 1, however it is no longer in use and this area now makes up part of Bush Forever Site 356. Further clearing and construction had commenced to the west of the site by 1995 (Plate 3). The current internal tracks on the site, visible in Plate 3 are not evident in the 1985 photo.

Plate 1: Historical Aerial Photography of the site from 1985 (Landgate, 2020)

Plate 2: Historical Aerial Photography of the site from 1995 (Landgate, 2020)

Plate 3: Aerial Photography of the site from 2020 (Landgate, 2020)

2.2 Topography

The site contains low dunal ridges and swales, with an elevation ranging between 5-12m Australian Height Datum (AHD) (Figure 2).

2.3 Geomorphology, Geology and Soils

The site is located on the Quindalup South System which consists of coastal dunes of the Swan Coastal Plain with calcareous deep sands and yellow sands of aeolian origin over sedimentary rocks (DAFWA, 2014). There are two soil units located on the site, described as (DAFWA, 2014):

- Quindalup South Qf2 Phase (211Qu_Qf2) consists of relict foredunes and gently undulating beach ridge plains on quaternary deposits in the coast between Rockingham and Dunsborough with deep uniform calcareous sands.
- Quindalup South Qf2a Phase (211Qu_Qf2a) consists of more prominent relict foredune ridges than occurring within unit 211Qu_Qf2, with deep uniform calcareous sands.

The majority of the site consists of the Quindalup South Qf2 Phase (Figure 3). Areas of Quindalup South Qf2a Phase are located in the eastern and north-eastern parts of the site and also in the central western and south-western areas.

Douglas Partners (2011) conducted a Preliminary Geotechnical Investigation on the site in 2011. The Investigation was to assess the sub-surface soil and groundwater conditions. Test pit locations are shown in Appendix 3. One location (BH28) contained uncontrolled sand filling to a depth of 0.2m. All test pit locations contained topsoil consisting of brown silty sand mostly to depths between 0.05m and 0.15m. Encountered at all the test pits below the topsoil was medium dense, brown and light yellow-brown sand. At locations TP6, TP8, TP9, TP19, TP22 and TP26 very low strength lithified sand layers were encountered. Test pit BH27 was the only location that contained organic sand consisting of loose, dark grey sand with low plasticity fines from 1.1m to 1.5m depth (Douglas Partners, 2011).

2.4 Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table these soils are benign and not acidic (potential acid sulphate soils). However if the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid (EPA, 2008).

The site is mapped as having a Low Risk of ASS occurring within 3m of the natural soil surface (Figure 4).

2.5 Hydrology

2.5.1 Groundwater

The Perth Groundwater Atlas shows the groundwater at the site to occur between 3-5.5m below the surface (DoW, 2020). These levels were recorded in May of 2003 which is an indication of low groundwater levels (Figure 5).

The site is located on the eastern half of the Stakehill Mound. As such the direction of groundwater flow is to the east towards Lake Walyungup (see groundwater map in Appendix 4 Figure 2).

The groundwater salinity at the site is brackish being between 1000-1500mg/L (DoW, 2014).

Groundwater monitoring for the site was carried out by JDA Consultant Hydrologists (2011). An investigation of the Average Annual Maximum Groundwater Level (AAMGL) for the site was conducted in October 2009 and followed by an 18 month predevelopment hydrological monitoring program. A summary of the groundwater monitoring program is provided below in Tables 1, 2 and 3 and the Ground Water Monitoring Report is provided in Appendix 4.

The summer minimum groundwater levels at the site ranged between 2.30 - 3.63mAHD and the winter maximum ranged between 2.64 - 4.25mAHD (Table 1). The depth to the maximum groundwater levels below the natural surface varied between 1.70 - 5.12m. The seasonal groundwater levels varied in the range of 0.3m - 0.62m across the site (JDA, 2011).

Table 1: Groundwater Data from Site Bores (JDA, 2011)

Bore	Natural Surface (mAHD)	Summer Minimum Feb 2010		Winter Maximum Oct 2009		Seasonal Groundwater Variation (m)
		mBNS	mAHD	mBNS	mAHD	
PK1	5.88	2.89	2.99	2.41	3.47	0.48
PK2	5.81	2.48	3.33	1.91	3.90	0.57
PK3	6.37	2.74	3.63	2.12	4.25	0.62
PK4	5.80	2.91	2.89	2.51	3.29	0.4
PK5	5.32	2.22	3.10	1.70	3.62	0.52
PK6	5.63	2.44	3.19	1.89	3.74	0.55
PK7	6.98	4.64	2.34	4.34	2.64	0.3
PK8	8.00	5.7	2.30	5.12	2.88	0.58

Table 2: Mean Physical Parameter Measurements at Site Bores (JDA, 2011)

Bore	EC (mS/cm)	pH
PK1	0.49	7.63
PK2	0.59	7.34
PK3	0.47	7.62
PK4	0.65	7.18
PK5	0.65	7.42
PK6	0.79	7.16
PK7	0.63	7.62
PK8	0.62	7.46

Table 3: Mean Nutrient Concentrations at Site Bores (JDA, 2011)

Bore	Total P (mg/L)	PO_4-P (mg/L)	Total N (mg/L)	NOx-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)
PK1	0.08	0.01	10.72	8.75	0.44	2.78
PK2						
PK3	0.09	0.01	4.19	2.58	0.30	1.26

PK4						
PK5	0.09	0.01	4.22	2.22	0.28	2.03
PK6						
PK7	0.08	0.01	2.78	1.25	0.33	1.54
PK8	0.09	0.01	9.63	7.55	0.35	2.16

2.5.2 Surface Water

The site does not contain any drainage lines. The sandy nature of the soil allows rapid infiltration of rainfall with very little to no overland flow during rainfall events.

2.6 Wetlands

2.6.1 Geomorphic Wetlands

The site contains four wetlands as mapped by the *Geomorphic Wetlands of the Swan Coastal Plain* Database (National Map, 2020). These are described in Table 4 and shown in Figure 6.

Table 4: Geomorphic Wetlands Located on the Site

Wetland Classification	Wetland Type	UFI Number	Wetland Name
Conservation	Dampland	6259	Point Becher Wetland
Conservation	Dampland	6473	Point Becher Wetland
Conservation	Dampland	6474	Point Becher Wetland
Resource Enhancement	Dampland	14638	Point Becher Wetland

Several studies have shown that the mapped wetlands do not align with the location of wetlands on the ground (Appendix 5). PGV Environmental (2016) undertook a wetland vegetation assessment and a wetland boundary assessment (2017) to resolve the differences in the two previous wetland studies and to assess the vegetation within the proposed conservation area. Eleven wetlands (wetlands 14, 15, 16, 17,18, 19, 20, 21, 22, A and B) were mapped on the site (Plates 4-14). The wetland mapping did not match the mapping in the *Geomorphic Wetlands of the Swan Coastal Plain* Database but aligned closely with the TEC 19 boundaries provided by DBCA (V. English)

The environmental value of each wetland was assessed by PGV Environmental according to its size, condition, and vegetation types (Table 5). Seven of the eleven wetlands were rated as having a Low value due to the small size, poor condition, and low diversity of vegetation types. Several of the Low rated wetlands were considered transitional wetlands/drylands. The remaining four wetlands were rated as having a Medium environmental value.

Plate 4: Wetland A

Plate 5: Wetland B

Plate 6: Wetland 14

Plate 7: Wetland 15

Plate 8: Wetland 16

Plate 9: Wetland 17

Plate 10: Wetland 18

Plate 11: Wetland 19

Plate 12: Wetland 20

Plate 13: Wetland 21

Plate 14: Wetland 22

2.6.2 Becher Point Wetlands

The wetlands on the site are not part of the Becher Point Wetlands site which is listed as a Ramsar site (Wetlands of International Importance). However, the wetlands in the Conservation Area to the west of the development site are proposed to be managed by DBCA and added to the Rockingham Regional Lakes. As such they may be added to the Becher Point Wetlands Ramsar listing and managed accordingly.

Table 5: PGV Environmental Evaluation of Wetlands on the Site

Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments
14	19a	*Ficinia nodosa* Sedgeland mixed with *Bromus diandrus,* Oats, *Acacia saligna, Hakea prostrata.*	Good - Degraded	M	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
15	19b	*Melaleuca rhaphiophylla* Low Forest over weeds, some *Ficinia nodosa.*	Degraded	M	Good stand of Paperbark (*Melaleuca rhaphiophylla*) trees with degraded understorey.
16	No	*Xanthorrhoea preissii, Acacia saligna, Lepidosperma longitudinale,* some *Baumea juncea, Ficinia nodosa*.	Good	L	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
17	19a	Central area of *Lepidosperma longitudinale, Ficinia nodosa, Gahnia trifida* Sedgeland and *Adriana quadripartita* shrubs surrounded by *Acacia saligna, Xanthorrhoea preissii* Shrubland	Good	M	Very small wetland, good surrounding vegetation.
18	No	*Xanthorrhoea preissii/Acacia rostellifera* Shrubland with few *Ficinia nodosa, Lepidosperma longitudinale* sedges.	Good - Degraded	L	Small marginal wetland in poor condition, very low wetland diversity.
19	No	Dense *Acacia saligna* Tall Shrubland over *Bromus diandrus* dense grassland. Some *Lepidosperma longitudinale* sedges.	Degraded	L	Poor quality marginal wetland.
20	19a	*Acacia rostellifera/ A. saligna* Shrubland over *Melaleuca systena, Bromus diandrus, Euphorbia terracina,* Oats. Very small amount of *Ficinia nodosa, Baumea juncea, Gahnia trifida, Lepidosperma longitudinale*.	Degraded	L	Poor quality marginal wetland.
21	19a	*Ficinia nodosa/Baumea juncea* Sedgeland with *Bromus diandrus* and Oats weeds. Surrounded by *Acacia rostellifera.*	Good - Degraded	M	Moderate size wetland in average condition, low wetland diversity.
22	19a	*Ficinia nodosa, Centella asiatica, Baumea juncea* surrounded by *Hakea prostrata, Acacia rostellifera, Acacia saligna*	Good	L	Small wetland in average condition, low wetland diversity.
A	19a	*Ficinia nodosa* Sedgeland mixed with weeds *Bromus diandrus*, Oats.	Good - Degraded	L	Poor condition wetland with low diversity.
B	19a	Some *Ficinia nodosa* sedges among *Xanthorrhoea preissii/Acacia rostellifera* Shrubland	Good	L	Very small wetland in average condition and low wetland diversity.

Environmental Value H – High M – Medium L - Low

2.7 Vegetation and Flora

2.7.1 Vegetation Complex

The vegetation on the site consists of the Quindalup Vegetation Complex (RPS-BBG, 2006) as identified by Heddle *et al.* (1980).

Assessments made in 1998 and quoted in Bush Forever estimated that there is approximately 47% of the Quindalup Vegetation Complex remaining on the Swan Coastal Plain of which 20% is protected or proposed for protection at that time (Government of Western Australia, 2000).

2.7.2 Vegetation Types

RPS-BBG (2006) conducted a Level 2 Spring Vegetation and Flora Survey in accordance with *Guidance Statement No. 51* (EPA, 2004). The report is provided at Appendix 6.

The following vegetation types were recorded (Appendix 6 - Figure B1):

- Dune System
    - 1a Open Low Heath of *Acacia rostellifera*, *Melaleuca systena* on Dune Swales and Crests
    - 1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
- Wetlands, Damplands and Depressions in Dune Swales
    - 2a Closed Sedgeland of *Baumea juncea*, *Baumea articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*
    - 2b Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
    - 2c Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

2.7.3 Vegetation Condition

RPS-BBG (2006) rated the condition of the vegetation based on the vegetation condition rating scale provided by Keighery in Bush Forever (Government of Western Australia, 2000) (Table 6).

Table 6: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
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.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. 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.

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.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These 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.

The vegetation condition was assessed by PGV Environmental in September 2014 during a survey of weeds and in October 2016 during the spring flora survey.

PGV Environmental considered that the rating of Very Good for most of the western half of the site was a bit high and rated it as Good to Very Good with small areas of Degraded to Completely Degraded adjacent to the tracks and around the perimeter. The eastern half was considered to be Good with some areas Good to Degraded. The main weed species on the site were:

- *Avena fatua* (Wild Oats);
- *Bromus diandrus* (Great Brome);
- *Euphorbia terracina* (Geraldton Carnation Weed);
- *Lolium perenne* (Annual Ryegrass); and
- *Trachyandra divaricata* (Onion Weed)

The vegetation condition mapping for the site is shown in Appendix 6 - Figure B1.

2.7.4 Conservation Significant Vegetation

The Threatened Ecological Community (TEC) SCP 19 '*Sedgelands in Holocene dune swales of the southern Swan Coastal Plain'* is known to occur on the site. The TEC is listed as Endangered under the EPBC Act and Critically Endangered at the State level.

Two sub-types of SCP 19 are recognised at State level although the TEC listing is for the overall SCP type (DEC, 2011). SCP 19a includes 'sedgelands in Holocene dune swales' while SCP 19b includes 'woodlands over sedgelands in Holocene dune swales'. SCP 19b is generally associated with the older occurrences of the community.

Six occurrences of TEC 19 are mapped on the site by DBCA (Figure 6). Five of the six occurrences are the sub-type 19a while one contains trees and is mapped as sub-type 19b. The three northern most TEC 19 areas were recognised by DBCA as being degraded due to firebreaks and weed impacts.

According to the wetland/TEC assessment undertaken by PGV Environmental (2016) the TEC mapping on the site is reasonably accurate, with some minor modifications (Figure 8). PGV Environmental (2016) mapped one additional occurrence of TEC 19a (Wetland B) on the site and assessed the vegetation in wetland 19 as not beingTEC19.

In total, PGV Environmental consider there are 8 occurrences of TEC19 in the development lot and 14 in the proposed conservation lot.

The vegetation types of the dryland vegetation on the site were analysed by RPS-BBG (2006) to be representative of SCP 29b ''*Acacia shrublands on taller dunes, southern Swan Coastal Plain*" which is recognised as a Priority 3 Ecological Community at State level. PGV Environmental concurs with the identification of 29b for the dryland vegetation.

2.7.5 Flora

A search of the EPBC Act Protected Matters Search Tool and the Naturemap database was conducted by PGV Environmental and identified eight species of significant flora that may potentially occur within 5km of the site (Table 7). The likelihood of these species occurring on the site is shown in Table 8. Strategen (2012) conducted a DPaW Declared Rare Flora and Priority Flora database search with a 10km radius around the site for which they found three records of *Jacksonia sericea* (P4) and one record of *Acacia benthamii* (P2) occurring within 10km of the site.

Table 7: Conservation Significant Flora likely to occur within 5km of the Site

Taxa	Common Name	Status under Biodiversity Conservation Act	Status under EPBC Act
Caladenia huegelii	King Spider Orchid	Schedule 1	Endangered
Drakaea elastica	Glossy-leafed Hammer Orchid	Schedule 1	Endangered
Drakaea micrantha	Dwarf Hammer Orchid	Schedule 2	Vulnerable
Diuris purdiei	Purdie's Donkey Orchid	Schedule 2	Endangered
Diuris drummondii	Tall Donkey Orchid	Schedule 3	Endangered
Diuris micrantha	Dwarf Bee-orchid	Schedule 3	Vulnerable
Beyeria cinerea subsp. *cinerea*		Priority 3	
Jacksonia sericea	Waldjumi	Priority 4	

Table 8: Likelihood of Identified Significant Flora Species Occurring on the Site

Species	Preferred Habitat*	Likelihood to be present on the site
Diuris drummondii	The Tall Donkey Orchid grows in low-lying depressions, swamps, in areas that contain surface water well into summer (Brown et al., 2013).	No
Caladenia huegelii	The Grand Spider-orchid prefers sand or clay loam. This species generally does not survive in disturbed areas.	No
Diuris micrantha	The Dwarf Bee-orchid is usually found on cleared firebreaks or open sandy patches that have been disturbed with in Jarrah Banksia woodland or thickets of Spearwood (Kunzea ericifolia/glabrescens) (Williams et al., 2001).	No
Diuris purdiei	Purdie's Donkey Orchid occurs in grey-black sand in moist winter-wet swamps.	No
Drakaea elastica	The Glossy-leafed Hammer Orchid prefers low-lying situations adjoining winter-wet swamps. This species does not survive in disturbed areas.	No

Species	Preferred Habitat*	Likelihood to be present on the site
Drakaea micrantha	Dwarf Hammer-orchid occurs in grey sands over dark, grey to blackish, sandy clay-loam substrates in winter wet depressions or swamps.	No
Beyeria cinerea subsp. *cinerea*	Beyeria cinerea subsp. cinerea grows in sand over limestone on road verges, gullies	No
Jacksonia sericea	Calcareous & sandy soils.	No

*sourced from Florabase, DoE SPRAT Database as well as the DPaW database searches.

A level 2 flora and vegetation survey of the site was undertaken in 2006 (RPS-BBG, 2006). The survey included sampling from sixteen 10m x 10m quadrats as well as recording species outside of the quadrats over a period spanning 31 August to 23 November 2006.

A more recent spring flora survey was also undertaken by PGV Environmental on 18 and 27 October 2016 by Dr Paul van der Moezel. The survey did not include sampling from quadrats as the 2006 survey was considered adequate in that regard. The 2016 survey included a thorough walk over the site to record plant species within the site and the proposed conservation area.

A total of 119 species were recorded from the site in the 2006 RPS survey. The total included 117 naturally occurring species and two planted ornamental species. Of the 119 species, 61 were native and 58 were introduced. The percentage of introduced species (49%) is relatively high and reflects the low quality of vegetation particularly on the eastern half of the site as well as along the tracks and edges of the site next to developed areas and roads.

The 2016 spring survey by PGV Environmental recorded 101 species, including 55 native and 46 introduced species. The percentage of introduced species (46%) was similar to that recorded by RPS in 2006.

PGV Environmental recorded 13 additional species not recorded in 2006 including six native and seven introduced species.

The total number of species recorded on the site between the two surveys is 132 (Lots 1 and 2), comprising 63 native and 69 introduced (46%) (Appendix 7).

2.7.6 Conservation Significant Flora

No Threatened (Declared Rare) or Priority Flora were recorded in the RPS-BBG survey in 2006 or the PGV Environmental survey in 2016.

2.8 Fauna

2.8.1 Fauna Habitat

A Level 1 fauna survey was undertaken by Bamford Consulting Ecologists (Bamford) in June 2011 to identify the fauna values over Lots 1 and 2 (Appendix 8). Bamford recorded two major fauna habitat types which were further divided into sub-units. These were:

- Sand dunes system

- Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes, sandplain and swales;
- Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes;

- Wetlands, Damplands and Seasonal Drainage Depressions in Dune Swales

  - Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*;
  - Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*;
  - Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgland of *Ficinia nodosa* and *Baumea juncea*.

The fauna habitat present is not considered to be key habitat for Priority or Threatened species.

2.8.2 Conservation Significant Fauna

A search of the EPBC Act Protected Matters Search Tool and the Naturemap database was conducted by PGV Environmental and identified 41 species of significant fauna that may potentially occur within 5km of the site (Table 9). Marine mammals, marine birds (albatross), turtles and fish were not included in Table 8.

Table 9: List of Fauna Species Identified from Database Searches

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Birds			
Anous tenuirostris melanops	Australian Lesser Noddy	Schedule 1	Vulnerable
Botaurus poiciloptilus	Australasian Bittern	Schedule 1	Endangered
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	Schedule 1	Endangered
Leipoa ocellata	Malleefowl	Schedule 1	Vulnerable
Numenius madagascariensis	Eastern Curlew	Schedule 1	
Limosa lapponica menzbieri	Bar-tailed Godwit	Schedule 1	Critically Endangered
Numenius madagascariensis	Eastern Curlew	Schedule 1	Critically Endangered
Calidris ferruginea	Curlew Sand Piper	Schedule 1	Critically Endangered
Botaurus poiciloptilus	Australasian Bittern	Schedule 2	Endangered
Calidris canutus	Red Knot	Schedule 2	Endangered
Rostratula australis	Australian Painted Snipe	Schedule 3	Endangered
Sternula nereis nereis	Australian Fairy Tern	Schedule 3	Vulnerable
*Actitis hypoleucos (*also listed as *Tringa hypoleucos)*	Common Sandpiper	Schedule 3	Marine/Migratory
Apus pacificus	Fork-tailed Swift	Schedule 3	Marine/Migratory
*Puffinus carneipes (*also listed as *Ardenna carneipes)*	Flesh-footed Shearwater	Schedule 3	Marine/Migratory
Calidris melanotos	Pectoral Sandpiper	Schedule 5	Marine/Migratory
Pandion haliaetus	Osprey	Schedule 5	Marine/Migratory
Tringa nebularia	Common Greenshank	Schedule 3	Marine/Migratory
Motacilla cinerea	Grey Wagtail	Schedule 5	Migratory
Mammals			
Pseudocheirus occidentalis	Western Ringtail Possum	Schedule 1	Critically Endangered
Bettongia penicillata ogilbyi	Woylie	Schedule 1	Endangered

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Dasyurus geoffroii	Chuditch	Schedule 3	Vulnerable
Isoodon fusciventer	Southern Brown Bandicoot	Priority 4	
Reptiles			
Morelia spilota subsp. *imbricata*	Carpet Python	Schedule 4	
Lerista lineata	Perth Slider, Lined Skink	Priority 3	
Insects			
Synemon gratiosa	Graceful Sunmoth	Priority 4	

Outlined below in Table 10 is a short description of each of the species that were identified in the NatureMap Species Report search and the EPBC Protected Matters Search Tool in Table 9. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present was determined.

Table 10: Likelihood of Conservation Significant Species being Present on the Site

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Birds			
Anous tenuirostris melanops	Australian Lesser Noddy	The Australian Lesser Noddy usually occupies coral-limestone islands that are densely fringed with White Mangrove *Avicennia marina* (DoE, 2014).	Species *unlikely* within the site.
Botaurus poiciloptilus	Australasian Bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands (DoE, 2014).	Species *unlikely* visitor to the site.
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Forest Red-tailed Black-Cockatoos frequent the humid to subhumid south-west from Gingin in the north, Albany in the south and west to Cape Leeuwin and Bunbury (DoE, 2014). It nests in tree hollows with a depth of 1-5m, that are predominately Marri, Jarrah and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri and Jarrah (Johnstone and Kirkby, 2011).	Species *unlikely* within the site.
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	Baudin's Black-Cockatoo mainly occurs in eucalypt forests, especially Jarrah (*E. marginata*), Marri (*Corymbia calophylla*), also Karri (*E. diversicolor*) forest, often feeding in the understorey on proteaceous trees and shrubs, especially banksias (Johnstone and Kirkby, 2011).	Species *unlikely* within the site.
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell) (SEWPaC, 2012)	Species *unlikely* within the site.

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Leipoa ocellata	Malleefowl	Malleefowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards in mallee bushland (DoE, 2014).	Species *unlikely* within the site.
Numenius madagascariensis	Eastern Curlew	The Eastern Curlew is a large wading bird most commonly found along sheltered coasts, particularly estuaries, bays, harbours, inlets and coastal lagoons that have large intertidal mudflats or sandflats, often containing seagrass. They often occur where there are mangroves (DoE, 2014).	Species *unlikely* within the site.
Limosa lapponica	Bar-tailed Godwit	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays (DoE, 2014).	Species *unlikely* within the site.
Calidris ferruginea	Curlew Sand Piper	Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms.	Species *unlikely* within the site.
Botaurus poiciloptilus	Australasian Bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands.	Species *possible* infrequent visitor to the site.
Calidris canutus	Red Knot	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs.	Species *unlikely* within the site.
Rostratula australis	Australian Painted Snipe	The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses (DoE, 2014).	Species *possible* infrequent visitor to the site.
Sternula nereis nereis	Australian Fairy Tern	The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation (DoE, 2014).	Species *unlikely* within the site.
*Actitis hypoleucos (*also listed as *Tringa hypoleucos)*	Common Sandpiper	The Common Sandpiper can be found in saltwater and freshwater wetlands, however it is mostly found around muddy margins or rocky shores and often associated with mangroves (DoE, 2014).	Species *unlikely* within the site.
Apus pacificus	Fork-tailed Swift	The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (DoE, 2014).	Species *possible* infrequent visitor to the site.
Calidris melanotos	Pectoral Sandpiper	The Pectoral Sandpiper prefers shallow fresh to saline wetlands and is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	Species *unlikely* within the site.

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Pandion haliaetus	Osprey	Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals.	Species *unlikely* within the site.
Tringa nebularia	Common Greenshank	The Common Greenshank is a wader and does not breed in Australia. This species can be found in many types of wetlands and has the widest distribution of any shorebird in Australia. This species typically feeds on molluscs, crustaceans, insects, and occasionally fish and frogs (DoE, 2014)	Species *possible* infrequent visitor to the site.
Motacilla cinerea	Grey Wagtail	The Grey Wagtail is mostly recorded in coastal areas in Western Australia (ALA, 2015) however is widespread. There is non-breeding habitat only in Australia and the species has a strong association with water, particularly rocky substrates along water courses but also lakes and marshes.	Species *possible* infrequent visitor to the site.
Mammals			
Dasyurus geoffroii	Chuditch	The Chuditch have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles (DoE, 2014).	Species *unlikely* within the site.
Bettongia penicillata ogilbyi	Woylie	The Woylie habitat types ranged from forest to grassland, coastal and inland. During the day the Woylie shelters under patches of dense undergrowth, logs and rock-cavities and occasionally in burrows (DoE, 2014)	Species *unlikely* within the site.
Pseudocheirus occidentalis	Western Ringtail Possum	The Western Ringtail Possum is confined to the south-west of Western Australia where it occurs mainly in coastal forests with *Agonis flexuosa*. The species is an arboreal and nocturnal herbivorous marsupial with a relatively small home range of 0.5-6ha, dependent on habitat type. It builds dreys for shelter in tree canopies and uses tree hollows. They are primarily arboreal, but will often move through the understorey or open ground to feed or gain shelter (DoE, 2014).	Species *unlikely* within the site.
Isoodon. fusciventer	Southern Brown Bandicoot	Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2012)	Species occurs within the site.
Reptiles			

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Morelia spilota subsp. *imbricata*	Carpet Python	The Carpet Python is a large snake found across the south-west of Western Australia, from Northampton, south to Albany and eastwards to Kalgoorlie including undisturbed remnant bushland near Perth and the Darling Ranges. This subspecies has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands and grasslands (AROD, 2012).	Species *possible* within the site.
Lerista lineata	Perth Slider, Lined Skink	The Perth Slider inhabits loose soil and leaf litter particularly in association with Banksias and white sands underneath shrubs and heath (PES, 2011).	Species *possible* within the site.
Insects			
Synemon gratiosa	Graceful Sun-moth	The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of *Lomandra maritima* and *Lomandra hermaphrodita* exclusively and therefore require the presence of one or both of these species to be present in an area (Bishop *et al.,* 2011).	Species occurs within the site.

2.8.3 Significant Fauna under the *WA Wildlife Conservation Act* 1950

Two species of conservation significance were recorded by Bamford (2011) within the site, Southern Brown Bandicoot (*Isoodon fusciventer)* which is listed as Priority 5 fauna by DPaW and the Graceful Sun-moth (*Synemon gratiosa*) which is a listed as a Priority 4 fauna by DPaW.

2.8.4 Significant Fauna under the EPBC Act 1999

Two species of conservation significance under the EPBC Act were recorded as being possible infrequent visitors to the site the Fork Tailed Swift (*Apus pacificus)* and Rainbow Bee-eater (*Merops ornatus.* Both of these species are migratory and are not reliant on the site for their survival.

The Forest Red-tailed Black Cockatoo was recorded flying over the site by Bamford (2011). The site does not contain foraging habitat for Black Cockatoos and there is no suitable breeding or roosting habitat.

2.8.5 Potential Pest Species

Feral cats would frequent the site due to the existing adjoining residential housing. Foxes may also be present on the site. These pest species would prey on the native species. Rabbits are a potential issue and will cause damage to native vegetation and limit the rehabilitation of native flora.

2.9 Heritage

2.9.1 Aboriginal Heritage

There are no registered aboriginal sites recorded in the Aboriginal Heritage Inquiry System as occurring on the site (National Map, 2020).

2.9.2 Cultural Heritage

There are no cultural sites recorded in the Heritage Council WA- States Register as occurring on the site (National Map, 2020).

2.10 Contaminated Sites

There are no reported Department of Environment and Regulation contaminated sites occurring on or adjacent to the site (National Map, 2020).

3 LEGISLATION, POLICY AND GUIDELINES

The environmental assessment of this site has taken into consideration the following legislation, policy and guidelines and these will guide the required and expected management outcomes from the Commonwealth, State and Local government agencies.

3.1 State Legislation

3.1.1 Ministerial Statement 368

The site was rezoned to Industrial in the MRS as part of major Amendment No. 938/33 in 1994. The Amendment included the following land use changes:

- Creation of a Rapid Transport Reserve for the Perth-Mandurah rail;
- Rezoning of the north-west corner of System 6 Area M103 for Public Purposes;
- Rezoning of the south-west portion of System 6 Area M103 west of Ennis Avenue for Urban and Industrial uses; and
- Widening of Safety Bay Road between Ennis Avenue and Mandurah Road.

The Amendment was referred to the Environmental Protection Authority (EPA) by the Department of Planning and Urban Development (now called the Department of Planning) in 1993. The EPA considered that the Amendment had potential for significant impacts on System 6 Areas M103 and M104, and on several lakes and wetlands and their vegetation. As a result, the EPA set the level of assessment as a Public Environmental Review (PER).

The assessment of scheme amendments under Section 38 of the *Environmental Protection Act 1986* (EP Act) was allowable in 1994 as that pre-dates the 1996 amendment to the EP Act which introduced Section 48A that required all schemes and scheme amendments to be referred to the EPA.

The Minister for the Environment approved the Amendment on 11 October 1994 (Ministerial Statement No. 368)

3.1.2 Vegetation Clearing under the Environmental Protection Act 1986

Under the EP Act, clearing of native vegetation requires a permit from DWER unless there is an exemption under the Schedule 6 of the EP Act or under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Proposals that have approval by means of a Ministerial Statement and which are implemented in accordance with that Statement have a Schedule 6 (Clause 2) exemption from requiring a clearing permit to clear native vegetation. Clearing in accordance with an approved subdivision is exempt under Clause 9 of Schedule 6.

The Department of Water and Environmental Regulation has confirmed with DevelopmentWA that any clearing that will be required for the development will be exempt from the requirement of a clearing permit as the site has been formally assessed under section 38 of the EP Act.

3.1.3 Biodiversity Conservation Act

The *Biodiversity Conservation Act 2016* (BC Act) protects all native species and Threatened Ecological Communities. The BC Act recognises that activities involving the taking of flora or fauna (other than threatened species) and the disturbing of fauna (including threatened species) that are approved under the EP Act do not require further approval under the BC Act if they are undertaken in accordance with any biodiversity conservation conditions that are applied to an authorisation. These activities include clearing of native vegetation done in accordance with an implementation decision under Part IV of the EP Act.

The occurrences of TEC19a that will be cleared for development will not require approval under the BC Act due to the original environmental approval (MS 368) giving approval to clear all native vegetation on the site.

3.2 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important heritage places, ecological communities, flora and fauna that are defined in the Act as matters of national environmental significance.

The EPBC Act applies to the following seven matters of national environmental significance:

- World heritage sites;
- National heritage places;
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed);
- Nationally threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions.

A significant impact, under the EPBC Act, is determined by the value, quality and sensitivity of the environment which is to be impacted and the magnitude, duration, intensity and geographic extent of the impacts (DoE, 2013). *The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DoE, 2013) provides a guide for determining the significance of an impact. Proposed actions that are deemed to have a significant impact should be referred to the Minister.

The EPBC Act applies to 'actions' which:

- Have a 'significant impact' on 'matters of national environmental significance';
- Are undertaken by Commonwealth government agencies and have a significant impact on the environment anywhere in the world; or
- Are undertaken by any person and have a significant impact on Commonwealth land (even if the activity is not actually carried out on the Commonwealth land).

One Threatened Ecological Community (TEC 19) that occurs on the site is listed under the EPBC Act. However, the State environmental approval (MS 368) predates the EPBC Act, and according to Section 43A of the EPBC Act, the prior approval, which is still valid, means the EPBC Act does not apply in this case.

3.3 State Policy

3.3.1 State Planning Policy No. 2.8 Bushland Policy for the Perth Metropolitan Region

SPP 2.8 in conjunction with Bush Forever (Government of Western Australia, 2000) seeks to ensure the protection of at least 10 per cent of the original extent of each vegetation complex within the Perth Metropolitan Region. SPP 2.8 was developed to ensure that bushland protection and management issues are appropriately addressed and integrated as a part of future land use. Bush Forever identified approximately 51,200 hectares of regionally significant vegetation for retention. The management of these areas include reservation and acquisition by the State government, negotiated planning solutions with owners who are seeking urban and/or industrial development and advice, assistance and incentive programs to support private conservation.

There are no Bush Forever sites within the site. Bush Forever Site No. 356 is located south of the site separated by Port Kennedy Drive. However, SPP 2.8 also applies to Local Bushland which includes the site. SPP 2.8 encourages local government to prepare a local bushland protection strategy which should aim at a number of things including identifying significant bushland sites for protection and management based on environmental, social and economic criteria, taking into consideration existing approvals and commitments.

3.3.2 State Planning Policy No. 2.9 Water Resources

SPP 2.9 aims to ensure the protection and appropriate management of water resources in line with state guidelines as included within the planning framework. The broad aims of this policy are to:

- Protect, conserve and enhance water resources;
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and other biological life and to maintain or improve the quality and quantity of water resources; and
- Promote and assist in the management and sustainable use of water resources.

As a part of implementing this policy, the Better Urban Water Management framework was developed (WAPC, 2008). The framework provides detail on how water resources should be considered at each stage of planning by identifying the various actions and investigations required with regard to regional and local planning strategies, town planning schemes, structure plans, subdivisions, strata subdivision and development applications (WAPC, 2008).

At subdivision, an Urban Water Management Plan will be prepared in accordance with the WAPC Better Urban Water Management Framework.

3.3.3 State Planning Policy No. 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning

SPP 5.4 addresses transport noise from within major transport corridors, including freight routes, and its impact on noise sensitive land uses. The policy aims to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best-practice design and construction standards for new development proposals and new or redeveloped transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

Major transport (road) corridors are defined as:

- State roads and national highways;
- Urban primary distributors as described on the metropolitan functional road hierarchy (MRWA, local government) network;
- Other urban roads carrying more than 20,000 vehicles per day;
- Primary freight roads (Perth metropolitan region);
- Primary freight roads (South-West region); and
- Primary freight roads (State-wide).

The noise criteria outlined in SPP 5.4 is applied to the outdoor areas of sensitive premises and describes the level of noise which must be met.

3.3.4 State Planning Policy 3.7 – Planning for Bushfire Prone Areas

The intent of this policy is to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfire on property. The policy objectives are to:

The objectives of this policy are to:

- Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.
- Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.
- Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.
- Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change

A Fire Management Plan will be prepared in accordance with SPP3.7 as part of the detailed subdivision process.

3.3.5 Wetlands Conservation Policy for Western Australia

The *Wetland Conservation Policy for Western Australia* (Government of Western Australia, 1997) outlines the State government's commitment to identify, maintain and manage the State's wetland resources which include lakes, swamps, marshes, springs, damplands, impoundments, intertidal flats and mangroves.

The objectives of the Policy are to:

- Prevent further loss or degradation of valuable wetlands and wetland types;
- Include viable representation of all major wetland types within the conservation reserve;
- Maintain viable wild populations which include the species and genetic diversity of wetland dependant flora and fauna; and
- Increase community awareness and appreciation for wetlands.

The site contains 3 Conservation wetlands (6259, 6473, 6474) and one Resource Enhancement (14638) wetland as mapped in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset. PGV Environmental mapped five additional wetlands on the site (Figure 7).

One wetland mapped as wetland 15 has been retained in the proposed subdivision. DBCA recognise the industrial zoning approved in 1994 (allowed complete development of both Lots 4 and 17) which was environmentally acceptable to the EPA.

3.3.6 Environmental Protection Authority Guidance Statement No. 33 Environmental Guidance for Planning and Development

The purpose of EPA Guidance Statement No. 33 *Environmental Guidance for Planning and Development* (EPA, 2008) is to outline the significance of environmental factors and to provide the key definitions associated with the environmental factors. Ensuring that environmental factors are considered in line with the EPA's principals and objectives and within the planning framework is what this EAR is primarily targeted at. In particular, EPA Guidance Statement No. 33 aims to:

- Provide an overview to environmental protection processes and information;
- Describe the referral and environmental impact assessment process under Part IV of the EP Act; and
- Provide the EPA's position and advice on a range of environmental factors, outlining how to protect, conserve and enhance the environmental values.

3.3.7 Environmental Protection Authority Guidance Statement No. 3 Separation Distances between Industrial and Sensitive Land Uses

This guidance statement specifically addresses generic separation distances between industrial and sensitive land uses to avoid conflicts between these land uses. It takes into account protection of the environment as defined by the *Environmental Protection Act 1986* (EP Act) with a focus on protecting sensitive land uses from unacceptable impacts on amenity that may result from industrial activities, emissions and infrastructure.

A number of emissions are generated by industrial, commercial and rural activities and infrastructure. These include noise and air emissions (gases, dust and odours). The levels of emissions may at times exceed amenity levels considered acceptable in residential areas and at other sensitive land uses.

4 CONCEPT PLAN

A Concept Plan has been prepared by Element for the site (Appendix 9). The plan creates 117 Lots for General Industry use in accordance with the MRS zoning.

The central wetland identified by PGV Environmental as wetland 15 and containing a small area of TEC19b has been retained with a management buffer of 50m as Public Open Space in the Concept Design. The core area of the wetland will be managed for conservation purposes. Some public facilities such as seating and tables may be included around the central core area.

The interface with proposed Lot 1 (conservation lot) has a road separating the conservation area from the development along the eastern side and a pedestrian path along the northern side separating lots from the development to meet the requirements of DBCA. The hard interface will assist in managing weeds and also provide additional setback for fire management purposes.

5 ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

5.1 Landform and Soils

The landforms and soils contained on the site are not a constraint to development.

The geotechnical investigation did not identify any constraints to development and a classification 'Class A" in accordance with AS2870-2011 would be suitable for the site provided the site preparation identified in the Geotechnical Report is carried out.

5.2 Acid Sulphate Soils

The site is mapped as having a low risk of Acid Sulphate soils and therefore is not a constraint to development.

5.3 Stormwater Management

5.3.1 Water Sensitive Urban Design Principles and Objectives

WAPC (2008) outlines the principal objectives of Water Sensitive Urban Design (WSUD) as:

Implementation of sustainable best practice in water management which should:

- Encourage environmentally responsible development to meet catchment management intentions;
- Provide clarity for agencies involved with implementation;
- Facilitate adaptive management responses to the monitored outcomes of development;
- Minimise public risk, including risk of injury or loss of life; and
- Maintain the total water cycle.

5.3.2 Potential Impacts

Surface and groundwater can be impacted by a variety of activities:

- Groundwater level changes can occur as a result of a change in land use;
- Removal of vegetation and installation of impervious surfaces can lead to an increase in runoff during rainfall events;
- Development can increase the potential for industrial pollutants such as nutrients, hydrocarbons, metals and sediment being discharged via runoff and can influence the water chemistry of wetlands;
- Nutrient loading to the groundwater and surface water can occur; and
- Stormwater drainage can facilitate the transportation of nutrients (through surface run-off) and potential contaminants (e.g. litter) through the subject land.

5.3.3 Management Measures

To ensure that the quantity and quality of water is maintained to protect the receiving and surrounding environments, an Urban Water Management Plan (UWMP) will be prepared as part of the detailed subdivision design:

The UWMP will include the following Water Sensitive Urban Design (WSUD) principles:

- Provide protection to life and property from a 1 in 100 year flood event;
- Manage stormwater to minimise run off as high in the catchment as possible;
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features, regimes and processes and integrate these into the industrial landscape;
- Maximise water use efficiency and reduce potable water demand;
- Minimise pollutant inputs through implementation of appropriate non-structural source controls.

A summary of the WSUD strategies to be applied are:

- Compliance with environmental quality criteria;
- Compliance with relevant stormwater management policies;
- Application of WSUD treatment trains (where applicable);
- Preparation of water management strategies;
- Minimum percentage area of deep rooted perennial vegetation;
- Building and landscape guidelines; and
- Construction and building site management.

5.4 Sewer Connection

The development is required by the Western Australian Water Corporation to tie into the sewer main to the west of the conservation lot adjacent to Bessemer Road that services the existing western sector of the Business Park. It is proposed that the sewer main will be installed through the conservation area using horizontal boring to a depth of 6m. Other options have been investigated, however they will all require fill being brought into the site to get the required levels for the sewer main operation. The costs and indirect impacts (import of fill, potential vegetation clearing to source fill) of raising the lot are greater than horizontal boring.

The impact on the groundwater and conservation area (wetlands and vegetation) from the horizontal boring for the connection into the sewer line to the west have been considered. The horizontal drilling method will avoid any surface impacts to the conservation area and will minimise impacts on the hydrological regime of the wetlands. Both the direction of the sewer line and the groundwater flow will be in an easterly direction, therefore a barrier to the groundwater flow will not be formed and interruption of flows are expected to be negligible, if any.

As with all construction activities, there are risks that need to be managed in connecting the sewer line. In addition, the Water Corporation will need to operate the asset in the future. It is proposed to build in redundancy with the drill shot under the conservation area to manage the above. This will be achieved by:

- Drilling a larger diameter sleeve under the conservation area. A larger diameter sleeve (approximately 800mm diameter) brings greater accuracy and the ability to manage variable ground conditions. This minimises the risk of any excavations within the conservation area.
- The larger sleeve also allows two parallel sewers to be installed internally. This provides a backup line for the Water Corporation in case of a blockage. Flows can be transferred to the alternate line very easily and any maintenance works can occur without the need to bypass flows.

This is an accepted common practice where access over the sewer is not available.

To manage the extent of dewatering during these sewer works, it is suggested the Contractor utilise plugged base caissons at the bore and receival pits. This will remove the need to dewater, minimising the impact on the water levels under the wetlands in the conservation area.

5.5 Wetlands

5.5.1 Potential Impacts

Nine wetlands detailed in Table 11 will be impacted by the development while wetlands 14 and 15 will be retained.

Table 11: Wetlands on the Development Lot

PGV Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments	Retained in Concept Plan Y/N
14	19a	*Ficinia nodosa* Sedgeland mixed with *Bromus diandrus,* Oats, *Acacia saligna, Hakea prostrata.*	Good - Degraded	M	Small, wetland in average condition. Lack of diversity of wetland vegetation types.	Y will be included in conservation lot
15	19b	*Melaleuca rhaphiophylla* Low Forest over weeds, some *Ficinia nodosa.*	Degraded	M	Good stand of Paperbark (*Melaleuca rhaphiophylla*) trees with degraded understorey. Likely to be retained as POS in the future development plan.	Y included in POS
16	No	*Xanthorrhoea preissii, Acacia saligna, Lepidosperma longitudinale,* some *Baumea juncea, Ficinia nodosa*.	Good	L	Small, wetland in average condition. Lack of diversity of wetland vegetation types.	N
17	19a	Central area of *Lepidosperma longitudinale, Ficinia nodosa, Gahnia trifida* Sedgeland and *Adriana quadripartita* shrubs surrounded by *Acacia saligna, Xanthorrhoea preissii* Shrubland	Good	M	Very small wetland, good surrounding vegetation.	N
18	No	*Xanthorrhoea preissii/Acacia rostellifera* Shrubland with few *Ficinia nodosa, Lepidosperma longitudinale* sedges.	Good - Degraded	L	Small marginal wetland in poor condition, very low wetland diversity.	N
19	No	Dense *Acacia saligna* Tall Shrubland over *Bromus diandrus* dense grassland. Some *Lepidosperma longitudinale* sedges.	Degraded	L	Poor quality marginal wetland.	N
20	19a	*Acacia rostellifera/ A. saligna* Shrubland over *Melaleuca systena, Bromus diandrus, Euphorbia terracina,* Oats. Very small amount of *Ficinia nodosa, Baumea juncea, Gahnia trifida, Lepidosperma longitudinale*.	Degraded	L	Poor quality marginal wetland.	N
21	19a	*Ficinia nodosa/Baumea juncea* Sedgeland with *Bromus diandrus* and Oats weeds. Surrounded by *Acacia rostellifera.*	Good - Degraded	M	Moderate size wetland in average condition, low wetland diversity.	N
22	19a	*Ficinia nodosa, Centella asiatica, Baumea*	Good	L	Small wetland in average condition, low wetland	N

PGV Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments	Retained in Concept Plan Y/N
		juncea surrounded by *Hakea prostrata, Acacia rostellifera, Acacia saligna*			diversity.	
A	19a	*Ficinia nodosa* Sedgeland mixed with weeds *Bromus diandrus*, Oats.	Good - Degraded	L	Poor condition wetland with low diversity.	N
B	19a	Some *Ficinia nodosa* sedges among *Xanthorrhoea preissii/Acacia rostellifera* Shrubland	Good	L	Very small wetland in average condition and low wetland diversity.	N

5.5.2 Management Measures

The Concept Plan has retained the highest environmental value wetland (Wetland 15) that contains a mature stand of Paperbarks in POS. The wetland has been retained with a 50m buffer and will be managed for conservation. Some public facilities may be placed around the periphery of the management buffer to provide seats and tables.

Wetland 14 will be added to the conservation area through a variation to the WAPC 156342 approval. The variation will move the boundary between the lots so that Wetland 14 is within the conservation area (see Appendix 2).
For the wetlands retained in the proposed Lot 1 (Conservation Area) the concept plan provides road around the eastern interface and a pedestrian path along the northern end to provide a hard management buffer to the conservation area. The wetlands in the proposed Lot 1 conservation area will be managed for conservation purposes with the end goal being to include the conservation area in the Rockingham Lakes Regional Park and managed by DBCA.

No stormwater from the development area will be disposed of into the POS or the Conservation Area. Groundwater under the future development area flows to the east towards Lake Walyungup. As a result, the groundwater under the development site is moving away from the wetlands in the Conservation Area reducing any potential impacts of development on the wetlands. Nevertheless, a Water Sensitive Urban Design approach to stormwater management will be undertaken for the development.

Construction activities need to be managed to minimise the impact to the conservation area during the bulk earthworks and construction phases. Impacts may include nuisance dust generation during bulk earthworks, accidental release of pollutants (fuel storage), vehicular activities, disturbance of acid sulphate soils and associated dewatering. These impacts are manageable through appropriate engineering design and good site management practices.

A Conservation Area Management Plan (CAMP) will be prepared in accordance with WAPC 156342 Condition 2 and will cover the following aspects prior to any construction works on the site:

- Fencing the boundary of the Conservation Area;
- Removal of rubbish;
- Rehabilitating areas of degraded vegetation to a suitable standard that the Conservation Public Open Space can be handed to City of Rockingham for management;
- Retaining or creating appropriate access tracks for the public and fire management;
- Closing and rehabilitating existing tracks where appropriate;
- Installing signage for public awareness of environmental values;
- Undertaking weed control;
- Monitoring vegetation health; and
- Implementation, monitoring, reporting and responsibility.

The CAMP will be submitted to the DBCA for approval.

The two wetlands to be retained in the development lot, together with the 17 included in the Lot 1 conservation area, will result in a total of 19 wetlands being protected. Existing environmental approval allows for all vegetation and wetlands on the Lots 4 and 17 to be cleared. Therefore, the retention of 19 wetlands is an excellent environmental outcome.

5.6 Vegetation and Flora

5.6.1 Potential Impacts

The main potential impact to native vegetation within the subject land from the proposed development is removal of vegetation from the site.

5.6.2 Vegetation Retention

The only vegetation retained on the site is associated with wetland 15 and its management buffer, the remainder of the native vegetation will be cleared for development.

The occurrences of TEC19 on the site are described in Table 11. Five small occurrences of TEC19a will be cleared for development (Table 12). The TEC19b occurrence in wetland 15 has been retained in the POS and the area of TEC19 in wetland 14 will be added to the conservation area.

Fourteen instances of the TEC have been retained in the conservation area to the west.

Table 12: Summary of TECs

Subdivision Design	TEC		
	19a	19b	Total
Inside Conservation Area - retained	13	1	14
In Development Area - retained	1	1	2
In Development Area - cleared	6	0	6

5.6.1 Management Measures

A CAMP will be prepared and implemented to ensure the protection and improvement of the flora, vegetation, wetlands and fauna in the proposed conservation area.

The conservation area will be separated from the development area by a road reserve which will assist in providing a buffer between the development and the conservation area.

The following measures will be undertaken in the area to be cleared of native vegetation:

- The location and limit of clearing of vegetation within all work areas will be clearly identified on site and delineated on appropriate plans. These will be supplied to contractors and site personnel prior to commencement of works;
- The conservation Public Open Space will be surveyed, fenced and if required dust curtains will be put in place to minimise dust impacts form the construction area;
- Native vegetation to be cleared will be removed in a systematic manner and stockpiled where appropriate for later use in rehabilitation and landscaping of POS areas.
- The stockpiling of cleared vegetation of a poor quality will be separate to that of good quality to minimise the spread of weeds. Only good quality vegetation will be used for mulch and rehabilitation.
- No burning of cleared vegetation will be permitted during any stage of construction.

5.7 Fauna

5.7.1 Potential Impacts

The main impact to fauna and fauna habitat on the site includes:

- Loss of habitat through vegetation clearing;
- Land clearing and vehicle movement may result in death or injury of fauna as a result of collisions;
- Species interactions, including predation and competition; and
- Disturbance of fauna off-site from light spill, noise and human disturbance.

5.7.2 Management Measures

Prior to clearing, a fauna trapping exercise will be undertaken to relocate as much fauna as possible to nearby reserves. Following that, clearing should be undertaken from east to west to allow any remaining fauna to move into the Conservation Area.

5.8 Noise and Dust Management

Land use around the site includes the following:

- Residential development to the north;
- Rockingham Lakes Regional Park to the east and south; and
- Light industry to the west.

Port Kennedy Drive and Ennis Ave are main roads and the Perth-Mandurah passenger rail line is located on the east side of Ennis Ave.

5.8.1 Potential Impacts

Existing noise sources are considered unlikely to impact on the development of the site for light industrial purposes.

With respect to noise emissions from the site, future development must comply with the *Environmental Protection (Noise) Regulations 1997.*

Dust emissions during the construction phase have the potential to impact on the residential area to the north.

5.8.2 Management Measures

Land uses considered suitable for light industrial areas under the Town Planning Scheme are generally unlikely to exceed the *Environmental Protection (Noise) Regulations 1997.*

The residential land to the north of the site is considered to be a 'sensitive land uses' under EPA *Guidance Statement No. 3: Separation Distance between Industrial and Sensitive Land Uses* (2005). The proposed development will comply with the Guidance Statement to ensure adequate separation distances and or management measures for any industry that may cause noise emissions.

The northern interface to the residential area will consider appropriate low impact industrial land uses to preserve the amenity of adjoining residences.

A Dust Management Plan will be prepared to meet the City of Rockingham guidelines in accordance with the subdivision approval prior to commencement of construction.

5.9 Fire Management

The proposed development will be near bushland to the south of Port Kennedy Drive, to the west in the proposed Conservation Area. A bushfire hazard assessment and management plan will be prepared in accordance with *State Planning Policy 3.7 and Guidelines -Policy and regional information for planning in bushfire prone areas.*

6 SUMMARY AND CONCLUSIONS

This Environmental Assessment Report has reviewed the environmental values of proposed Lot 2 (the site) Port Kennedy Drive, Port Kennedy and assessed the potential environmental impact of a Concept Plan and the future development of the site for industrial purposes. The conclusions of the assessment are:

- Full development of the 50.67ha site has environmental approval as a result of the EPA assessment of the rezoning to Industrial in 1994 and Ministerial Statement No. 368 which approved the rezoning. Nevertheless, DevelopmentWA is not seeking full development of the site;
- Development of the whole site includes industrial development on 34.3ha and the creation of a conservation area on the western 16.4ha;
- The conservation area protects a large proportion of the significant wetlands, TEC19 and native vegetation types on the whole site;
- The development site's key environmental values are:
  - eleven individual wetlands, rated as having medium and low environmental values;
  - Threatened Ecological Community (TEC) 19a and 19b in eight of the wetlands; and
  - Fauna habitat for some conservation significant fauna species;
- The Concept Plan will retain the most important wetland (number 15) and an example ofTEC19b in POS (1.7452ha). The Conservation Area will be expanded to include an additional wetland/TEC19 (wetland 14) on the southern boundary;
- ;
- remaining occurrences of TEC19a proposed to be cleared are mostly small and in poor quality, some of which are considered marginal TECs;
- No Declared Rare or Priority Flora occur within the site;
- Fauna relocation, including Quenda, will be undertaken prior to clearing native vegetation from the development site;
- An Urban Water Management Plan will be prepared to facilitate stormwater development of the site in accordance with Water Sensitive Urban Design principles;
- The proposed sewer connection from the development site westwards through the conservation area can be installed without any environmental impact on the vegetation and wetlands in the conservation area;
- With respect to noise emissions from the site, future development must comply with the *Environmental Protection (Noise) Regulations 1997*; and
- A bushfire hazard assessment and Bushfire Management Plan will be required to guide the future subdivision of the development lot.

This Environmental Assessment Report concludes that development of the site in accordance with the Concept Plan and the associated management measures outlined in this report, as well as the retention of a conservation area in the western part of Lot 17, will protect the important environmental assets of the site.

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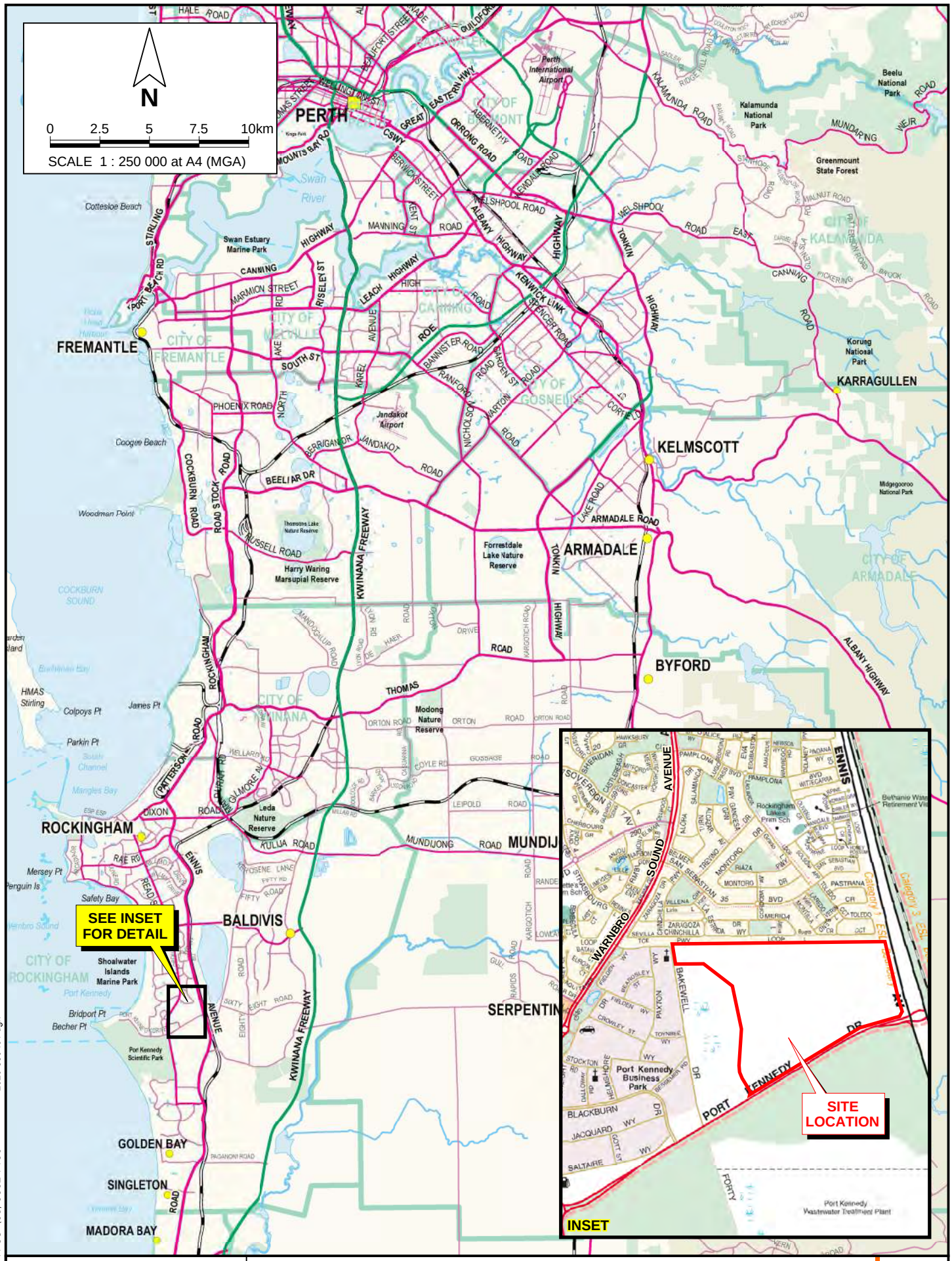
FIGURES



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ENVIRONMENTAL ASSESSMENT REPORT
PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

SITE LOCATION

Figure 1

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

KENNEDY DRIVE

PORT

ENNIS AVENUE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

4830 R 47412

4831

4920

8045

8046

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- Topographic Contour

CADASTRAL SOURCE: Landgate, December 2020.
CONTOUR SOURCE: Department of Agriculture, 2000.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

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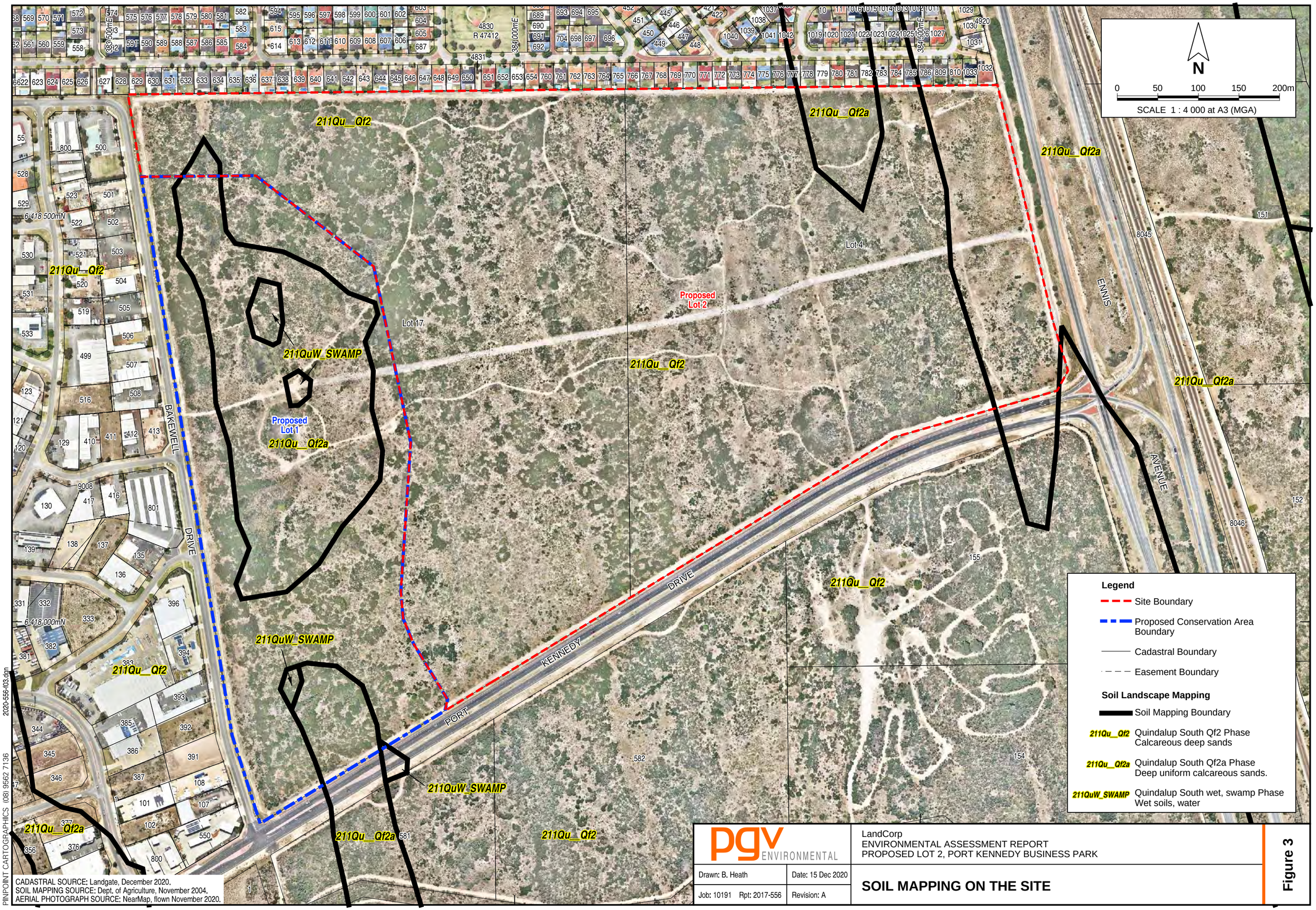
SITE BOUNDARY AND TOPOGRAPHY

Figure 2



CADASTRAL SOURCE: Landgate, December 2020.
SOIL MAPPING SOURCE: Dept. of Agriculture, November 2004.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f03.dgn

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SOIL MAPPING ON THE SITE

Figure 3

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

383 500mE

384 000mE

384 500mE

385 000mE

6 418 500mN

6 418 000mN

BAKEWELL DRIVE

ENNIS AVENUE

KENNEDY DRIVE

PORT

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary

Acid Sulfate Soil Risk

- High to Moderate Risk

ASS SOURCE: DER, January 2010.
CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f04.dgn

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PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

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ACID SULFATE SOIL RISK MAPPING

Figure 4

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

383 500mE

384 000mE

384 500mE

385 000mE

6 418 500mN

6 418 000mN

BAKEWELL DRIVE

PORT KENNEDY DRIVE

ENNIS AVENUE

Proposed Lot 1

Proposed Lot 2

Lot 4

Lot 17

1

2

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- Minimum Groundwater Contour

CADASTRAL SOURCE: Landgate, December 2020.
GROUNDWATER CONTOUR SOURCE: DoW, May 2003.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

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PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

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REGIONAL GROUNDWATER

Figure 5

2020-556-f05.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

14638
14639
6259
6471
6472
6260
6261
6262
6263
6265
6452
6235
6473
6474
6453
6234
6238
6240

Lot 17
Lot 4
Proposed Lot 1
Proposed Lot 2

BAKEWELL DRIVE
ENNIS AVENUE
KENNEDY DRIVE
PORT

6418 500mN
6418 000mN
383 500mE
384 000mE
384 500mE

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary

Threatened Ecological Community

- SCP19a
- SCP19b

Geomorphic Wetlands

- Conservation Category (CCW)
- Resource Enhancement (REW)
- 6263 Wetland UFI

TEC SOURCE: DPaW, August 2016.
WETLANDS SOURCE: DPaW, March 2016.
CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f06.dgn

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ENVIRONMENTAL ASSESSMENT REPORT
PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

DBCA GEOMORPHIC WETLAND AND FCT 19 MAPPING

Figure 6

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

KENNEDY DRIVE

PORT ENNIS AVENUE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

4830 R 47412

4831

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- PGV Wetland Mapping

Environmental Value

- H
- M
- L

CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f07.dgn

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PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

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PGV ENVIRONMENTAL WETLAND MAPPING

Figure 7

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Drill Alignment for Sewer

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

ENNIS AVENUE

KENNEDY DRIVE

PORT KENNEDY DRIVE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- PGV Wetland Mapping
- TEC 19a
- TEC 19b

Environmental Value

- H
- M
- L

CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f08.dgn

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Job: 10191 Rpt: 2017-556 | Revision: A

PGV ENVIRONMENTAL FCT19 MAPPING

Figure 8

APPENDIX 1

MINISTERIAL STATEMENT 368

Ass # 838

Bull # 746

State # 368

WESTERN AUSTRALIA

MINISTER FOR THE ENVIRONMENT

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

CHANGES OF LAND USE AFFECTING SYSTEM SIX AREAS AND LAKES PROTECTED UNDER THE ENVIRONMENTAL PROTECTION POLICY TO URBAN, INDUSTRIAL, SPECIAL USES AND TRANSPORTATION PURPOSES, TO BE REFLECTED IN THE MAJOR METROPOLITAN REGION SCHEME AMENDMENTS FOR THE SOUTH-WEST CORRIDOR (838)

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

This proposal may be implemented subject to the following conditions:

1 Proponent Commitments
The proponent has made a number of environmental management commitments in order to protect the environment.

1-1 In implementing the proposal, the proponent shall fulfil the commitments made in the Public Environmental Review and in response to issues raised following public submissions; provided that the commitments are not inconsistent with the conditions or procedures contained in this statement. These commitments are consolidated in Environmental Protection Authority Bulletin 746 as Appendix 4. (A copy of the commitments is attached.)

2 Implementation
Changes to the proposal which are not substantial may be carried out with the approval of the Minister for the Environment.

2-1 Subject to these conditions, the manner of detailed implementation of the proposal shall conform in substance with that set out in any designs, specifications, plans or other technical material submitted by the proponent to the Environmental Protection Authority with the proposal. Where, in the course of that detailed implementation, the proponent seeks to change those designs, specifications, plans or other technical material in any way that the Minister for the Environment determines on the advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

Published on

11 OCT 1994

12th FLOOR, DUMAS HOUSE, 2 HAVELOCK STREET, WEST PERTH, 6005 TELEPHONE (09) 321 3333 FAX (09) 322 5140

3 Rapid Transport Reserve Alignment

3-1 The proponent shall modify the Metropolitan Region Scheme amendments 937/33 and 938/33 to be consistent with the alignment of the Rapid Transport Reserve as shown in Figures 1 to 12 (Copies attached).

3-2 Prior to construction commencing, to ameliorate and minimise the environmental impacts associated with the construction and operation of the Rapid Transport System, the proponent shall prepare an Environmental Management Programme to the requirements of the Minister for the Environment on advice of the Department of Environmental Protection and the Department of Conservation and Land Management. (See procedure 3).

This Programme, which shall be released for public review for four weeks, shall address, but not be limited to:

1 impacts on vegetation, fauna, hydrology and wetlands; and

2 access to reserves.

4 Deletions from System Six Area M103

4-1 The proponent shall not take any action which will remove the north-west part of System Six Area M103 in Hillman from 'Parks and Recreation Reserve' for 'Public Purposes', or any other purpose which will jeopardise its tenure and management for conservation. (See Figure 14 attached).

4-2 The proponent may allow the development of the area west of Ennis Avenue which is currently within System 6 Area M103 subject to the following requirements:

1 Land owned by the State Planning Commission generally known as Lark Hill shown on Figure 13 (copy attached) west of Warnbro Sound Avenue between Port Kennedy Drive and Secret Harbour and east of the area subject to the Port Kennedy Development Act to be secured and managed for conservation purposes;

2 Land owned by the State Planning Commission reserved under the Metropolitan Region Scheme for Public Purposes generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue, south of Port Kennedy Drive and west of Ennis Avenue and Mandurah Road to be secured and managed for recreational and conservation purposes;

3 A linkage to be provided between the greater part of System 6 Area M103 east of Ennis Avenue through to the coast at Port Kennedy, consistent with recommendations made for System 6 Area M106; and

4 Integration of the management of the area referred to in requirements 1, 2 and 3 above with the management of the Port Kennedy conservation area and the greater area of System Six Area M103.

4-3 Prior to 31 December 1995, the proponent shall ensure that a single integrated Management Plan is prepared for the entire area of the conservation estate (i.e. System Six Area M103, Lark Hill and Port Kennedy conservation areas), to the requirements of the Environmental Protection Authority on advice of the Department of Conservation and Land Management and the Commissioner for Soil and Land Conservation.

This Plan shall identify:

1 the management purpose of specific areas;

2 linkages provided between the greater part of System 6 Area M103 east of Ennis Avenue and the coast at Port Kennedy; and

3 agencies responsible for its implementation; and

4 provide a timetable for implementation.

5 Widening of Safety Bay Road

5-1 Prior to construction of Safety Bay Road between Ennis Avenue and Mandurah Road, Rockingham, the proponent shall prepare an Environmental Management Programme to the requirements of the Minister for the Environment on advice of the Department of Environmental Protection. (See procedure 4).

This Programme shall address, but not necessarily be limited to the following elements:

1 selection of an alignment and construction to minimise the clearing of vegetation;

2 selection of an alignment and construction to minimise or avoid impacts on wetlands;

3 management of fauna; and

4 maintenance and improvement of hydrological connections in the area.

6 Proponent

These conditions legally apply to the nominated proponent.

6-1 No transfer of ownership, control or management of the project which would give rise to a need for the replacement of the proponent shall take place until the Minister for the Environment has advised the proponent that approval has been given for the nomination of a replacement proponent. Any request for the exercise of that power of the Minister shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the project in accordance with the conditions and procedures set out in the statement.

7 Compliance Auditing

In order to ensure that environmental conditions and commitments are met, an audit system is required.

7-1 To help verify environmental performance, the proponent shall prepare periodic Progress and Compliance Reports in consultation with the Department of Environmental Protection.

Procedure

1 The Department of Environmental Protection is responsible for verifying compliance with the conditions contained in this statement, with the exception of conditions stating that the proponent shall meet the requirements of either the Minister for the Environment or any other government agency.

2 If the Department of Environmental Protection, other government agency or proponent is in dispute concerning compliance with the conditions contained in this statement, that dispute will be determined by the Minister for the Environment.

3 At an appropriate time prior to construction of the Rapid Transport System, the Minister for the Environment will effect a transfer of proponent, under Section 38(7) of the

Environmental Protection Act, from the current proponent to the agency responsible for the construction of the System. (See condition 3-2).

4 At an appropriate time prior to construction of Safety Bay Road between Ennis Avenue and Mandurah Road, Rockingham, the Minister for the Environment will effect a transfer of proponent, under Section 38(7) of the Environmental Protection Act, from the current proponent to the agency responsible for the construction of the road. (See condition 5-1).

Kevin Minson MLA
MINISTER FOR THE ENVIRONMENT

10 OCT 1994

PROPONENT'S ENVIRONMENTAL MANAGEMENT COMMITMENTS

CHANGES OF LAND USE AFFECTING SYSTEM SIX AREAS & LAKES PROTECTED UNDER THE ENVIRONMENTAL PROTECTION POLICY

TO URBAN, INDUSTRIAL, SPECIAL USES & TRANSPORTATION PURPOSES,

TO BE REFLECTED IN THE MAJOR METROPOLITAN REGION SCHEME AMENDMENTS FOR THE SOUTH-WEST CORRIDOR (838)

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

10.0 COMMITMENTS BY THE PROPONENT

Subject to the understanding that DPUD is not a statutory decision making body (except in a minor way by delegation) and that DPUD has only an advisory role to the Minister for Planning, the State Planning Commission and the Metropolitan Planning Council, and subject to the understanding that many decisions made on the advice of DPUD can be overturned on appeal, and subject to the understanding that DPUD does not have responsibility for the actual construction of major roads and other items of transport infrastructure, DPUD, as proponent of this PER makes the following commitments.

1. The additional areas proposed for rezoning to Parks and Recreation in the 1993 Structure Plan for the South West Corridor will be zoned for this purpose. That is, subsequent to implementation of the current Stage A and B Amendments, DPUD will recommend that additional amendments are initiated to achieve all of the Parks and Recreation allocations as proposed in the Structure Plan.

2. In the event that minor modifications to proposed Parks and Recreation Reserves are considered desirable prior to formal zoning, then DPUD will recommend that adjustments be made to ensure that there will not be a reduction in the overall allocation of open space for conservation purposes in the South West Corridor.

3. During future implementation of infrastructure proposals within transport reserves established by the Stage A and B Amendments, DPUD will recommend that a detailed Environmental Management Program (EMP) is required prior to construction (to be prepared to the satisfaction of the EPA). In particular, the following elements will be addressed by future EMP's:

    - the rapid transport route and its effects on important areas of natural environment, including but not limited to System 6 area M103 (Rockingham Lakes), The Spectacles, Stakehill Swamp and Anstey Swamp;

    - the Eighty Road extension and its impingement on the Tamworth Hill EPP wetland;

    - the proposed Beeliar Drive and its crossing of M92 and an EPP wetland;

- the widening of Russell Road through the Beeliar Regional Park (M93), and

- the proposed upgrading of Safety Bay Road through System 6 area M103.

4. As urbanisation of the South West Corridor progresses, DPUD will endeavour to ensure that the environmental protection requirements implicit to this PER are implemented, where appropriate, in Town Planning Schemes, District and Local Structure Plans and Subdivision Plans. In general, the aim will be to achieve adequate protection of Structure Plan wetlands (including EPP wetlands) and the following specific environmental features;

- the EPP wetland in the proposed regional sporting centre for the City of Cockburn (part of a proposed Parks and Recreation Reserve north of Beeliar Drive and east of the new Forest Road alignment) will be protected from recreational development;

- the two small wetlands in an area of proposed Urban Deferred (west of Hammond Road and north of Russell Road) will be incorporated within open space;

- the extreme north-eastern side of Tamworth Hill Swamp extends into a proposed urban area and, whilst completely degraded, it will be protected from adverse drainage and water quality changes which may affect Tamworth Hill Swamp;

- the small areas of System 6 area M92 which are not included as Parks and Recreation Reserve will be incorporated into local open space; and

- the southern 'spur' of System 6 area M93, which includes two wetlands, will be protected in local open space.

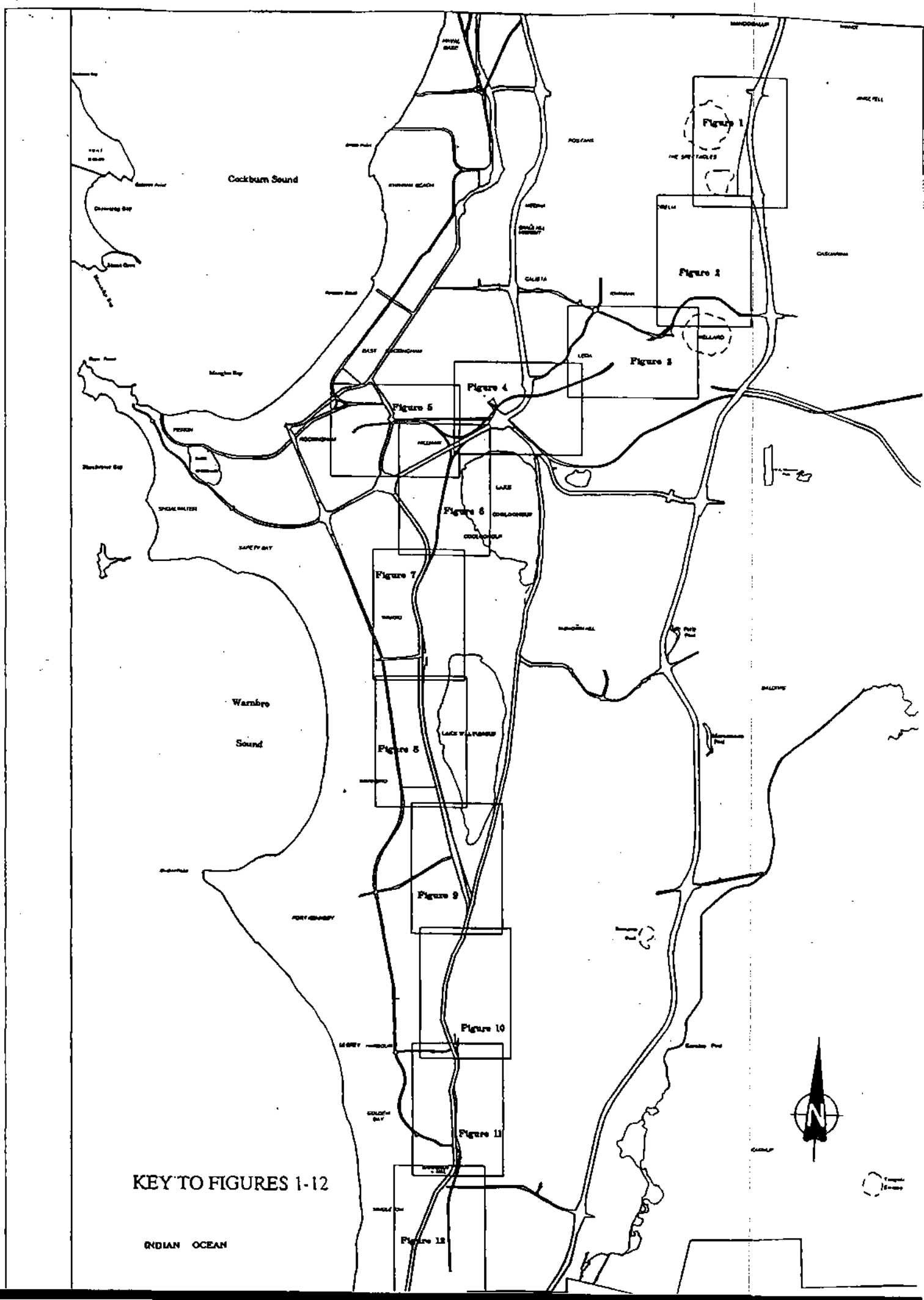
5. Where the rapid transport reserve crosses public land, such as the Leda open space and northern sector of M103, flexibility in the alignment will be accommodated via minor amendments to the MRS in the event that detailed environmental assessment (during preparation of the EMP) identifies an alternative, acceptable alignment with reduced environmental impact.

6. A detailed re-assessment of the configuration of the Garden Island Highway and rapid transport reserve will be conducted for the interchange area in the vicinity of Dixon Road (east) and the Mundijong railway, to determine whether or not the EPP wetland can be avoided and the rapid transport route deviated further to the north from Lake Cooloongup.

7. DPUD will prevail upon the City of Rockingham to negotiate with Special Rural landholders adjacent to the Naim Road reserve to attempt to avoid the EPP wetland which will currently be affected by future road construction. The option of wetland replacement will be discussed with the City of Rockingham.

8. DPUD will conduct further assessment of the alternatives for the rapid transport reserve in the vicinity of The Spectacles, with a view to minimising potential adverse effects on this important area.

9. DPUD will recommend that the proposed Hillman Public Purposes Reserve be deleted from the Stage B Major Amendment to the Metropolitan Region Scheme on the basis of findings of this PER.


Cockburn Sound
Figure 1
Figure 2
Figure 3
Figure 4
Figure 5
Figure 6
Figure 7
Figure 8
Figure 9
Figure 10
Figure 11
Figure 12
Warnbro
Sound
KEY TO FIGURES 1-12
INDIAN OCEAN
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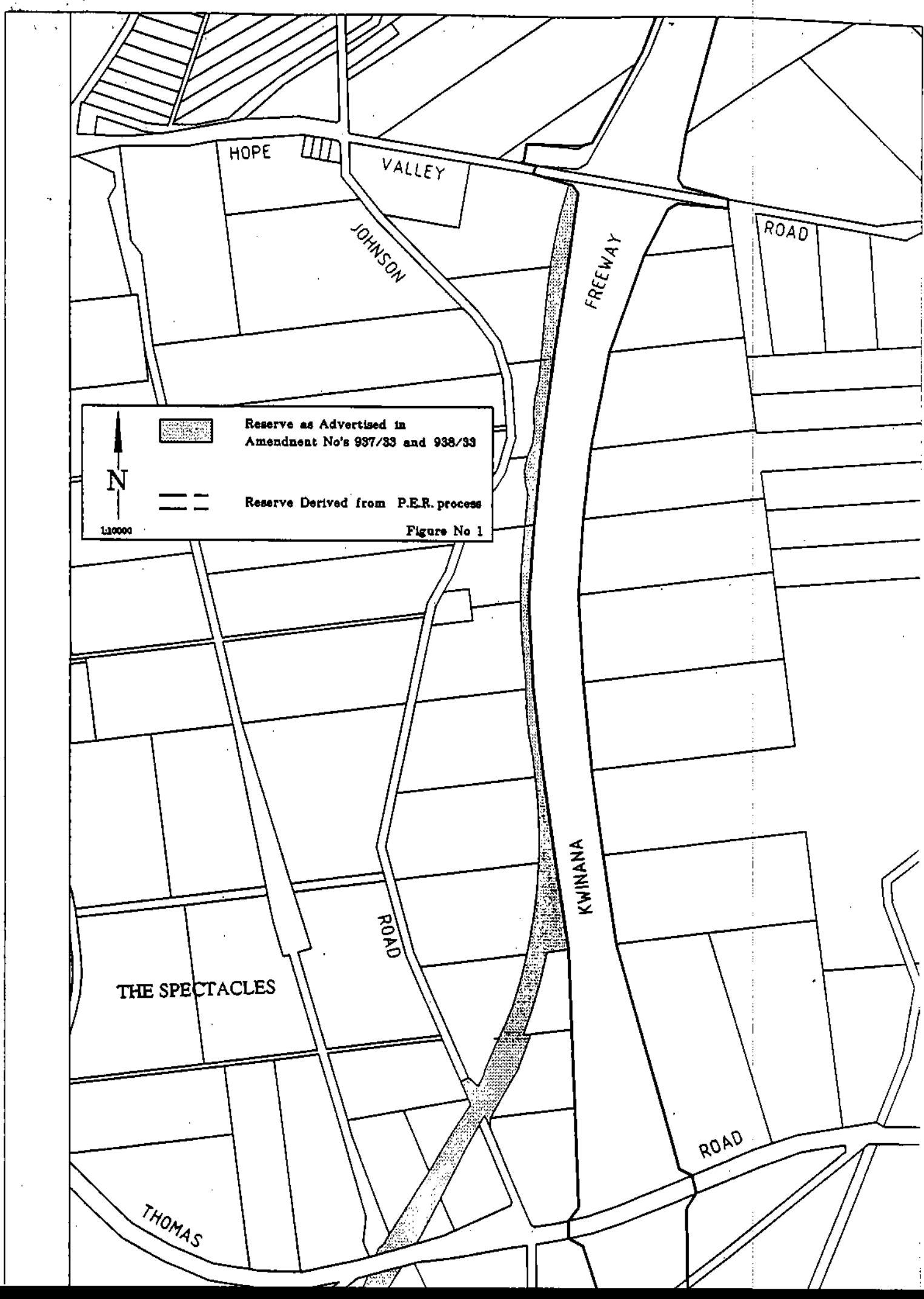
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JOHNSON
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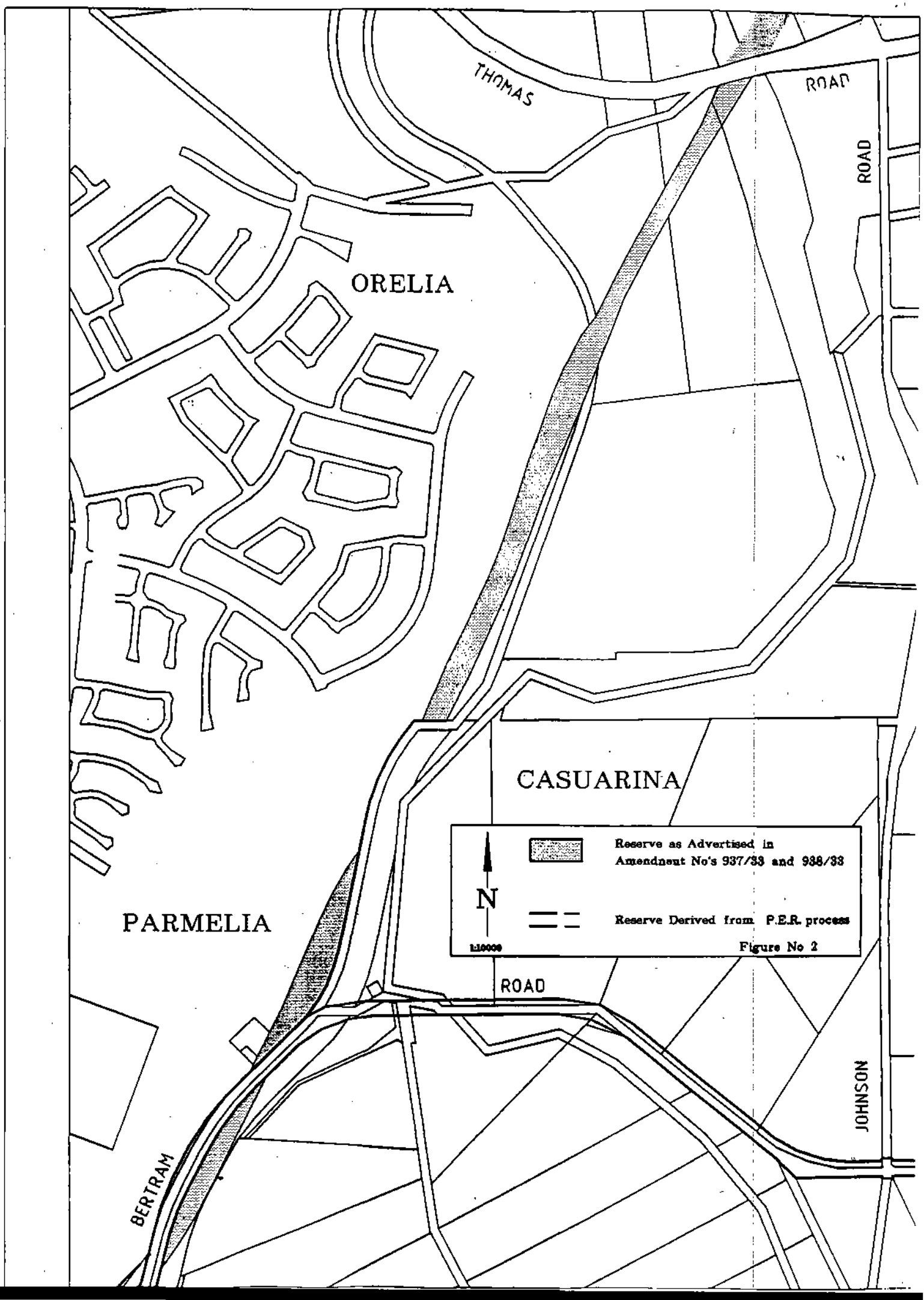
THE SPECTACLES
ROAD
THOMAS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CASUARINA
PARMELIA
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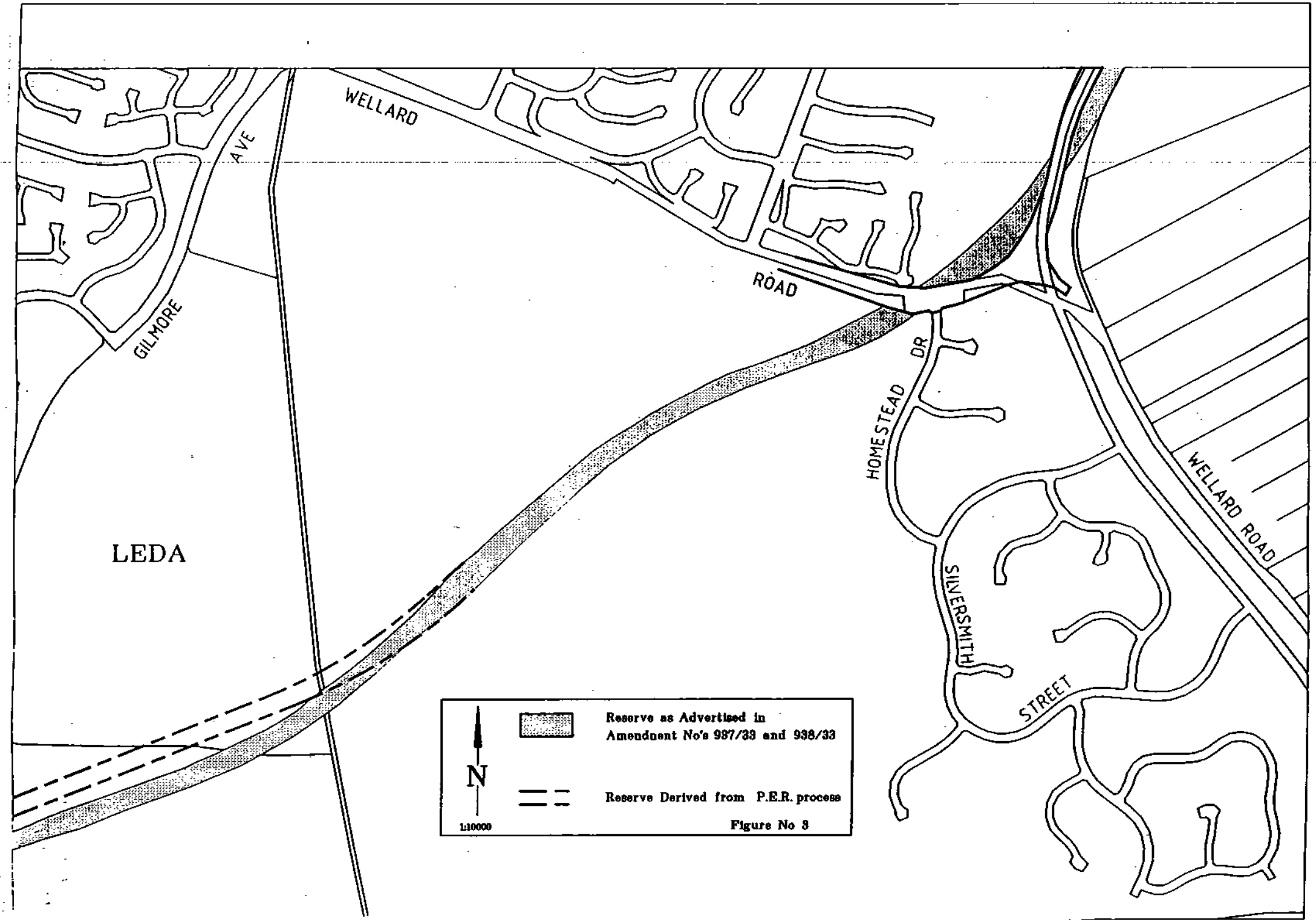
BERTRAM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AVE
ROAD
GILMORE
HOMESTEAD DR
WELLARD ROAD
SILVERSMITH
STREET
LEDA
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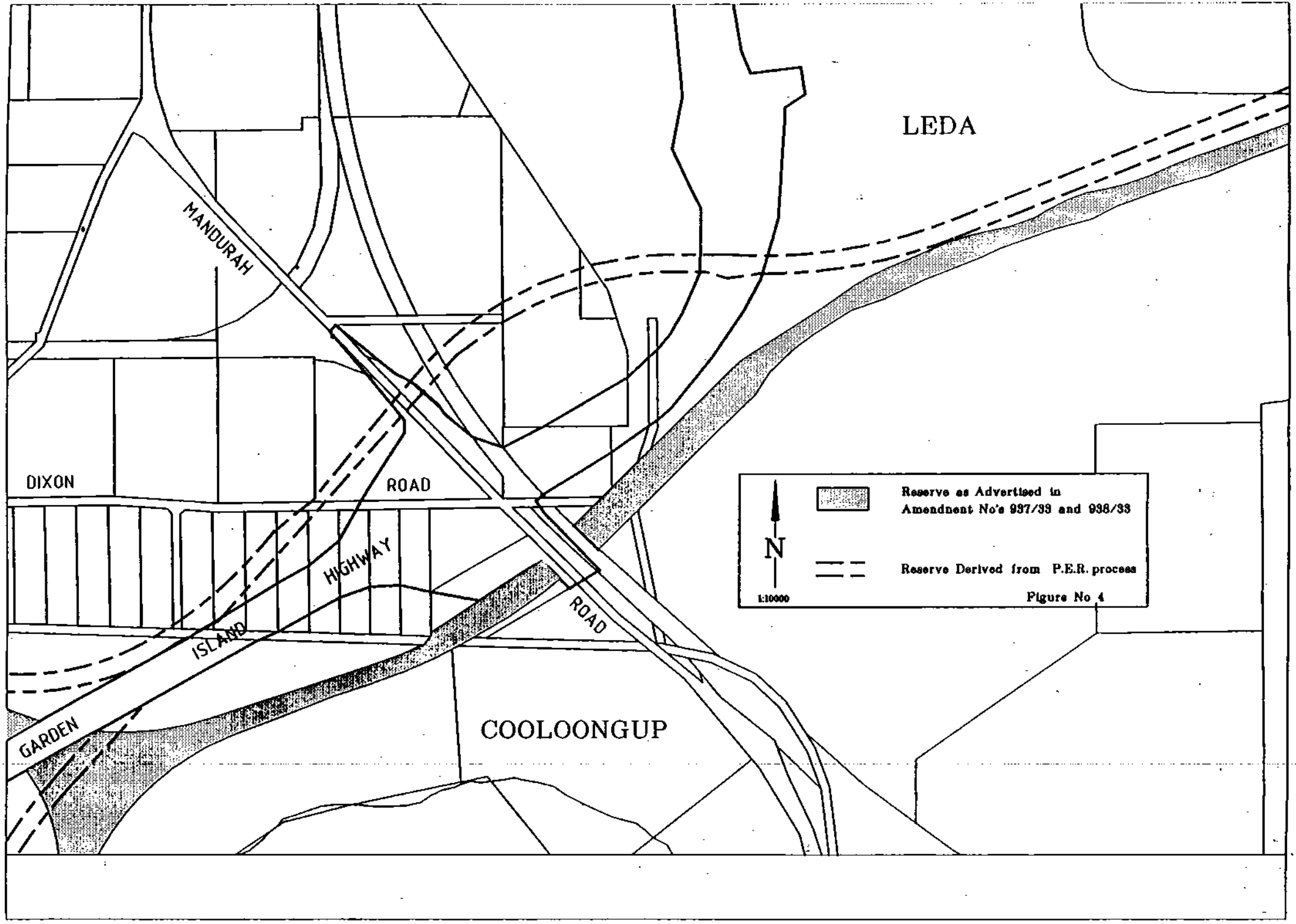
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DIXON
ROAD
HIGHWAY
ISLAND
ROAD
GARDEN
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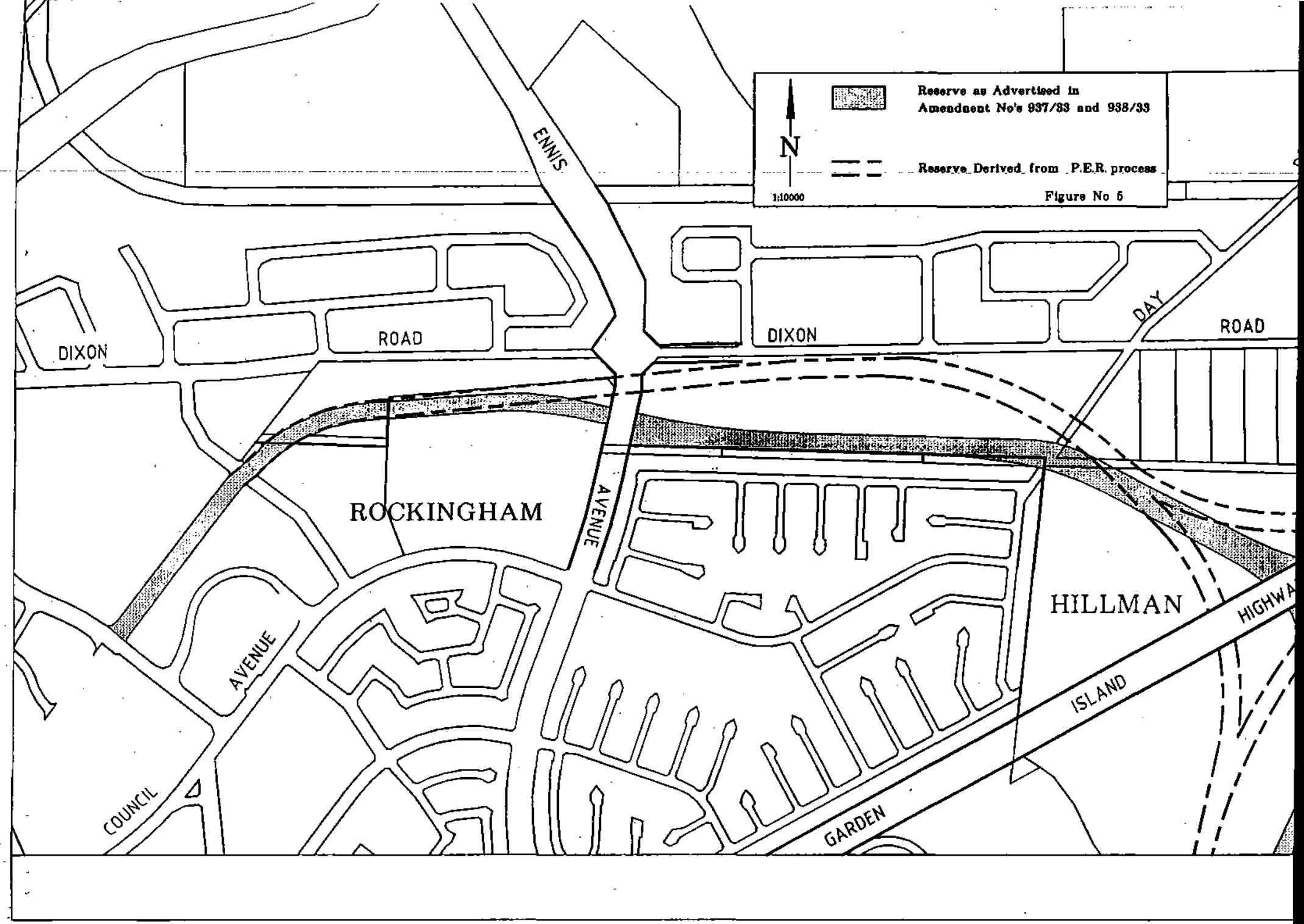
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ROAD
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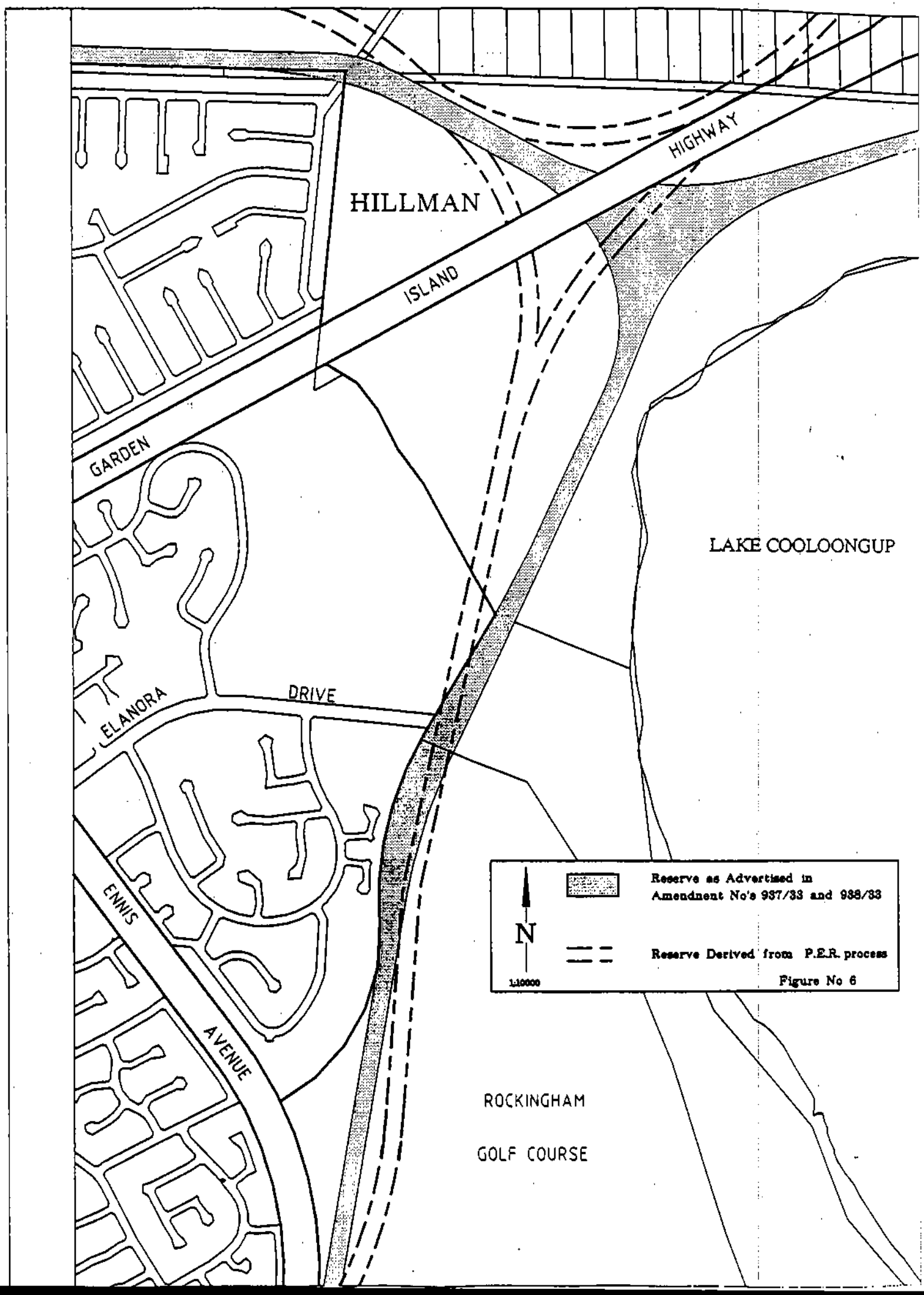
AVENUE
AVENUE
HILLMAN
HIGHWA
ISLAND
COUNCIL
GARDEN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HIGHWAY
ISLAND
GARDEN
LAKE COOLOONGUP
ELANORA
DRIVE
ENNIS
AVENUE
ROCKINGHAM
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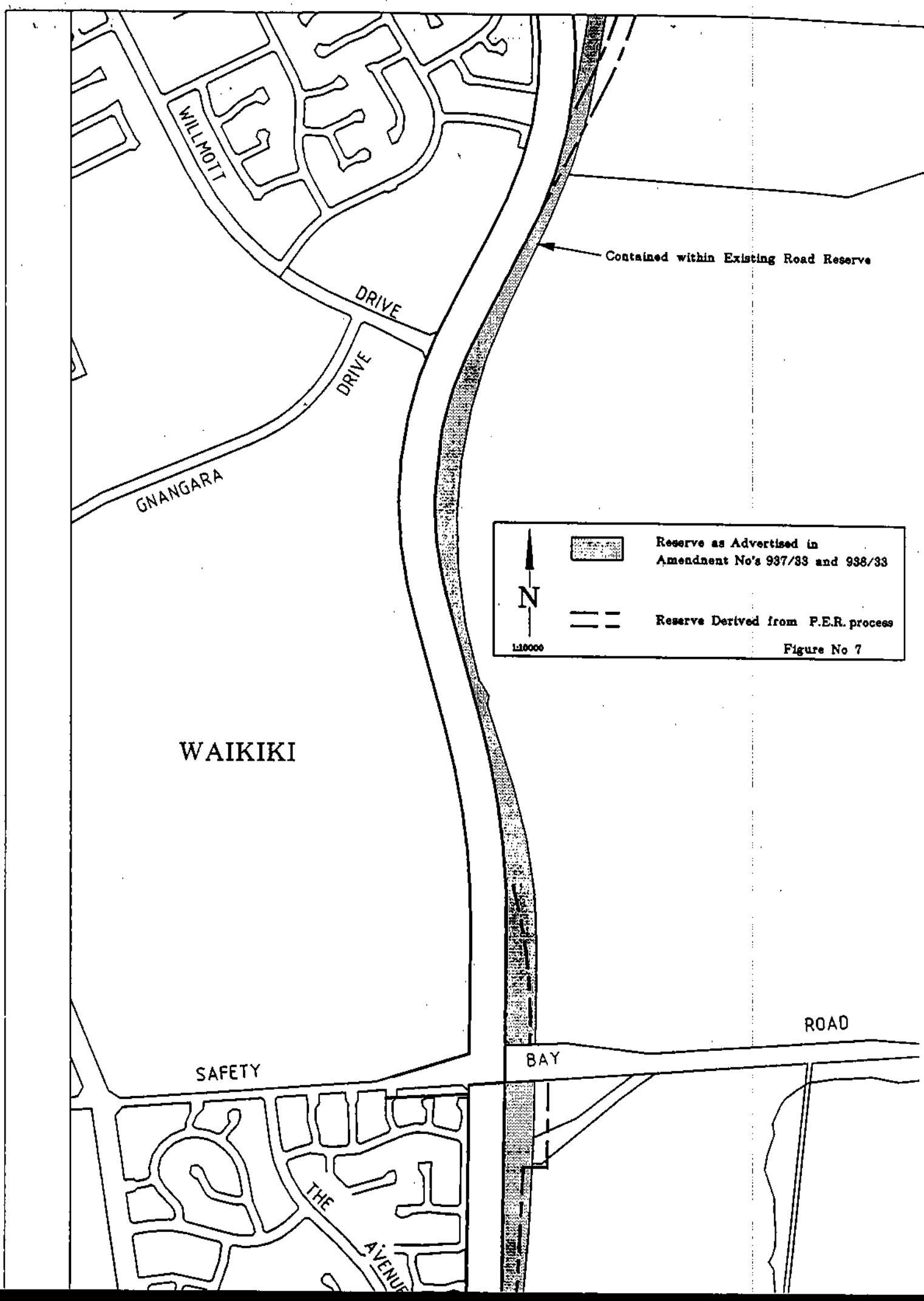
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DRIVE
GNANGARA
Contained within Existing Road Reserve
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Reserve as Advertised in Amendnent No's 937/33 and 938/33
Reserve Derived from P.E.R. process
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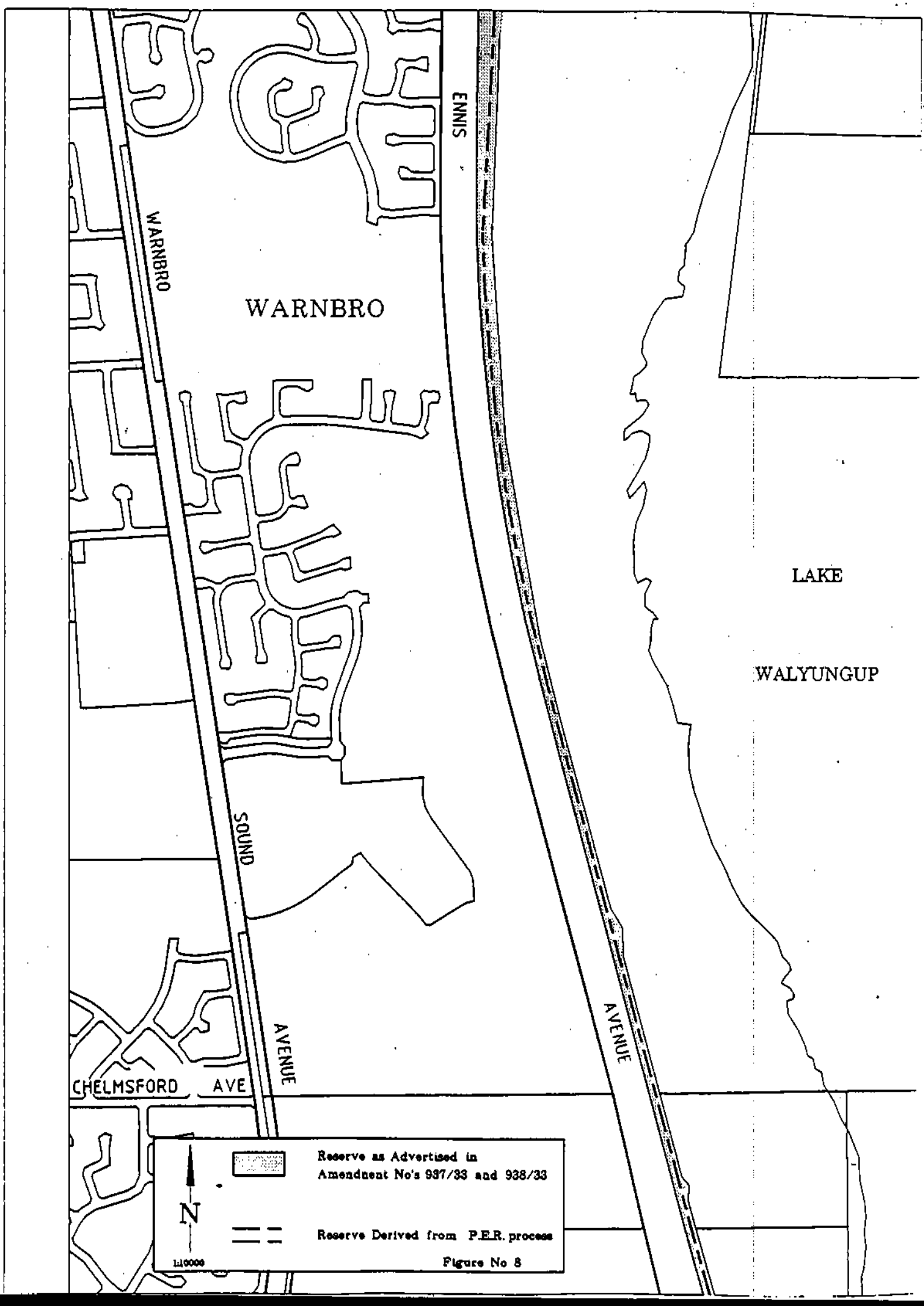
ROAD
BAY
SAFETY
THE
AVENUE

Figure No 7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WARNBRO
WARNBRO
LAKE
WALYUNGUP
SOUND
AVENUE
AVENUE
CHELMSFORD
AVE
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Amendment No's 937/33 and 938/33
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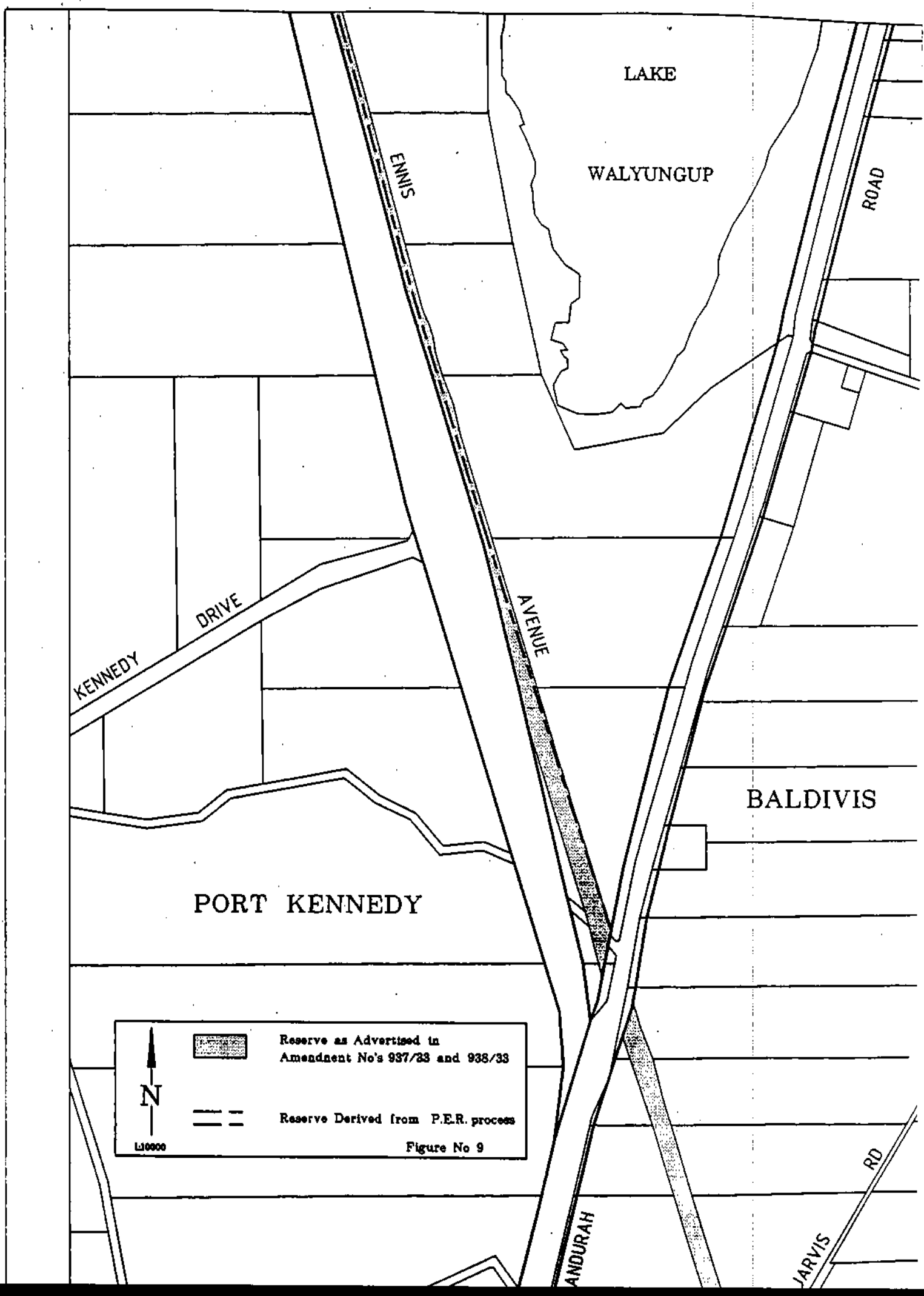
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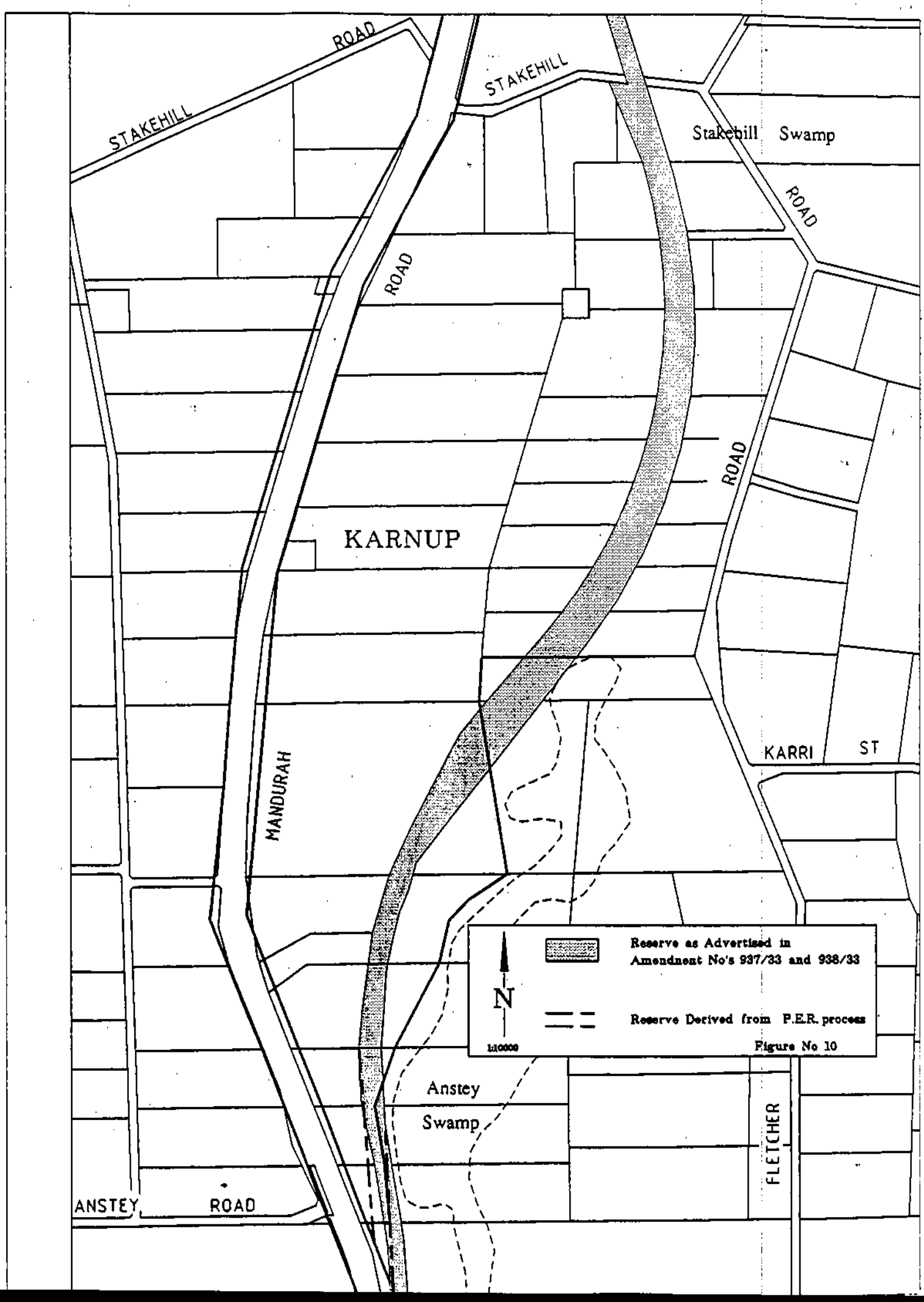
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STAKEHILL
Stakehill Swamp
ROAD
ROAD
ROAD
KARNUP
MANDURAH
KARRI ST
Reserve as Advertised in Amendment No's 937/33 and 938/33
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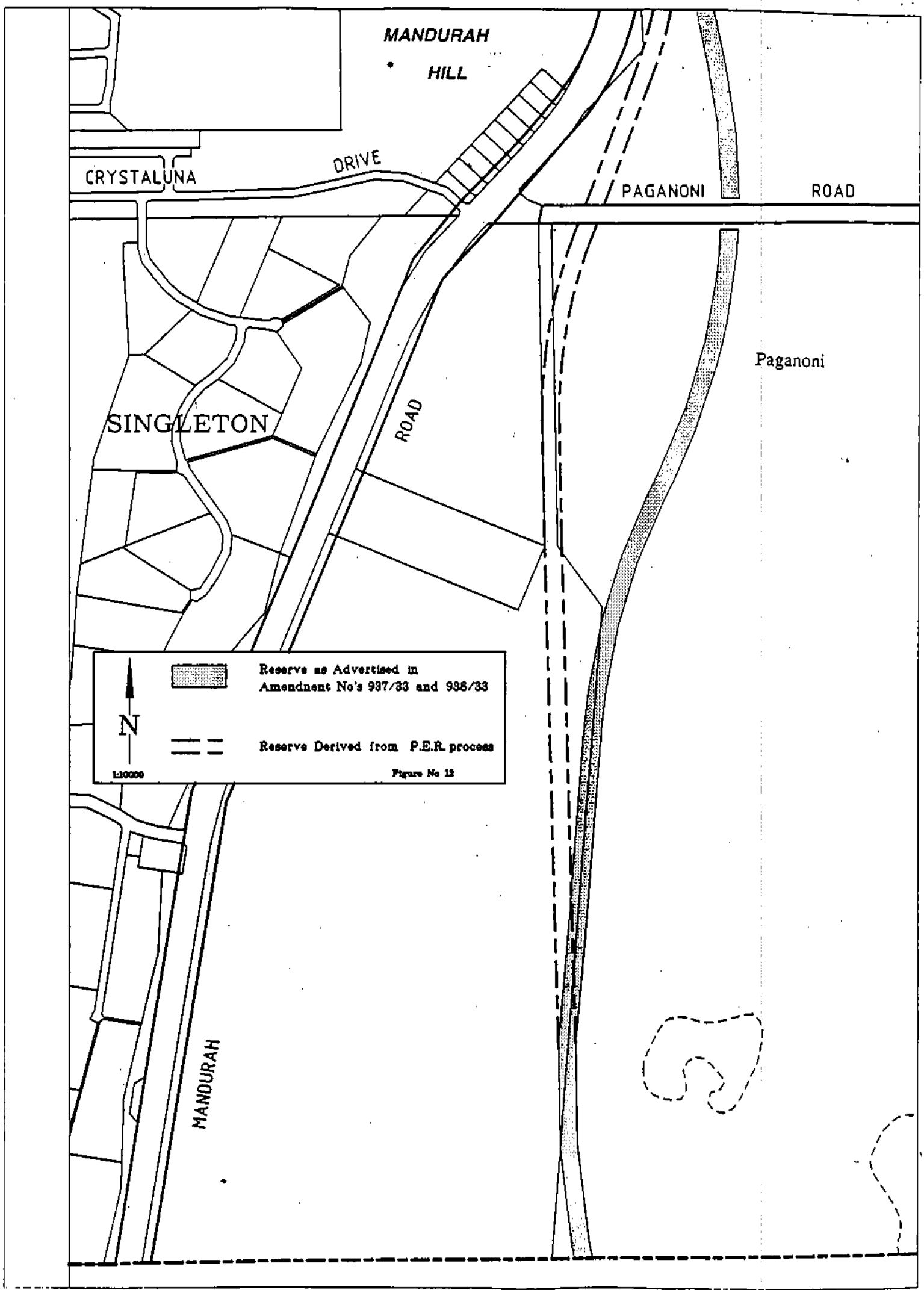
FLETCHER
ANSTEY ROAD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CRYSTALUNA
DRIVE
PAGANONI
ROAD
Paganoni
SINGLETON
ROAD
MANDURAH
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Reserve Derived from P.E.R. process
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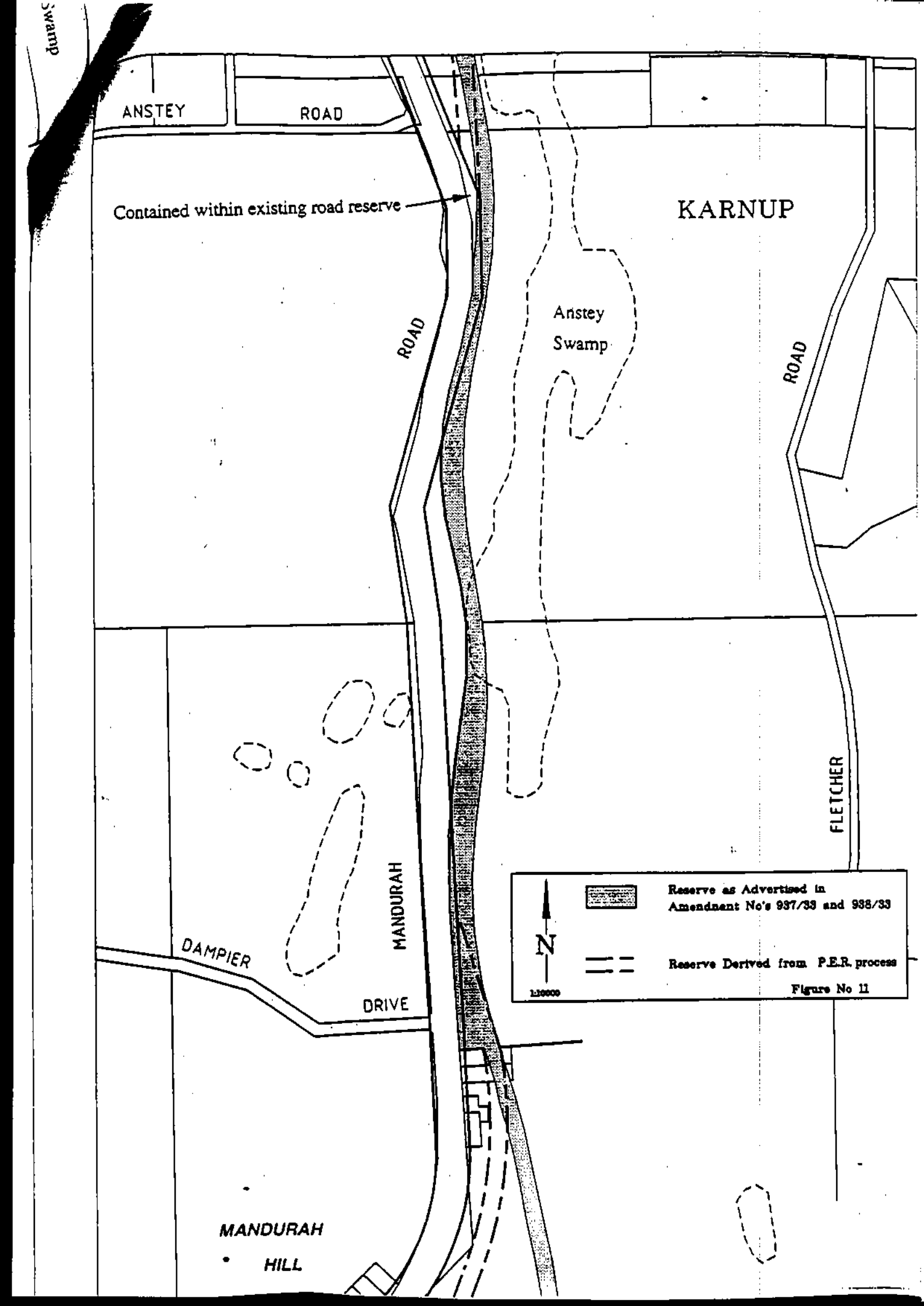
Figure No 12


ANSTEY
ROAD
Contained within existing road reserve
KARNUP
ROAD
Anstey
Swamp
ROAD
FLETCHER
MANDURAH
DAMPIER
DRIVE
MANDURAH
HILL
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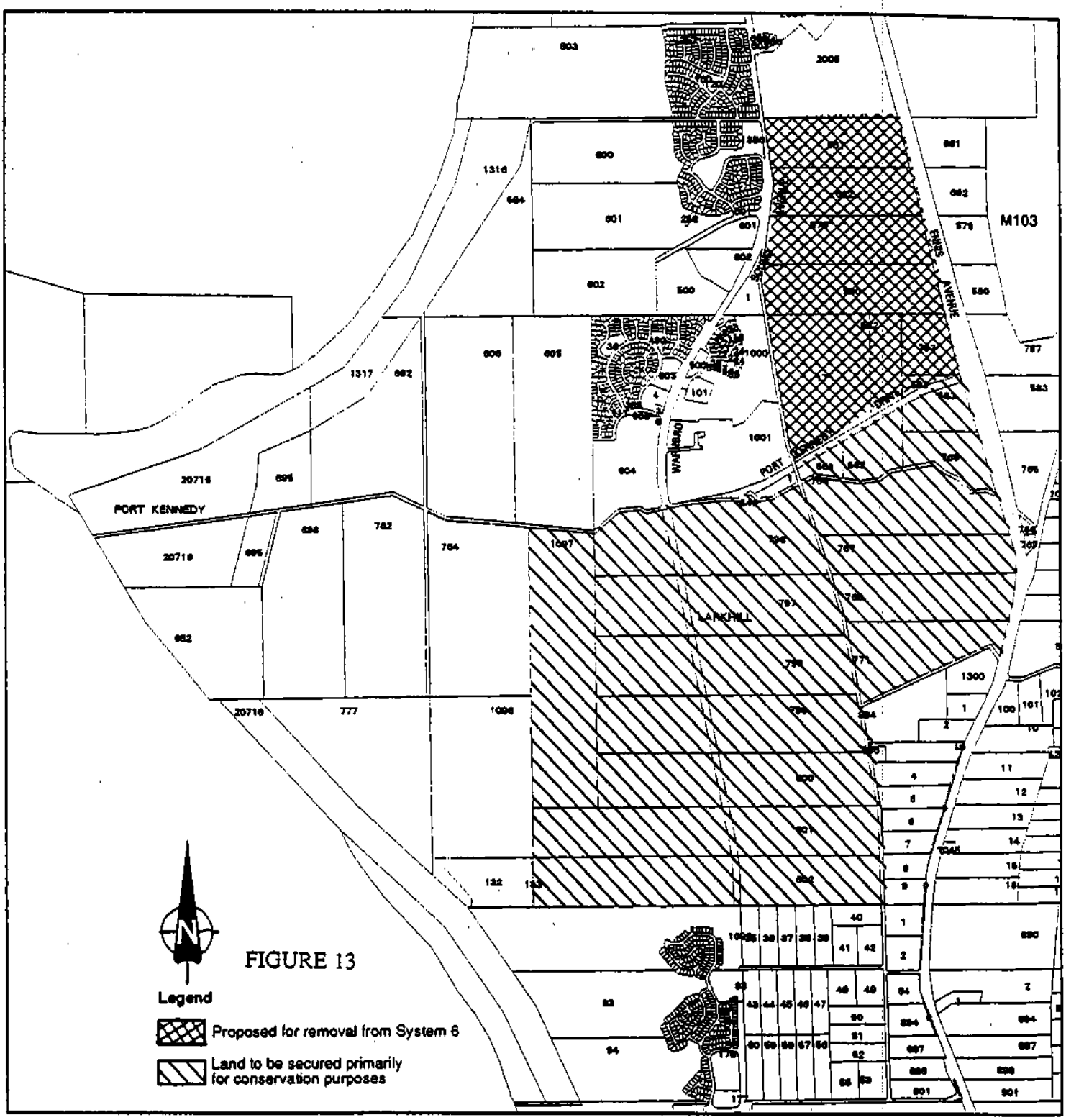
M103
PORT KENNEDY
LANKHILL
ENNIS AVENUE
WARREN RD
PORT KENNEDY DRIVE
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Legend
Proposed for removal from System 6
Land to be secured primarily for conservation purposes

FIGURE 13

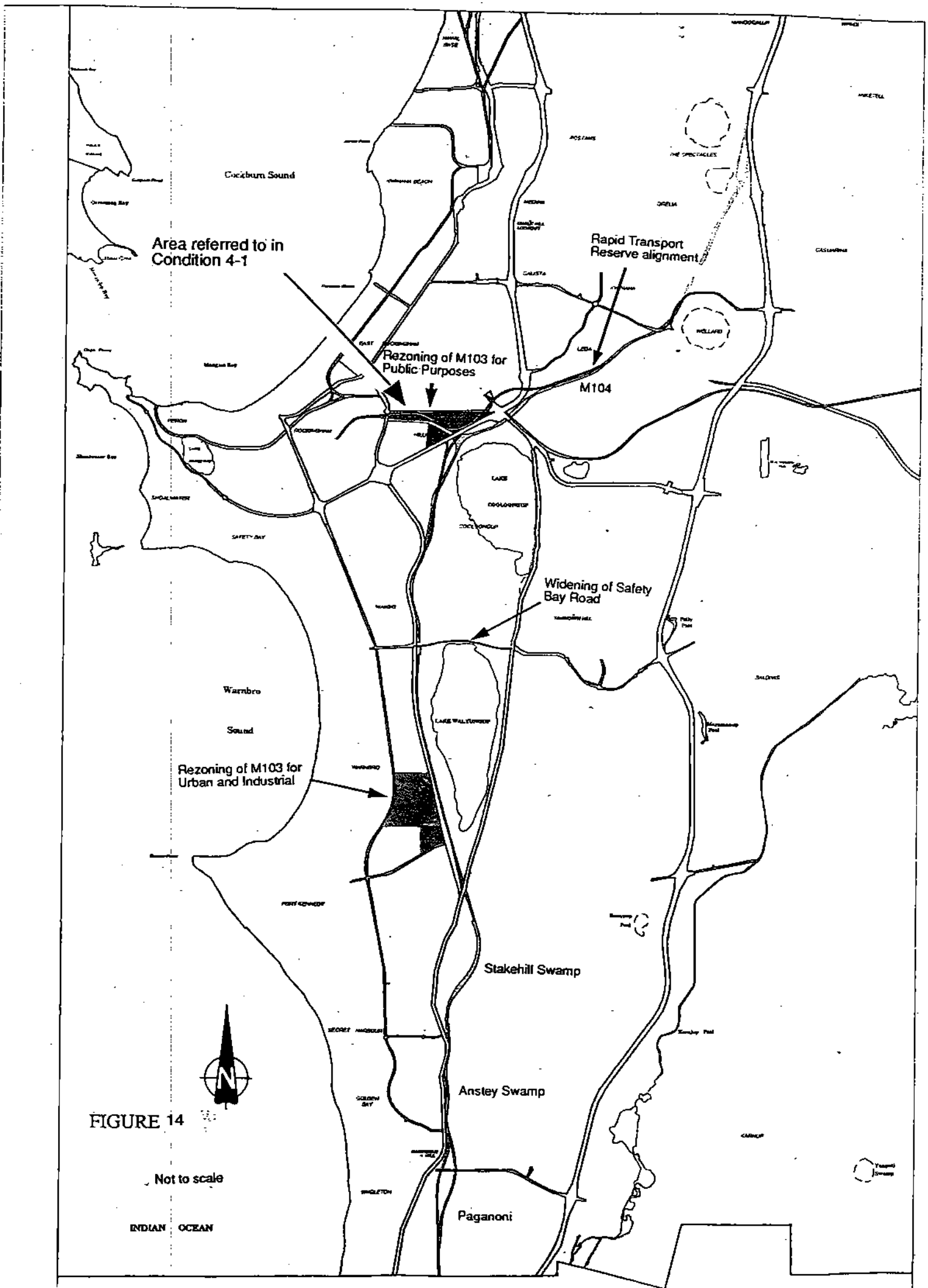

Cockburn Sound
Area referred to in Condition 4-1
Rapid Transport Reserve alignment
Rezoning of M103 for Public Purposes
M104
Widening of Safety Bay Road
Warnbro Sound
Rezoning of M103 for Urban and Industrial
Stakehill Swamp
Anstey Swamp
Paganoni
N
Not to scale
INDIAN OCEAN

FIGURE 14

APPENDIX 2

WAPC APPROVAL 156342

Your Ref : 17-278

TPG Town Planning, Urban Design And Heritage
Level 18 191 St Georges Terrace
PERTH WA 6000

Approval Subject To Condition(s)
Freehold (Green Title) Subdivision

Application No : 156342

Planning and Development Act 2005

Applicant	:	TPG Town Planning, Urban Design And Heritage Level 18 191 St Georges Terrace PERTH WA 6000
Owner	:	Landcorp The Esplanade PERTH WA 6000
Application Receipt	:	1 March 2018

Lot Number	:	4 & 17
Diagram / Plan	:	D065566, D094300
Location	:	
C/T Volume/Folio	:	1663/339, 2126/431
Street Address	:	Lots 4 And 17 Port Kennedy Drive, Port Kennedy
Local Government	:	City of Rockingham

The Western Australian Planning Commission has considered the application referred to and is prepared to endorse a deposited plan in accordance with the plan date-stamped **01 March 2018** once the condition(s) set out have been fulfilled.

This decision is valid for **three years** from the date of this advice, which includes the lodgement of the deposited plan within this period.

The deposited plan for this approval and all required written advice confirming that the requirement(s) outlined in the condition(s) have been fulfilled must be submitted by **06 July 2021** or this approval no longer will remain valid.

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

Reconsideration - 28 days

Under section 151(1) of the *Planning and Development Act 2005*, the applicant/owner may, within 28 days from the date of this decision, make a written request to the WAPC to reconsider any condition(s) imposed in its decision. One of the matters to which the WAPC will have regard in reconsideration of its decision is whether there is compelling evidence by way of additional information or justification from the applicant/owner to warrant a reconsideration of the decision. A request for reconsideration is to be submitted to the WAPC on a Form 3A with appropriate fees. An application for reconsideration may be submitted to the WAPC prior to submission of an application for review. Form 3A and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Right to apply for a review - 28 days

Should the applicant/owner be aggrieved by this decision, there is a right to apply for a review under Part 14 section 251 of the *Planning and Development Act 2005*. The application for review must be submitted in accordance with part 2 of the *State Administrative Tribunal Rules 2004* and should be lodged within 28 days of the date of this decision to: the State Administrative Tribunal, Level 6, State Administrative Tribunal Building, 565 Hay Street, PERTH, WA 6000. It is recommended that you contact the tribunal for further details: telephone 9219 3111 or go to its website: http://www.sat.justice.wa.gov.au

Deposited plan

The deposited plan is to be submitted to the Western Australian Land Information Authority (Landgate) for certification. Once certified, Landgate will forward it to the WAPC. In addition, the applicant/owner is responsible for submission of a Form 1C with appropriate fees to the WAPC requesting endorsement of the deposited plan. A copy of the deposited plan with confirmation of submission to Landgate is to be submitted with all required written advice confirming compliance with any condition(s) from the nominated agency/authority or local government. Form 1C and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Condition(s)

The WAPC is prepared to endorse a deposited plan in accordance with the plan submitted once the condition(s) set out have been fulfilled.

The condition(s) of this approval are to be fulfilled to the satisfaction of the WAPC.

The condition(s) must be fulfilled before submission of a copy of the deposited plan for endorsement.

The agency/authority or local government noted in brackets at the end of the condition(s) identify the body responsible for providing written advice confirming that the WAPC's requirement(s) outlined in the condition(s) have been fulfilled. The written advice of the agency/authority or local government is to be obtained by the applicant/owner. When the written advice of each identified agency/authority or local government has been obtained, it

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

should be submitted to the WAPC with a Form 1C and appropriate fees and a copy of the deposited plan.

If there is no agency/authority or local government noted in brackets at the end of the condition(s), a written request for confirmation that the requirement(s) outlined in the condition(s) have been fulfilled should be submitted to the WAPC, prior to lodgement of the deposited plan for endorsement.

Prior to the commencement of any subdivision works or the implementation of any condition(s) in any other way, the applicant/owner is to liaise with the nominated agency/authority or local government on the requirement(s) it considers necessary to fulfil the condition(s).

The applicant/owner is to make reasonable enquiry to the nominated agency/authority or local government to obtain confirmation that the requirement(s) of the condition(s) have been fulfilled. This may include the provision of supplementary information. In the event that the nominated agency/authority or local government will not provide its written confirmation following reasonable enquiry, the applicant/owner then may approach the WAPC for confirmation that the condition(s) have been fulfilled.

In approaching the WAPC, the applicant/owner is to provide all necessary information, including proof of reasonable enquiry to the nominated agency/authority or local government.

The condition(s) of this approval, with accompanying advice, are:

CONDITIONS

1. The boundary between proposed Lots 1 and 2 being amended as per the attached plan dated 3 July 2018. (Local Government)

Environment

2. Prior to the commencement of subdivisional works a Conservation Area Management Plan is to be prepared for Conservation Area Lot 1 in consultation with the Department of Biodiversity, Conservation and Attractions and the City of Rockingham and approved to ensure the protection and management of the site's environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Biodiversity, Conservation and Attractions)

Fire and emergency infrastructure

3. Prior to the commencement of subdivision works, the proposed lots are to be searched for unexploded ordnance to a depth of at least one metre. (Department of Fire and Emergency Services)

4. A notification pursuant to section 165 of the *Planning and Development Act 2005* is to be placed on the certificate of title of the proposed lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification to state as follows:

   "This land has been used as an artillery range and for heavy explosive ordnance dumping and may contain unexploded ordnance. While the land has been searched to a depth of one metre no guarantee can be given that all unexploded ordnance have been located. Any ordnance found should be treated as dangerous and its location reported to police or defence establishment." (Western Australian Planning Commission)

Transport

5. Pursuant to Section 150 of the *Planning and Development Act 2005* and Division 3 of the *Planning and Development Regulations 2009* a covenant preventing vehicular access onto Ennis Avenue and part of Port Kennedy Drive (as per the attached plan dated 3 July 2018) being lodged on the certificate of title of proposed Lot 2 at the full expense of the landowner/applicant. The covenant is to prevent access, to the benefit of Main Roads Western Australia, and the covenant is to specify:

   "*No vehicular access is permitted to or from Ennis Avenue or this section of Port Kennedy Drive*." (Main Roads Western Australia)

ADVICE

1. With regard to Condition 2, the Conservation Area Management Plan is to include measures to rehabilitate degraded areas and monitor hydrology and vegetation health. Weed control, rubbish removal, safe management access and the installation of appropriate fencing or barriers is also be addressed. The Plan is to include a commitment and timeline for amending the classification of the Conservation Area with the vesting in the appropriate authority.

2. The City of Rockingham favours the retention of wetlands 15 and 17 within proposed Lot 2 as part of its future development.

3. The Department of Fire and Emergency Services (DFES) advises that historical research has revealed that during the past 100 years, former elements of the Australian Defence Forces may have conducted training and/or operational activities within or close to the area of the proposed subdivision. It is possible that as a result of these activities, the subject area may contain unexploded ordnance (UXO). Whilst it is considered that the possible risk from UXO on the land subject to this approval is minimal, an absolute guarantee that the area is free from UXO cannot be given. Should, during subdivisional works, or at any other time, a form or suspected form of UXO be located, DFES has advised that the following process should be initiated:

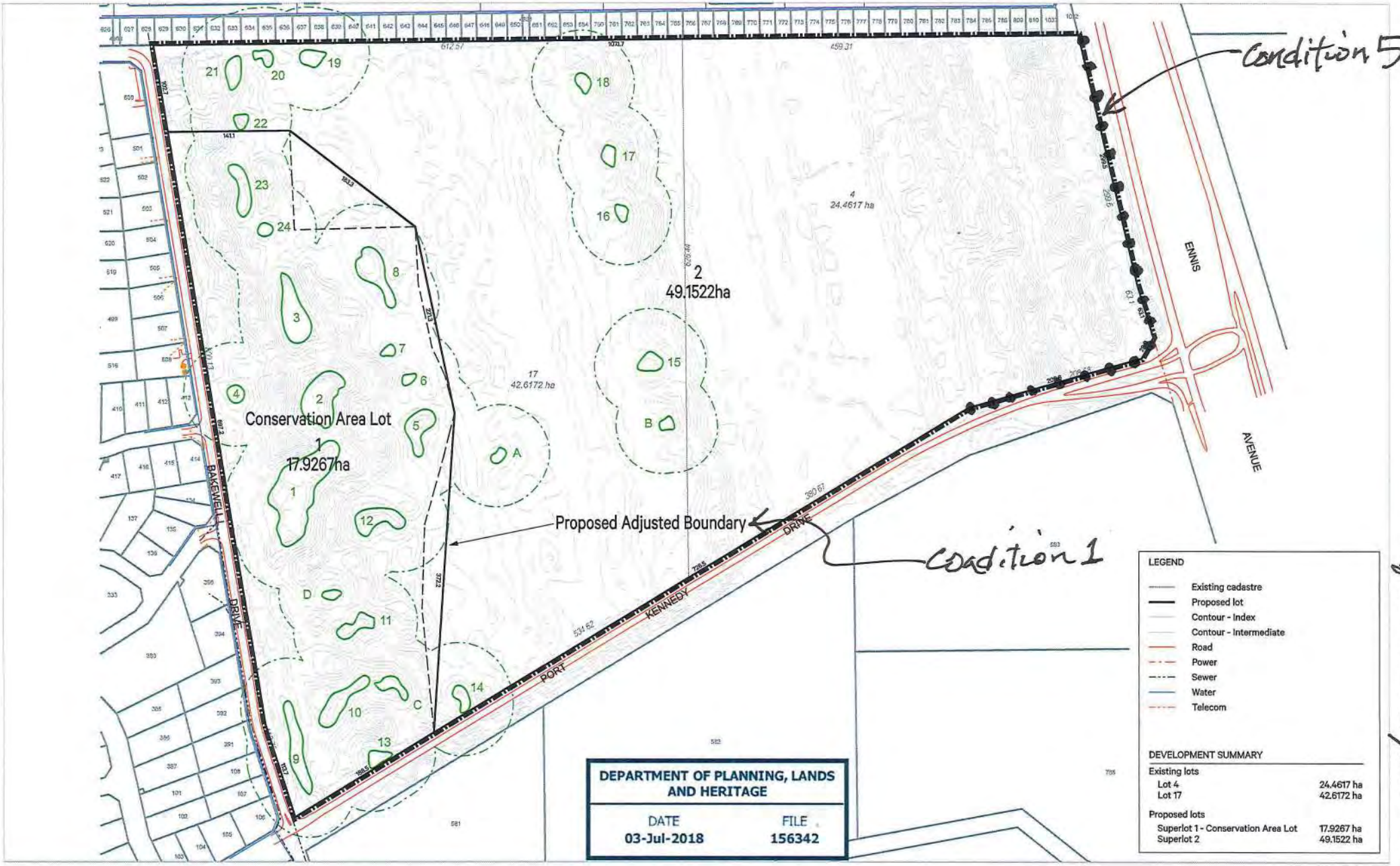
a) do not disturb the site of the known or suspected UXO;
b) without disturbing the immediate vicinity, clearly mark the site of the UXO;
c) notify Police of the circumstances/situation as quickly as possible; and
d) maintain a presence near the site until advised to the contrary by a member of the WA Police Service or Defence Forces.

Further advice on this issue may be obtained by contacting the Unexploded Ordnance Unit, Department of Fire and Emergency Services.

Ms Sam Fagan
Secretary
Western Australian Planning Commission
6 July 2018

Enquiries : Regan Douglas (Ph 6551 9289)

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493



Subdivision Plan - Amended

Lots 4 & 17 Port Kennedy Drive, Port Kennedy

Date: 7 May 2018 Scale: 1:4000 @A3 Drawing No. 717.278 SU1A Staff: LC/MR Checked: MR

element.

APPENDIX 3

GEOTECHNICAL REPORT

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Preliminary Geotechnical Investigation

Proposed Industrial and Commercial Development
Port Kennedy Business Park
Port Kennedy, WA

Prepared for
Porter Consulting Engineers

Project 76219
July 2011

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	76219	Document No.	1
Document title	Report on Preliminary Geotechnical Investigation Proposed Industrial and Commercial Development		
Site address	Port Kennedy Business Park		
Report prepared for	Porter Consulting Engineers		
File name	P:\76219 Port Kennedy Business Park\Docs\76219 Report on Preliminary Geotechnical Investigation, Port Kennedy Business Park.doc		

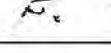
Document status and review

Revision	Prepared by	Reviewed by	Date issued
0	S Seenu	F Verheyde	15 July 2011

Distribution of copies

Revision	Electronic	Paper	Issued to
0	1	1	Porter Consulting Engineers

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		15/7/2011
Reviewer		15/7/2011

NCS INTERNATIONAL CERTIFIED QUALITY MANAGEMENT SYSTEM

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
36 O'Malley Street
Osborne Park WA 6017
Phone (08) 9204 3511
Fax (08) 9204 3522

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Report on Preliminary Geotechnical Investigation
Proposed Industrial and Commercial Development
Port Kennedy Business Park, Port Kennedy

1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken for a proposed industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA. The investigation was commissioned in an email, dated 27 May 2010, by David Porter of Porter Consulting Engineers, and was undertaken in accordance with Douglas Partners' proposal dated 19 April 2011.

The aim of the investigation was to assess the sub-surface soil and groundwater conditions across the site and thus:

- Provide a description of the soil, rock and groundwater conditions beneath the site.
- Determine the suitability of the site for the proposed development.
- Provide an appropriate classification of the site in accordance with the requirements of AS 2870-2011, and the earthworks requirements to achieve a 'Class A' classification.
- Provide recommendations on site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development.
- Suggest appropriate foundation system(s), including the assessment of allowable bearing pressures and likely settlements.
- Provide suitable parameters, including California Bearing Ratio (CBR) for the design of new pavements, based on field observations and limited laboratory testing.
- Provide permeability values for the soils encountered at the site based on observations made in the field and laboratory testing.

The investigation included the excavation of 26 test pits and laboratory testing on selected samples.

2. Site Description

The site comprises an area of approximately 67 ha, and is identified as Lots 4 and 17 Port Kennedy Drive in Port Kennedy, WA. It is bounded by Port Kennedy Drive to the south, Ennis Avenue to the east, Bakewell Drive to the west and a residential subdivision to the north.

At the time of the investigation, the site was generally covered with dense shrubs, medium length grasses and several small to medium sized trees and bushes. Several sand tracks transect the site. The ground surface, where exposed across the site, was sandy. A few stockpiles of filling approximately up to 1.0 m high, possibly associated with the construction of adjacent existing roads, were noted along the Bakewell Drive and Ennis Avenue.

The site topography was undulating owing to the presence of numerous sand dunes up to approximately 4.0 m high across the site. The surface levels generally vary from RL 5 in the level areas across the site to RL 10 in the eastern end of the site. At the western part of the site, the surface level reduces up to RL 3.7.

The Rockingham 1:50 000 Geology sheet indicates that shallow sub surface conditions beneath the site consist of calcareous sand of the Safety Bay Sand unit.

3. Field Work Methods

Field work was carried out on 1 June 2011 and 12 July 2011, and comprised the excavation of 26 test pits, drilling of four boreholes and Perth sand penetrometer (PSP) testing adjacent to each test locations.

It should be noted that dense vegetation and a requirement to undertake testing from existing tracks to minimise the impact of the investigation on vegetation, precluded access to some parts of the site. Boreholes (BH27 to BH30) were drilled to a depth of 2.0 m using a 110 mm diameter hand auger in these areas.

The test pits (TP1 to TP26) were excavated to a maximum depth of 2.6 m, using a 5 tonne Komatsu excavator equipped with a 600 mm wide toothed bucket.

Test pits and boreholes were logged in general accordance with test procedure AS 1726–1993 by a suitably experienced geotechnical engineer from Douglas Partners. Representative soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out in accordance with AS 1289.6.3.3 to assess the density of the shallow soils.

Test locations were determined using a GPS and are shown on Drawing 1. Surface elevations at each test location were interpolated from a survey provided by Porter Consulting Engineers and are quoted in metres above Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix A, together with notes defining descriptive terms and classification methods.

Ground conditions encountered generally comprised topsoil overlying sand. The intersected subsurface profile can be summarised as:

- **Filling** - loose, light yellow, uncontrolled sand filling was encountered at BH28 to a depth of 0.2 m;

- **Topsoil** - brown silty sandy topsoil generally to depths of between 0.05 m and 0.15 m observed at all test locations;
- **Sand** – generally medium dense, brown and light yellow-brown, sand was encountered at all test locations underlying topsoil to the terminated depth (2.6 m) of investigation. Extremely low strength lithified sand layers were encountered at TP6, TP8, TP9, TP19, TP22 and TP26.
- **Organic sand** – loose, dark grey, organic sand with some low plasticity fines was encountered at BH27 from a depth of 1.1 m to 1.5 m.

4.2 Groundwater

Free groundwater was observed at TP2 at a depth of 2.5 m (RL 3.0 AHD) below existing surface level on 1 June 2011. The test pits were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels.

The Perth Groundwater Atlas (2004) indicates that the groundwater level was approximately 1.7 m (RL 2 AHD) below the lowest part of the site, in May 2003.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of the particle size distribution on six samples.

Detailed test report sheets are given in Appendix B and the results are summarised in Table 1.

Table 1: Results of Laboratory Testing

Pit	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	Material
TP3	0.3	2	0.17	0.27	Sand – light brown with trace silt
TP6	0.8	2	0.16	0.27	Sand – light grey with trace silt
TP9	0.5	1	0.16	0.26	Sand – light yellow-brown with trace silt
TP13	0.5	1	0.16	0.27	Sand – light yellow-brown with trace silt
TP15	1.4	1	0.17	0.30	Sand – light yellow-brown with trace silt
TP23	0.6	1	0.17	0.29	Sand – light yellow-brown with trace silt

Where:

-The % fines is the amount of particles smaller than 75 µm.

-A d_{10} of 0.21 mm means that 10% of the sample particles are finer than 0.21 mm.

-A d_{60} of 0.50 mm means that 60% of the sample particles are finer than 0.50 mm.

6. Proposed Development

It is understood that the proposed development comprises the subdivision of the site into industrial allotments and associated access roads. The concept plan provided by the client indicates that a proposed public open space (POS) occupies the western part of the site (shown on Drawing 1 in Appendix A).

7. Comments

7.1 Site Classification

The shallow ground conditions beneath the site comprise generally medium dense sand. Based on the results of the investigation, a site classification 'Class A' in accordance with AS 2870-2011 should be suitable for this site provided site preparation is carried out as detailed in Section 7.2.

As detailed in Section 4.2, organic sand was encountered at BH27, which was located within the proposed public open space area. Organic soils are considered unsuitable for the support of structures. If similar soil is encountered within the proposed allotment areas during detailed investigation, then the above mention site classification would be affected.

7.2 Site Works, Preparation and Compaction

Prior to excavation for foundations and/or placement of fill, all deleterious material, including vegetation and topsoil, should be stripped from the proposed allotments and road reserve areas, and either removed from site or stockpiled for possible re-use for landscaping purposes only.

As detailed in the above section, organic sand is unsuitable for the support of structures. If such soil is encountered within the proposed allotments during detailed investigation, then it should be excavated and removed from the site or stockpiled for re-use as landscaping only.

Following removal of unsuitable material and prior to any filling, it is recommended that the exposed subgrade beneath the building envelopes and pavement areas be proof rolled using a medium to heavy (minimum of 12 tonne) vibrating smooth drum roller. Any areas that show signs of excessive deformation during compaction should be continually compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural filling compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Care should be taken not to operate heavy plant and vibrating roller immediately adjacent to existing buildings and services.

Naturally occurring sand excavated from the site should be suitable for re-use as structural fill, provided it is free from organic material and particles greater than 150 mm in size. Imported filling, if required, should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that naturally occurring sand at this site and imported sand filling be placed in loose lift thickness of not more than 300 mm, within 2% of its optimum moisture content

with each layer compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Compaction control of the sand at the site could be carried out using a PSP in accordance with test method AS 1289.6.3.3.

All proposed building envelopes and pavement areas should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 1.0 m and 0.75 m below foundation level of the proposed buildings and proposed pavement subgrade respectively. Compaction control of the sand at the site could be carried out using a Perth sand penetrometer (PSP), as suggested above.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.3 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for 'Class A' conditions, provided that site preparation is carried out as detailed in Section 7.2.

AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. For buildings not covered by AS 2870-2011, a presumptive allowable bearing pressure of 200 kPa is suggested for foundation design of strip and pad footings founded at a minimum depth of 0.5 m in at least medium dense sand. This should ensure that total and differential settlements will be less than 5 mm.

7.4 Pavement Design Parameters

Based on field observations it is recommended that a subgrade CBR of 12% be used for the design of flexible pavements on sand subgrade encountered at this site, provided that such subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction, as determined by AS 1289.5.2.1.

7.5 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand, therefore it is considered that stormwater disposal using soakwells and sumps should be feasible at this site.

A permeability value was derived using grading results of soil samples and the Hazen's formula, which applies for sand in a loose state. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of the Derived Permeability Values

Pit	Depth (m)	Derived Permeability (m/s)	Material
TP3	0.3	2.9×10^{-4}	Sand – light brown with trace silt
TP6	0.8	2.6×10^{-4}	Sand – light grey with trace silt
TP9	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP13	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP15	1.4	2.9×10^{-4}	Sand – light yellow-brown with trace silt
TP23	0.6	2.9×10^{-4}	Sand – light yellow-brown with trace silt

Results of the analyses indicate permeability values ranging between 2.6×10^{-4} m/s and 2.9×10^{-4} m/s for the sand encountered at this site. Given that the density of the sand at the site is likely to be increased during earthworks operations, a design permeability value of 1×10^{-4} m/s is suggested. It is emphasised that a lower permeability value than that indicated may be appropriate for a long-term design value which takes into account long term bio-build up and/or siltation of the infiltration surface.

8. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
3. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
4. Australian Standard AS 2870-2011, Residential Slabs and Footings
5. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.

9. Limitations

Douglas Partners (DP) has prepared this report for an industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA in accordance with DP's proposal dated 19 April 2011 and acceptance received from Mr David Porter of Porter Consulting Engineers on 27 May 2011. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Porter Consulting Engineers for this project only and for the purposes described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and

also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings
Results of Field Work

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

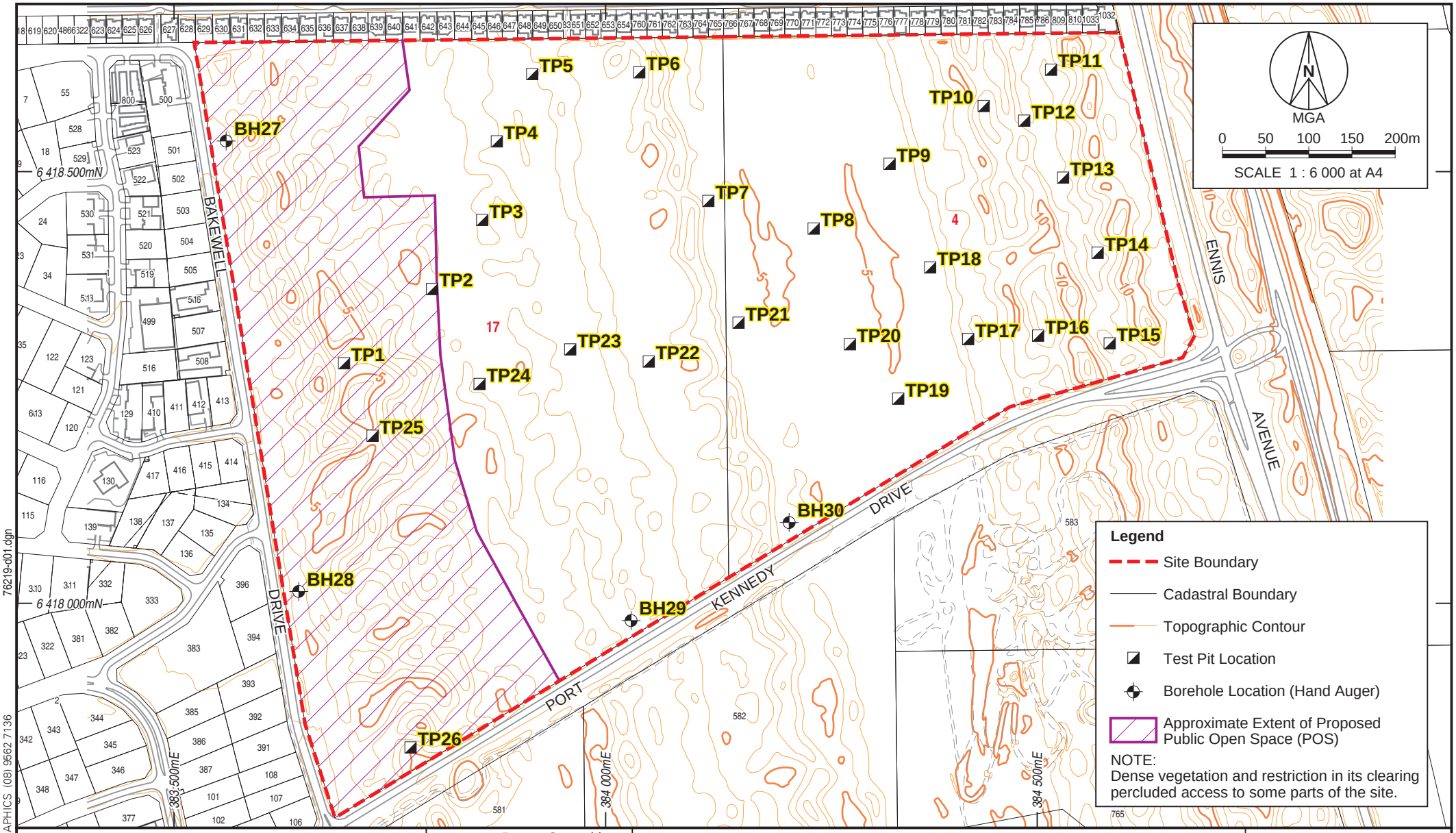
Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.



76219-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Porter Consulting Engineers
OFFICE:	Perth
DATE:	13 Jul 2011

Location of Tests
Port Kennedy Business Park
Port Kennedy, WA

PROJECT No.:	76219
DRAWING No.:	1
REVISION:	A

APPENDIX 4

GROUNDWATER REPORT

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Attention :	Nicola Popenhagen	**Our Ref:**	J4511b
Email :	*NicolaPopenhagen@landcorp.com.au*	**Pages :**	19
cc :			

LOT 4 & 17 PORT KENNEDY DRIVE, PORT KENNEDY
Pre-Development Annual Monitoring Report 2010-2011

1 Introduction

This monitoring report has been prepared by JDA Consultant Hydrologists on behalf of Landcorp for Lot 4 &17 Port Kennedy Drive, Port Kennedy herein referred to as the Study Area (Figure 1).

JDA Consultant Hydrologists completed an investigation of the Average Annual Maximum Groundwater Level (AAMGL) for the Study Area in October 2009 (JDA 2009), which has been followed by an 18 month pre development hydrological monitoring program.

This report constitutes the first and final annual hydrological monitoring report for the Study Area. It presents a brief summary of groundwater data collected over the 18 month monitoring period from October 2009 to April 2011 with 16 months of predevelopment data.

2 Monitoring Program

On 28 September 2009 JDA installed eight shallow aquifer monitoring bores at the Study Area (PK1 – PK8). The bores were installed by 75mm push probe drill to depths between 4.5 m and 8.0 m. All bores were cased in 50 mm PVC pipe with end caps, and slotted 3m into the water table. Bore locations are shown in Figure 2 and details in Table 1.

Lithological logs recorded during the installation of the bores, indicate the general soil profile over the entire site consist of 0.5 m brown topsoil overlying white cream Safety Bay sands. Bore logs are included as Appendix A.

Department of Water (DoW) bores T430 OBS and T480 are the closest long term monitoring bores to the Study Area and were included in the monthly groundwater level monitoring program.

The following parameters were monitored over the 18 month period:

- Monthly monitoring of groundwater levels in the superficial aquifer of 8 JDA bores and the nearby DoW long term monitoring bore. Levels were measured using an electrical depth probe in metres below natural surface. Survey of the bores was used to convert measured levels to mAHD.
- Quarterly groundwater quality sampling of the JDA bores PK1, PK3, PK5, PK7 and PK8. Bores were analysed for nutrients (TN, NH_4, NOx, TKN, TP and PO_4); pH and EC were tested in situ. Samples were submitted to a NATA certified laboratory for analysis of the nutrients.

Table 1: JDA Groundwater Bore Details

Bore	Location (GDA 94)		Natural Surface (mAHD)	Top of Casing (mAHD)
	Easting	Northing		
PK1	383685	6417763	5.88	6.53
PK2	383599	6418208	5.81	6.42
PK3	383538	6418639	6.37	6.97
PK4	384144	6418033	5.80	6.41
PK5	384157	6418461	5.32	5.92
PK6	384163	6418645	5.63	6.23
PK7	384604	6418276	6.98	7.68
PK8	384570	6418638	8.00	8.64
T480	383643	6413859	-	8.62
T430 (OBS)	385714	6416781	-	7.18

3 Monitoring Data

3.1 Groundwater Levels

Recorded monthly groundwater levels are shown in Figure 3, with a summary of recorded annual maximum and minimum groundwater levels shown in Table2.

Winter maximum groundwater levels ranged from 2.64 mAHD (PK7) to 4.25 mAHD (PK3) across the Study Area. Depth to the maximum groundwater level below natural surface varied from 1.72 to 4.25 m across the Study Area. Summer minimum groundwater levels ranged from 1.72 mAHD (PK7) to 2.93mAHD (PK3) across the Study Area. Observed seasonal groundwater variations were in the range of 0.3m to 0.62 m across the site, which is typical of the Swan Coastal Plain.

The AAMGL investigation undertaken in October 2009 (figure 2) is consistent with the pre development groundwater monitoring program undertaken by JDA between 2009 and 2011.

Table 2: Groundwater Level Data

Bore	Natural Surface (mAHD)	Summer Feb 2010 minimum		Winter Oct 2009 maximum		Seasonal Groundwater Variation (m)
		mBNS	mAHD	mBNS	mAHD	
PK1	5.88	2.89	2.99	2.41	3.47	0.48
PK2	5.81	2.48	3.33	1.91	3.90	0.57
PK3	6.37	2.74	3.63	2.12	4.25	0.62
PK4	5.80	2.91	2.89	2.51	3.29	0.4
PK5	5.32	2.22	3.10	1.70	3.62	0.52
PK6	5.63	2.44	3.19	1.89	3.74	0.55
PK7	6.98	4.64	2.34	4.34	2.64	0.3
PK8	8.00	5.7	2.30	5.12	2.88	0.58

3.2 Groundwater Quality

All groundwater bores were monitored quarterly for nutrients. The monitoring results are shown in Table 3. Rubbish located close to many of the bores at the site may alter the groundwater quality of the samples obtained from the Study Area over time.

3.2.1 pH & Electrical Conductivity

pH and EC were recorded insitu at each of the 8 monitoring bores. pH ranged between a minimum of 6.61 at PK4 in January 2010 and a maximum of 8.32 at PK1 in July 2010. Mean pH is between 7.16 and 7.63 across all bores for the monitoring period.

pH results indicate groundwater is generally neutral with all bores within the Study Area showing pH values above 6.60, and mean values within the ANZECC guideline range of 6.5-8.0 pH units (ANZECC 2000).

Electrical conductivity (EC) was generally consistent at all bores over the monitoring period ranging from a minimum of 0.27 mS/cm (PK5, October 2010) to a maximum of 0.85 mS/cm (PK5, July 2010). Mean EC values were between 0.47 and 0.79 mS/cm. These mean EC values are within the expected range of 0.3-1.5 mS/cm for slightly disturbed ecosystems in south-west Australia (ANZECC 2000).

3.2.2 Nutrients

In general, all parameters for the sampled bores remained generally consistent for all monitoring events with the exception of Nitrogen Oxide (NOx) and Total Nitrogen (TN) parameters. Nutrient levels did not follow expected seasonal variation of elevated recordings during winter peaks and the initial flush of nutrients at the beginning of the monitoring period. The predevelopment monitoring levels for the nutrient parameters are shown in figure 4 and figure 5.

Ammonia (NH_4N) results were consistent and remained above 0.05mg/L, until October 2010 when all bore results decreased below 0.005mg/L, and remained low for the rest of the monitoring period. The mean values for NH_4H ranged between 0.28-0.44mg/L, above the ANZECC guideline value of 0.08mg/L (ANZECC 2000).

Bores PK3, PK5 and PK7 were consistent throughout the monitoring period for Nitrogen Oxide (NOx_N) with values below 5.3mg/L. PK1 and PK8 had much higher readings for NOxN ranging from 5.9-16mg/L with the exception of July 2010.

This was consistent with results for Total Nitrogen (TN), with PK1 and PK8 values above the mean for the monitoring period of 6.31mg/L, except in July 2010. July 2010 results were consistent for PK3, PK5 and PK7 bore results for both NOxN and TN.

Total Nitrogen (TN), TN varied from a minimum of 0.93 mg/L (PK1, July 2010 and PK3, April 2011) to a maximum of 22 mg/L (PK1 April 2010). Mean TN concentrations for individual bores ranged from 2.78 mg/L to 10.72 mg/L. These mean values exceed the ANZECC predevelopment value of 1.2 mg/L (ANZECC 2000).

Total Phosphorus (TP) varied from below the detectable limit (0.01 mg/L) to a maximum of 0.33 mg/L. Mean TP concentrations for individual bores ranged from 0.08 mg/L to 0.09 mg/L, which is above the ANZECC guideline value of 0.065mg/L (ANZECC 2000).

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Table 3: Groundwater Water Quality Data: pH, EC, TDS & Nutrients

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
pH	PK1	7.14	7.57	8.32	7.39	7.66	7.68	7.63
	PK2	7.15	7.36	7.50				7.34
	PK3	7.17	7.59	7.89	7.38	7.87	7.80	7.62
	PK4	6.61	7.39	7.53				7.18
	PK5	7.14	7.43	7.58	7.24	7.62	7.52	7.42
	PK6	6.92	7.24	7.33				7.16
	PK7	7.19	7.76	7.59	7.57	7.97	7.64	7.62
	PK8	7.12	7.48	7.56	7.48	7.68	7.42	7.46
EC (mS/cm)	PK1	0.62	0.65	0.30	0.27	0.53	0.55	0.49
	PK2	0.62	0.62	0.52				0.59
	PK3	0.52	0.50	0.55	0.43	0.40	0.4	0.47
	PK4	0.62	0.68	0.64				0.65
	PK5	0.62	0.65	0.85	0.57	0.56	0.64	0.65
	PK6	0.82	0.77	0.78				0.79
	PK7	0.80	0.64	0.57	0.66	0.56	0.57	0.63
	PK8	0.66	0.63	0.61	0.56	0.60	0.65	0.62
NH_4_N (mg/L)	PK1	0.33	2.30	0.024	<0.005	<0.005	<0.005	0.44
	PK2							
	PK3	0.29	1.50	0.019	<0.005	<0.005	<0.005	0.30
	PK4							
	PK5	0.13	1.50	0.028	<0.005	<0.005	<0.005	0.28
	PK6							
	PK7	0.18	1.70	0.087	<0.005	<0.005	0.009	0.33
	PK8	0.22	1.80	0.050	<0.005	<0.005	<0.005	0.35
NOx_N (mg/L)	PK1	9.40	16.00	0.12	6.40	11.00	9.60	8.75
	PK2							
	PK3	2.20	4.30	0.52	5.30	2.60	0.56	2.58
	PK4							
	PK5	1.80	2.00	0.32	3.50	2.60	3.10	2.22
	PK6							
	PK7	0.84	1.80	0.25	1.30	1.50	1.80	1.25
	PK8	16.00	5.90	0.91	9.70	6.70	6.10	7.55

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
Tot N (mg/L)	PK1	10.00	22.00	0.93	6.70	6.70	18.00	10.72
	PK2							
	PK3	3.90	5.50	4.00	5.40	5.40	0.93	4.19
	PK4							
	PK5	3.20	7.50	3.90	3.50	3.50	3.70	4.22
	PK6							
	PK7	2.10	6.50	2.60	1.50	2.00	2.00	2.78
	PK8	17.00	8.80	7.00	9.90	7.40	7.70	9.63
TKN (mg/L)	PK1	0.60	6.00	0.81	0.25	0.19	8.80	2.78
	PK2							
	PK3	1.70	1.20	3.50	0.13	0.70	0.34	1.26
	PK4							
	PK5	1.40	5.50	3.60	0.04	0.98	0.68	2.03
	PK6							
	PK7	1.30	4.70	2.30	0.21	0.49	0.21	1.54
	PK8	1.50	2.90	6.10	0.15	0.69	1.60	2.16
Tot P (mg/L)	PK1	0.06	0.33	0.06	0.01	0.02	0.02	0.08
	PK2							
	PK3	0.06	0.33	0.05	0.02	0.02	0.03	0.09
	PK4							
	PK5	0.06	0.33	0.05	0.02	0.04	0.04	0.09
	PK6							
	PK7	0.06	0.33	0.05	0.01	0.01	0.02	0.08
	PK8	0.06	0.33	0.06	0.02	0.01	0.03	0.09
PO4_P (mg/L)	PK1	0.008	<0.005	<0.005	0.009	0.006	0.01	0.01
	PK2							
	PK3	0.012	<0.005	<0.005	0.02	0.01	0.02	0.01
	PK4							
	PK5	0.013	<0.005	0.006	0.02	0.01	0.03	0.01
	PK6							
	PK7	0.01	<0.005	<0.005	0.006	0.007	0.02	0.01
	PK8	0.01	<0.005	0.007	0.02	0.01	0.02	0.01

4 Conclusions

Analysis of depth to groundwater at each of the 8 bores indicates a separation for natural surface to groundwater of greater than 1.7m at all bores. Typical building design requires clearance of at least 1.2m for soakwells. Groundwater levels at the site do not appear to pose any constraints to this requirement.

The results obtained during the 18 month monitoring period at Port Kennedy are considerably higher than the Groundwater Quality ANZECC guideline values for Fresh and Marine Water Quality (2000a). This is common for predevelopment monitoring within the superficial aquifer on the Swan Coastal Plain. Results obtained for predevelopment monitoring should be considered as baseline and for the basis upon which water quality reduction targets are formed. Rubbish located close to many of the bores at the site may also have influenced the groundwater quality of the samples obtained from the Study Area over time.

These conclusions and recommendations are supported by results collected over the 18 month monitoring period, and should be considered as the baseline for which water quality reduction targets are formed.

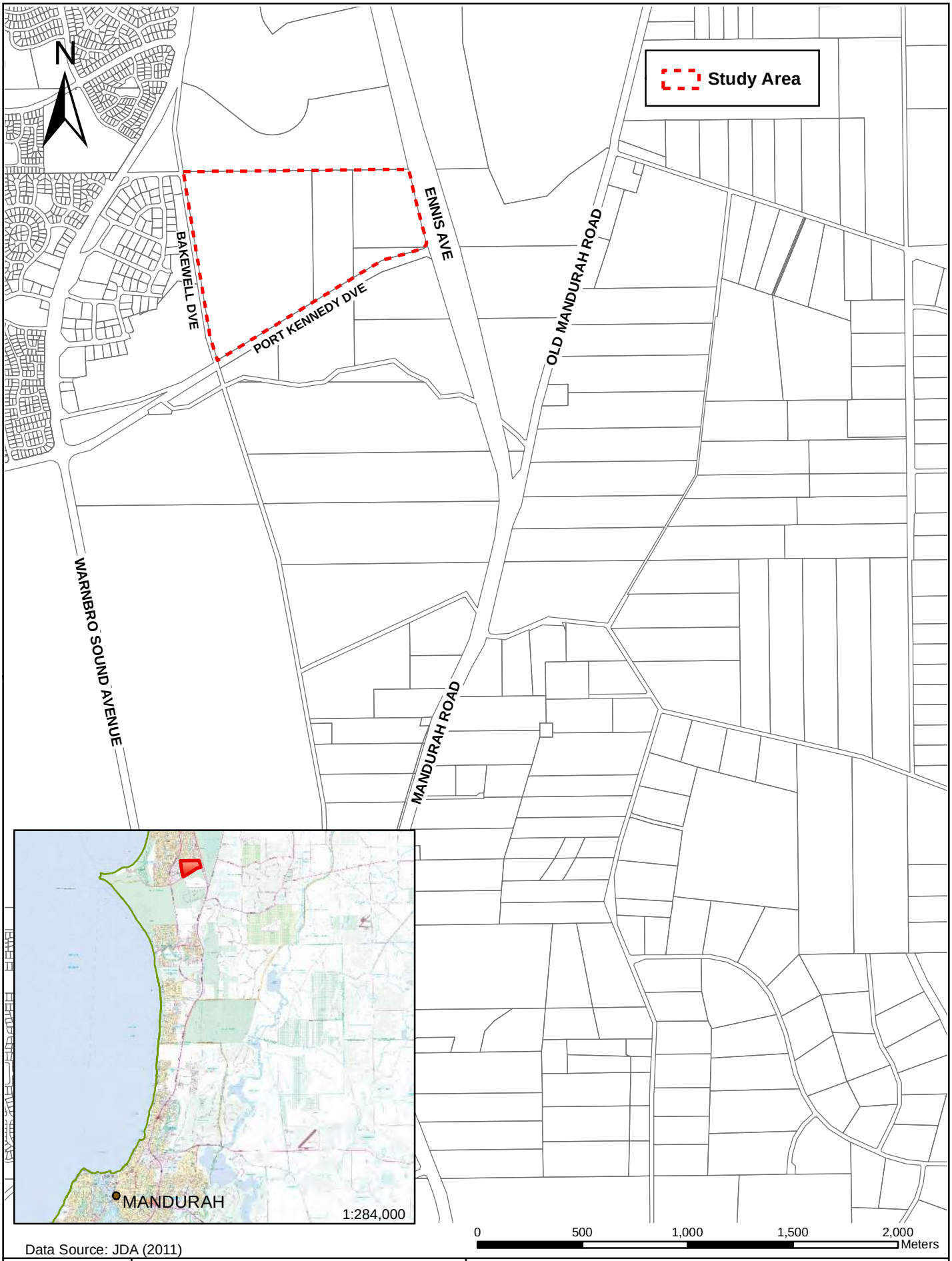
5 References

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, October 2000

JDA (2009) Lot 4 & 17 Port Kennedy Drive, Port Kennedy AAMGL Investigation, November 2009

Should you have any queries regarding the above report, please contact Matthew Yan or Kate Smith of this office.

JDA CONSULTANT HYDROLOGISTS



Data Source: JDA (2011)

Job No. J4511
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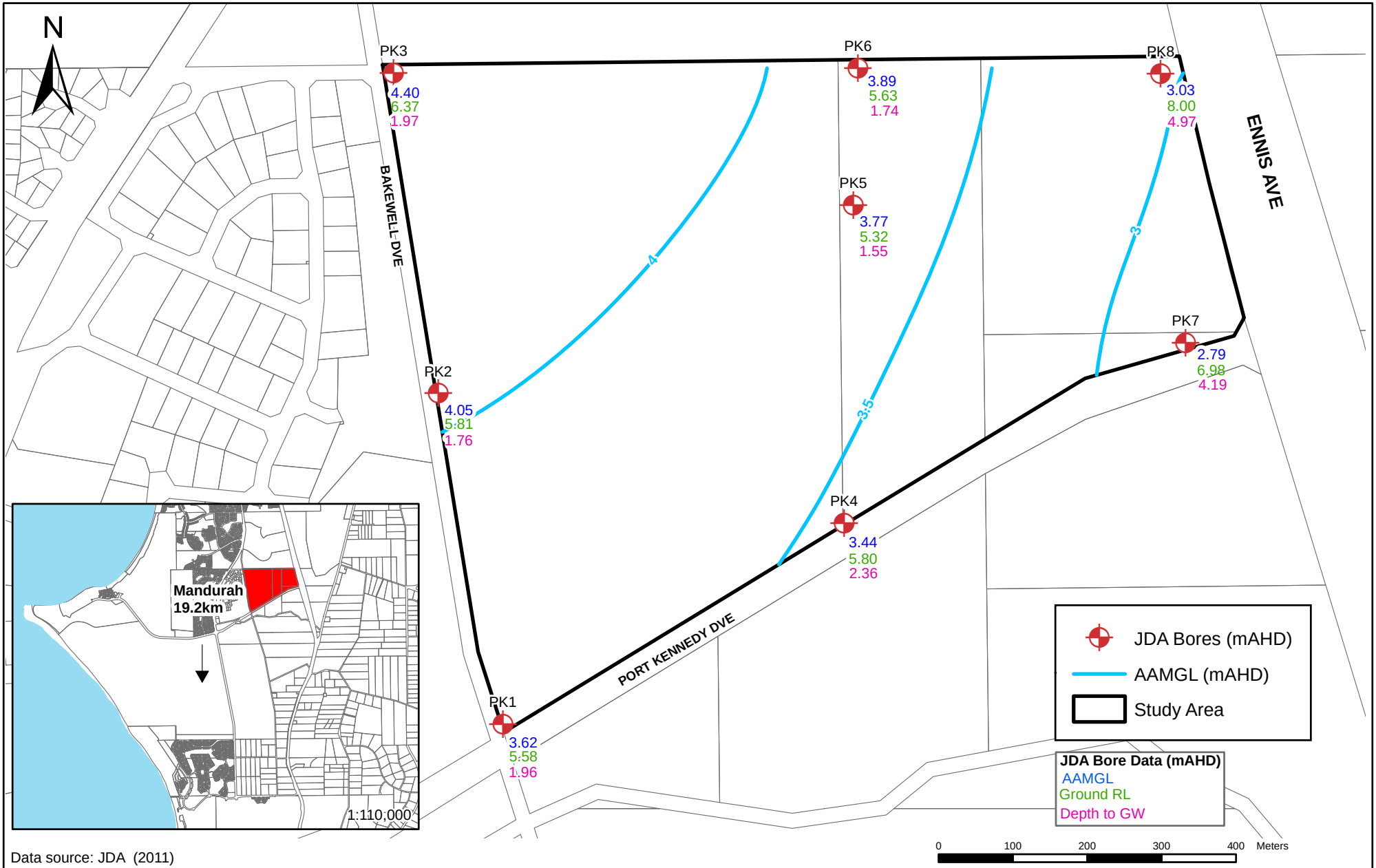
Landcorp
Lots 4 & 17 Port Kennedy Drive: Predevelopment Gorundwater Investigation
Figure 1: Location Plan



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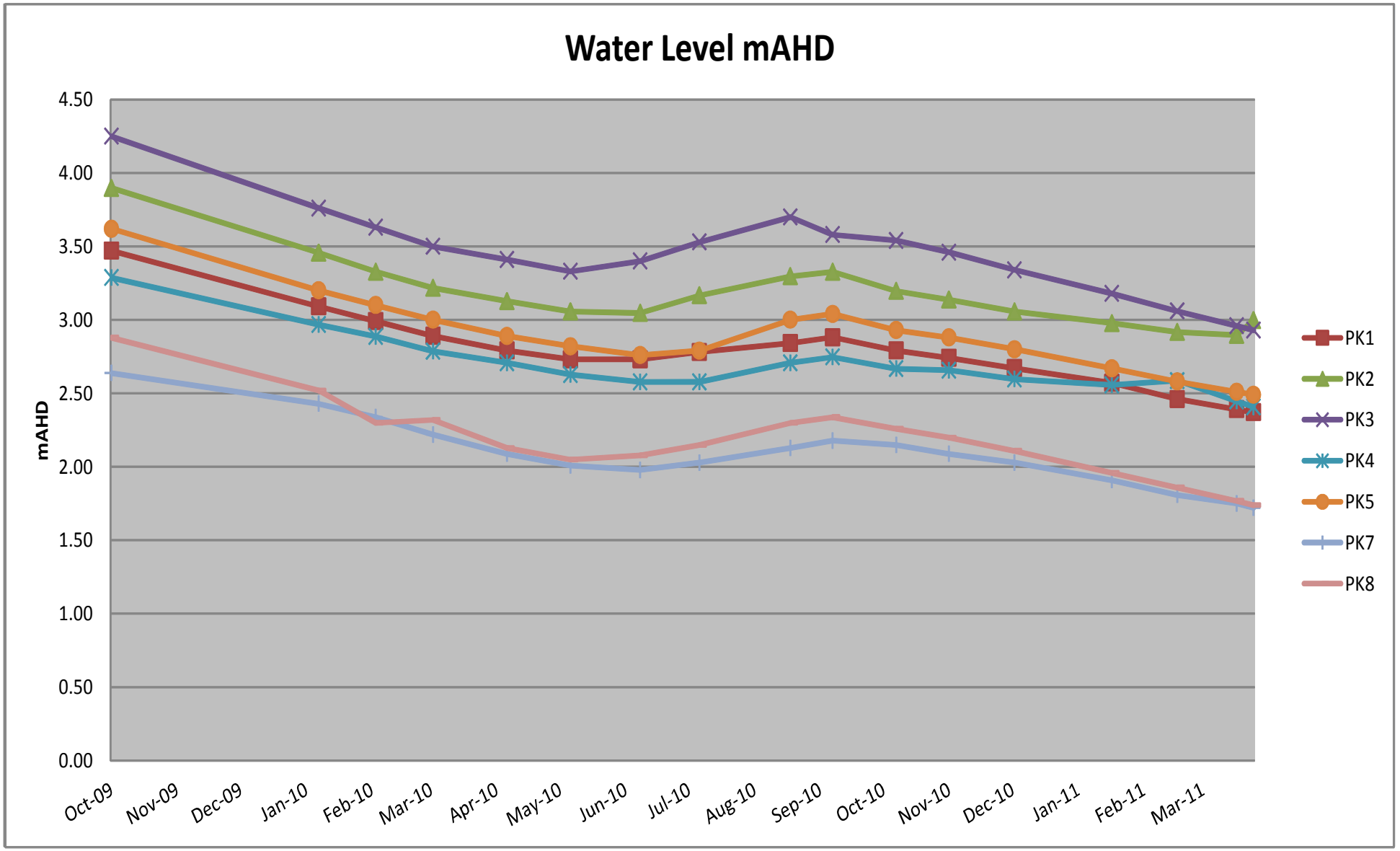
Landcorp

Lots 4 & 17 Port Kennedy Drive: PredevelopmentGroundwater Investigation

Figure 2: Groundwater Plan



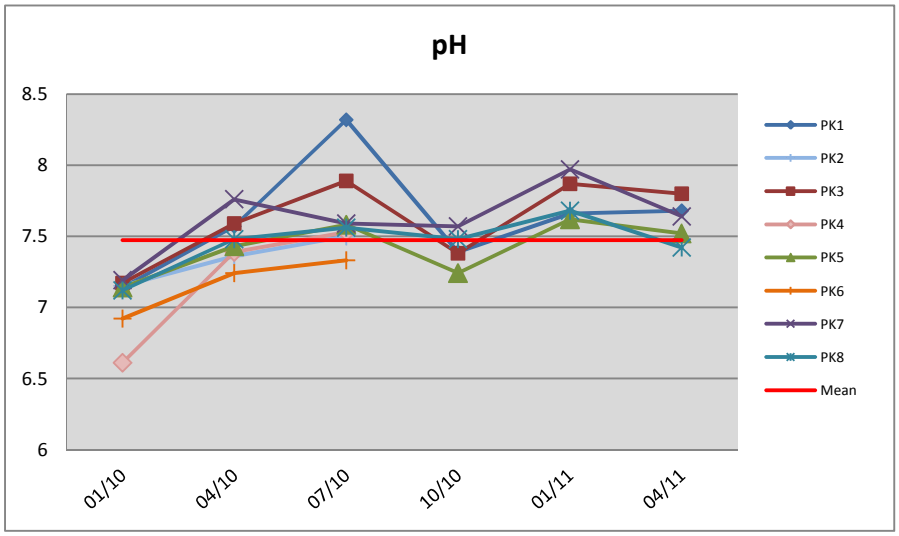
Data Source: JDA (2011)

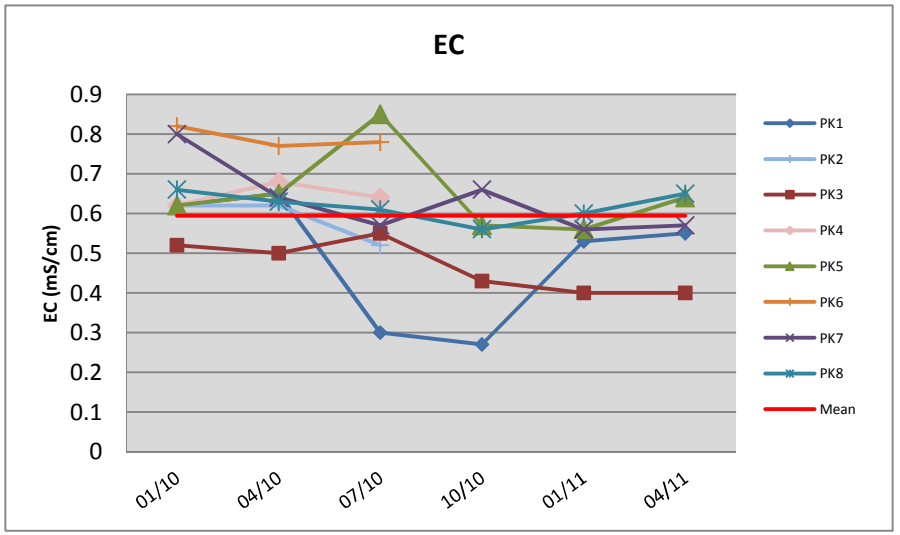
Job No. J4511

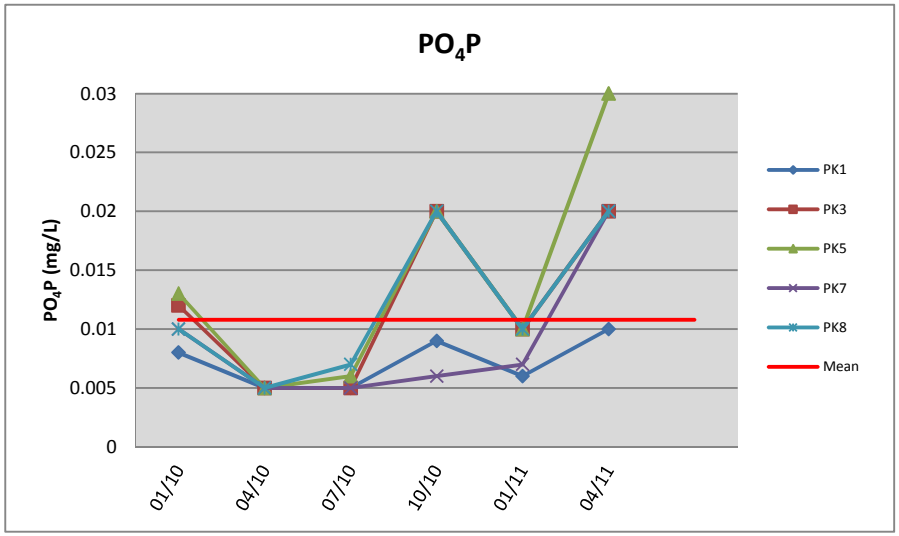
0 100 200 300 400 Meters

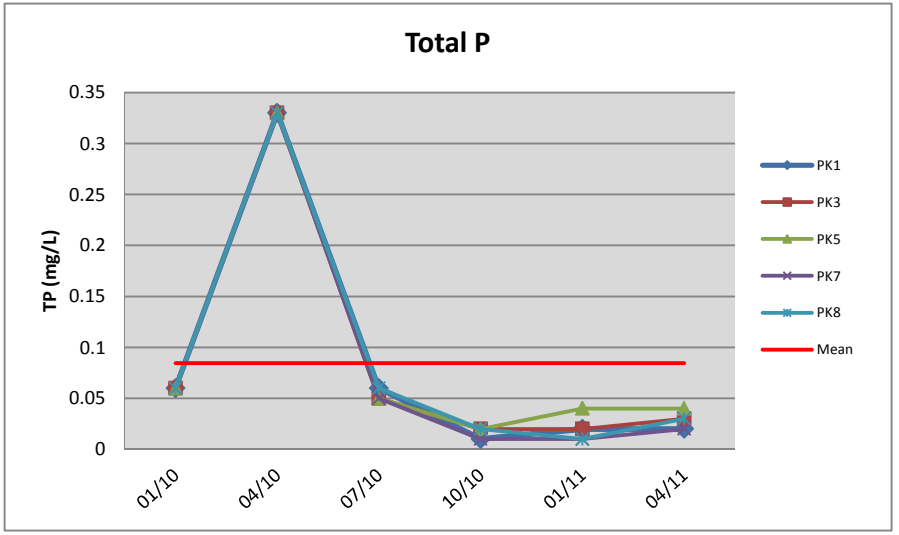
Landcorp
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 3: Groundwater Levels 2010-2011









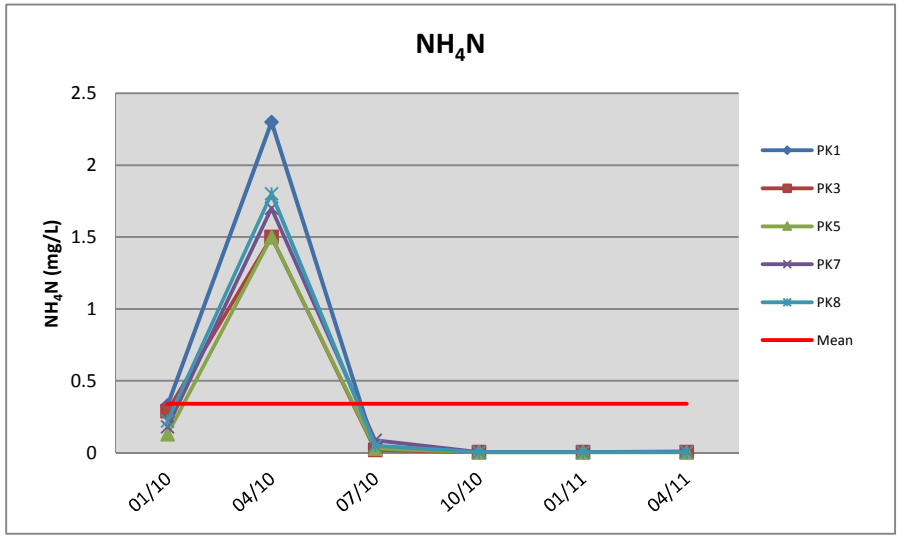
Data Source: JDA (2011)

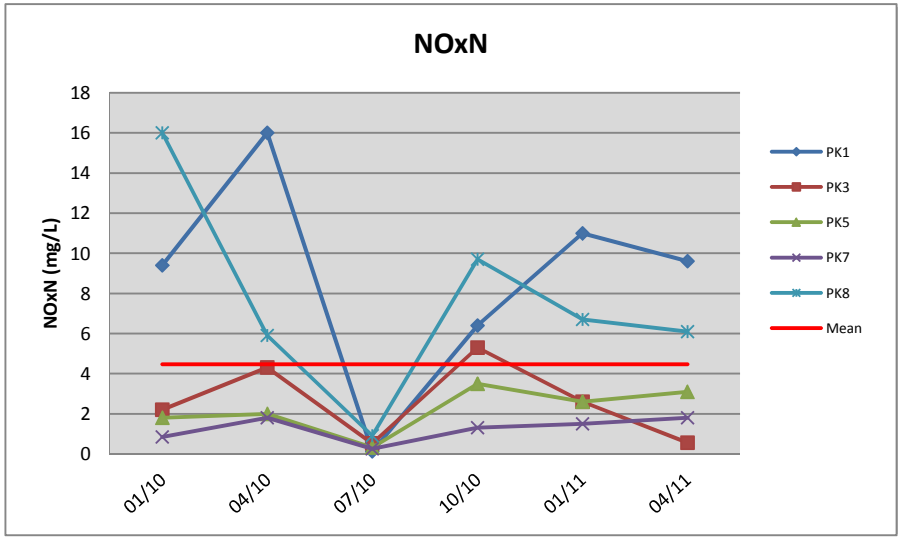
Job No: J4511

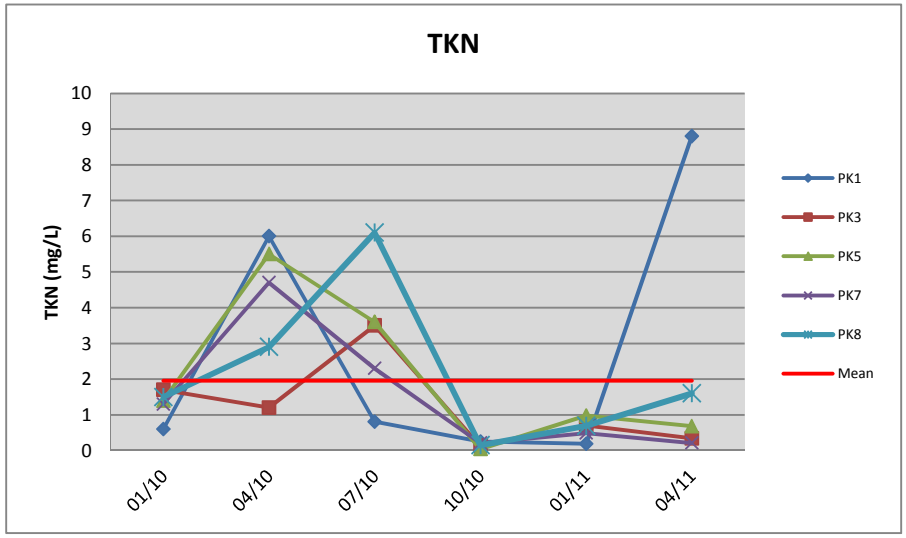
Landcorp

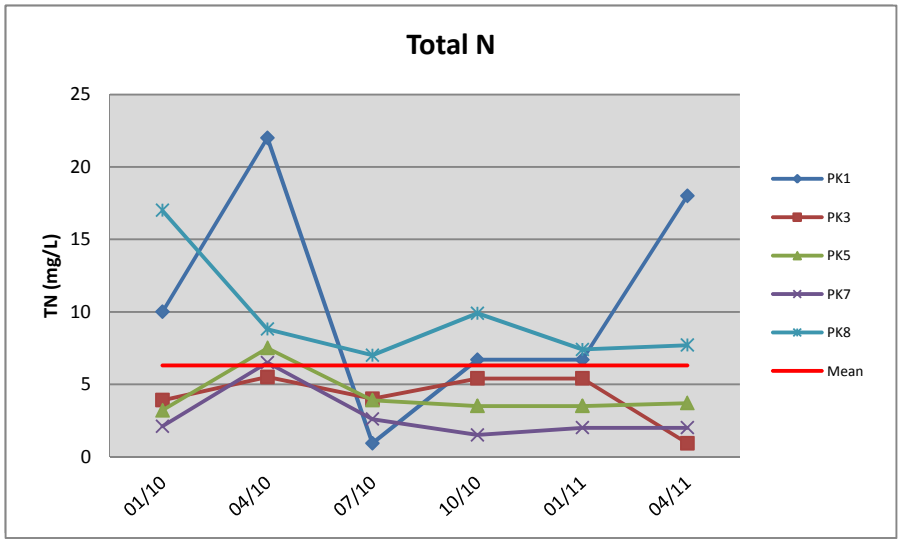
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 4: Monitoring Results 2010- 2011









Data Source: JDA (2011)

Job No: J4511

Landcorp

Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 5: Monitoring Results 2010- 2011

APPENDIX A

JDA Consultant Hydrologists
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Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383685 N6417762	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK1	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med round	sand well sorted	nil	nil	
				1.0m						
				1.5m	yellow/white	fine round	Safety Bay Sand well sorted			
				2.0m						
		▽		2.5m						
				3.0m						
				3.5m	yellow / white	fine	Safety Bay Sand some shells		moist	
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383606 N6418210	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK2	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)					Brown	fine	well sorted sand		nil	
				0.5m	light brown / white	fine	well sorted sand		nil	
				1.0m						
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m	light brown / white	fine	well sorted sand		moist	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	2.00pm
Bore location:	E383537 N6418639	Hole completed:	2.34pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK3	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	well sorted sand	some	dry	
				1.0m	yellow / white	fine	Safety Bay Sand well sorted	nil	dry	
		▽		1.5m						
				2.0m	white	fine	Ssfetly Bay sand	nil	moist	
				2.5m						
				3.0m						
				3.5m	yellow / white	med	gravelly sand	nil	moist	
				4.0m	yellow / white	fine	sand well sorted		saturated	
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E384143 N6418034	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK4	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med	sand	nil	nil	
				1.0m	light brown / white	fine	sand well sorted		nil	
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m						
				3.5m	light brown / white	fine	sand well sorted		moist	
				4.0m						
				4.5m			end of bore		saturated	
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	12.20pm
Bore location:	E384161 N6418456	Hole completed:	12.55pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK5	Total Depth:	4.2m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Dark brown	med	sand well sorted	some	dry	
				1.0m	light brown	fine	sand well sorted	nil	dry	
				1.5m						
		▽		2.0m	yellow / white	med	sand sorted some shells		moist	
				2.5m					saturated	
				3.0m						
				3.5m						
				4.0m			end of bore			
				4.5m						
				5.0m						

NOTES ON BORELOG

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Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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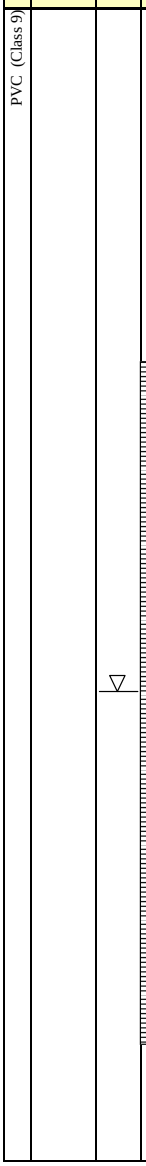
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	1:05
Bore location:	E384164 N6418647	Hole completed:	1:40
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK6	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
					Dark brown	fine	sand	some	dry	
				0.5m	yellow / white	fine	sand well sorted	nil	dry	
				1.0m						
				1.5m						
									moist	
				2.0m						
				2.5m						
		▽		3.0m						
					yellow / white	fine	sand	nil	saturated	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

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Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	10:30
Bore location:	E384607 N6418273	Hole completed:	11:.05
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK7	Total Depth:	6.0m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown	fine / med	round sand	nil	dry	
				1.5m						
				2.0m	white	fine	Safetly Bay Sand well sorted		dry	
				2.5m						
				3.0m						
				3.5m						
				4.0m					moist	
		▽		4.5m	white	fine	poorly sorted sand large rocks + shells		saturated	
				6.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

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Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……..…m

Stickup above NS: ……m

WL …….. m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	11:20
Bore location:	E384571 N6418642	Hole completed:	11:55
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK8	Total Depth:	7.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown white	fine	sand well sorted	none	dry	
				1.5m						
				2.0m	yellow / white	fine	sand well sorted	none	dry	
				4.0m						
		▽		5.0m	white	fine	sand some rocks fragments	none	moist	
				6.0m						
					white	fine	sand well sorted		saturated	
				7.0m	white	fine	clayey sand large rocks	end of bore	saturated	
				8.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark Brown, Red, Orange, Yellow, Grey, Blue
Medium Brown, Red, Orange, Yellow, Grey, Blue
Light Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

APPENDIX 5

RPS-BBG AND STRATEGEN WETLAND MAPPING

APPENDIX 6

RPS-BBG VEGETATION AND FLORA REPORT

APPENDIX B

Process for the Review of Wetland Management Categories

Review of Wetland Management Categories

As described previously in Section 2.5 the Environmental Protection Authority and the Water and Rivers Commission (WRC) have developed three evaluation/management categories for wetlands (Conservation, Resource Enhancement and Multiple use) as shown in Table 2.

The WRC considers that if a wetland is recognised in existing expert evaluations at the international, national and regional level in the following publications then it is automatically assigned to the Conservation category:

1. Ramsar Convention;
2. A Directory of Important Wetlands in Australia;
3. Register of the National Estate;
4. System 6 Conservation through Reserves;
5. The Perth-Bunbury Study; and
6. Bush Forever.

As discussed in the previous section Becher Suite wetlands and the Port Kennedy area have been recognised in all of the above documents, although not necessarily within the study area specifically.

The WRC however does recognise that over time the values of certain wetlands can change. If a proponent feels that the evaluation category of a wetland is incorrect and wishes the Commission to re-assess, the proponent can submit a request for the wetland management category to be changed. There are at least four Conservation category wetlands within the Port Kennedy site which have been heavily impacted by clearing which would warrant reassessment.

There is a standard protocol to be used when submitting requests for wetland management categories to be changed. The four steps in the wetland re-evaluation process are:

Step 1

The proponent requests the Commission to reassess the wetland evaluation category. This request must be supported by:

- A clear and recent aerial photograph of the area at an adequate scale to clearly delineate wetland vegetation;

- On ground photographs from all angles of the wetland showing each habitat, section, direction and distinguishable areas of the wetland clearly indicating the condition of the wetland;
- A map showing the location and direction of the photograph points; and
- A report outlining why the proponent considers that the values listed in the previous studies no longer exist.

Step 2

When the proponent has submitted the information required in Step 1 the Commission has three options available:

- The Commission may decide that there is enough evidence from the photos provided to reassess the evaluation and make a decision on the evaluation category. No further action is required and the Commission will advise the proponent of the new evaluation; or
- The Commission may decide that the photographs do not show the need for re-evaluation and refuse to re-assess the evaluation category; or
- The Commission may decide that further justification is needed and request that an EPA Bulletin 686 is completed.

Step 3

If the Commission decides that further justification is needed, the Commission usually requests the proponent to undertake an assessment of the wetland using the methodology set down in the EPA's Bulletin 686.

Bulletin 686 provides a questionnaire used to determine management categories for wetlands through a series of questions regarding natural and human use attributes. The questionnaire consists of four sections:

Part I	Presence of Gazetted Rare Species
Part II	Natural Attributes
Part III	Human-use Attributes
Part IV	Supplementary questions

Part I is a filtering question, whilst Parts II and III are made up of a series of questions that relate to specific wetland attributes. The answers to each question are given a score, which are tallied to give a total score for each part. The scores enable the wetland to be classified into a management category by plotting the results within a graph shown in Appendix 2 of Bulletin 686. The supplementary questions in Part IV are only completed

if the wetland is placed between two wetland categories when plotted on the graph, or if the wetland is located on private land with high private human-use values.

If after the submission of the 686 report, the Commission feels that there is adequate justification to show that the wetland management category may need to re-evaluated, then a site visit shall be undertaken by a Commission staff member to check the evaluation.

Step 4

Agreements to alter the management category are to be signed off by a Manager or Director of the Commission.

APPENDIX B

RPS 2006 Botanical Report

FLORA AND VEGETATION REPORT
LOT 4 MANDURAH ROAD & LOT 17
PORT KENNEDY DRIVE, PORT KENNEDY

Prepared for:

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Report No: L06215-B

Rev 0, December 2006

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1.0 BACKGROUND

In the following text, Lot 17 refers to 17 Warnbro Sound Avenue Port Kennedy 6172 and Lot 4 refers to 4 Mandurah Road Port Kennedy 6172.

A Level 2 survey (Environmental Protection Authority, 2004) was commissioned by Landcorp to quantitatively assess flora and vegetation on both Lots 17 and 4, for the purposes of assessing environmental constraints as part of a Due Diligence.

Partial studies of the survey area have previously been carried out. Val English of the Species and Communities Branch of the Department of Conservation and Environment (DEC) supervised a quantitative vegetation assessment of wetlands at the western end of Lot 17. These wetlands are known as the Bakewell Drive wetlands (English *et al.*, 2002). A preliminary assessment of wetland vegetation across both Lots 17 and 4 was done by RPSBBG botanists (RPSBBG, 2002).

The following is a Level 2 Vegetation and Flora survey (Environmental Protection Authority, 2004) of Lots 17 and 4. It is a comprehensive assessment of conservation significance of the flora and vegetation at the site.

2.0 METHODS

2.1 Field Survey

Survey methodology was based on a Level 2 Flora and Vegetation Survey as outlined in Guidance Statement 51 (Environmental Protection Authority, 2004) and is consistent with methodology established in Keighery *et al.*,(1994) for the Swan Coastal Plain.

Sixteen 10m by 10m plots were established by botanists A. Mercier, A. Weston, K. McCreery, M. Henson and V. Yeomans between 31 August and 1 September 2006 and 17 and 23 November 2006.

The information recorded at each 10m by 10m plot included:

- A GPS location at the NW corner (WGS84, accuracy <5m);
- Photographs;
- Vegetation structure (Table B1)(Western Australian Planning Commission, 2000);
- Species present (including height and density);
- Soil description;
- Landform description;
- Aspect;
- Condition (Western Australian Planning Commission, 2000)(Table B2); and
- Bare ground and litter cover estimates.

Table B1: Vegetation Structure Classes (Western Australian Planning Commission, 2000)

Life Form/ Height Class	Canopy Cover (percentage)			
	100% - 70%	70% - 30%	30% - 10%	10% - 2%
Trees 10-30m Trees < 10m	Closed Forest Low Closed Forest	Open Forest Low Open Forest	Woodland Low Woodland	Open Woodland Low Open Woodland
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs > 2m Shrubs 1-2m Shrubs <1m	Closed Tall Scrub Closed Heath Closed Low Heath	Tall Open Scrub Open Heath Open Low Heath	Tall Shrubland Shrubland Low Shrubland	Tall Open Shrubland Open 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

Table B2: Vegetation Condition Scale (Western Australian Planning Commission, 2000)

Condition		Definition
P	Pristine	No obvious signs of disturbance.
E	Excellent	Vegetation structure intact, disturbance affecting individual species ; weeds are non-aggressive species
V	Very Good	Vegetation structure altered; obvious signs of disturbance
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained
D	Degraded	Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good (sic) condition without intensive management
C	Completely Degraded	Vegetation structure not intact; the area completely or almost completely without native species ('parkland cleared').

The flora inventory was developed from all collections made from plots and releves and included opportunistic records. Flora specimens were identified using the resources of the Western Australian Herbarium. Taxonomy is based on the DEC's flora database, Florabase (www.florabase.calm.wa.gov.au). Atkins (2006) was used as the reference list of DRF and Priority flora.

Condition assessment mapping was conducted using 1:5000 aerial photo-interpretation and site confirmation.

Vegetation community mapping was conducted using a combination of ground truthing, aerial photo-interpretation, floristics and structure of vegetation as well as nearest neighbour PATN analysis (Appendix B4).

A PATN analysis was conducted by E.A. Griffin and Associates. This is a multi-variate analysis which enabled a comparison of 10m by 10m plot data with equivalent data in Gibson *et al.*, (1994). This report established Floristic Community Types (FCT's) across the southern Swan Coastal Plain (SCP). From this analysis, the vegetation could be assessed for Threatened Ecological Communities (TEC's). This is currently the most accurate quantitative method of determining FCT's and TEC's available.

In addition to Gibson *et al.*, (1994), data was obtained courtesy of DEC's Species and Communities branch from three sites within known TEC's at the western end of Lot 17. These sites are known as the Bakewell Drive wetlands. In total, the data from the current survey was compared to six known TEC19 sites: three from Gibson *et al.*, (1994) and three from the TEC Branch.

2.2 Assessing Conservation Significance

2.2.1 Flora

Declared Rare Flora (DRF) are flora that have been adequately surveyed and are considered to be in danger of extinction, rare or otherwise in need of special protection within Western Australia. DRF are protected under the *Wildlife Conservation Act 1950* (as amended).

Additionally in Western Australia there are four categories of Priority flora, which are not DRF, but their conservation status warrants some protection. Three categories of Priority Flora are allocated to species that are poorly known (Priority 1 to 3). These require more information to be assessed for inclusion as DRF. The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of priority flora (Priority 4) is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened.

Guidance Statement 51 (Environmental Protection Authority, 2004) lists species other than DRF and Priority Flora as of conservation significance where a species has:

- a keystone role;
- relictual status;
- anomalous features indicating a potential new discovery;
- a representation of a species range (range extensions, extremes or an outlier population);
- status as a restricted subspecies, variety, or naturally occurring hybrid;
- poor reservation; and
- status as a local endemic or has a restricted distribution.

This document states that conservation significance includes these criteria, but is not limited to them. In this instance, it includes flora that are poorly represented in the Western Australian Herbarium (WAH) and flora with few known populations.

Some flora species have additional protection under the *Environment Protection and Biodiversity Conservation Act (EPBC) 1999.* In Western Australia, this predominantly consists of DRF flora. These are defined as Threatened Flora Species under the *EPBC Act.* Penalties apply for any damage to individuals, populations or habitats of species protected.

2.2.2 Vegetation

Within Western Australia, Threatened Ecological Communities (TECs) are defined by CALM as those which are found to fit into one of the categories in Table B3. The categories "Data Deficient" and "Lower Risk" can be used to provide a list of communities not classified as threatened, but that require more information. Within Western Australia, TEC's have limited protection under the *Wildlife Conservation Act, 1950* and the *Environmental Protection Act, 1986* (as amended). TEC's will be protected by the proposed Biodiversity Conservation Act (in prep.)

Table B3: CALM Threatened Ecological Communities Category of Threat (English and Blyth, 1997)

Category	Definition
Presumed Totally Destroyed (PD)	An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies: A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats or B) All occurrences recorded within the last 50 years have since been destroyed.
Critically Endangered (CR)	An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria: A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and **either or both** of the following apply: • geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years) • modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capoable of being substantially rehabilitated. B) Current distribution is limited, and **one or more** of the following apply (i, ii or iii): • geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years) • there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes • there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years).

Category	Definition
Endangered (EN)	An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The estimated geographic range, and.or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii) • geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years) • modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is uynlikely to be capoable of being substantially restored or rehabilitated. B) Current distribution is limited, and one or more of the following apply (i, ii or iii): • geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years) • there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes • there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).
Vulnerable (VU)	An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated. B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.
Data Deficient (DD)	An ecological community which has not been adequately evaluated with respect to status or where there is currently insufficient information to assign it to a particular category. (An ecological community with poorly known distribution or biology that is suspected to belong to any of the above categories. These ecological communities have a high priority for survey and/or research.)
Lower Risk (LR)	An ecological community that has been adequately surveyed and does not qualify for any of the above categories of threat and appears unlikely to be under threat of significant modification or destruction in the short to medium term future.

The *EPBC Act* provides protection for TECs, which are defined as those communities which are:

- **Critically Endangered** (if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future);

- **Endangered** (if, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future); and

- **Vulnerable** (if, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future).

3.0 RESULTS

3.1 Flora

A total of 118 species were recorded from Lots 17 and 4. This is an estimated >80% of the flora species likely to exist at the site. Sixty four of the total 118 species were local flora and 54 were introduced.

3.1.1 Flora of Conservation Significance

No DRF or Priority flora were recorded from Lots 17 or 4. No species of conservation significance as defined by Guidance Statement 51 (Environmental Protection Authority, 2004) were recorded.

3.1.2 Introduced Flora

Sixty four introduced flora were recorded from Lots 17 and 4, which was 46% of the total flora recorded for the site.

The site has seven of the 34 weed species rated as High in the Environmental Weed Strategy for Western Australia (CALM, 1999). A high rating is given to those species which are known to have *'an ability to invade undisturbed bushland, have a wide current or potential distribution and have an ability to change the structure composition and function of ecosystems.'*

Table B4: Introduced Flora from Lots 17 and 4 in Environmental Weeds Strategy (High rating)

Species	Common Name	Survey Area Distribution
**Brassica tournefortii*	Mediterranean Turnip	Lot 17 & 4. Low density, occasional.
**Bromus diandrus*	Great Brome	Lot 17. One record at low density in wetland 2 (site PK02).
**Ehrharta calycinus*	Perennial Veldt Grass	Lot 17 & 4. Occasional at low density. Mainly near tracks and firebreaks.
**Eragrostis curvula*	African Lovegrass	Lot 17 & 4. Occasional in vegetation (adjacent to housing on north boundary).
**Euphorbia terracina*	Geraldton Carnation Weed	Lot 17 & 4. Widespread and naturalised. Densities from <1% to 35% total cover.

Species	Common Name	Survey Area Distribution
**Lagurus ovatus*	Hare's Tail Grass	Lot 17 & 4. Widespread and naturalised. Densities from <1% to 35% total cover.
**Pelargonium capitatum*	Rose Pelargonium	Lot 17 & 4. Scattered individuals from eastern boundary of Lot 17 eastwards.

A number of garden escapes have become weeds due to the dumping of garden waste at the site. Couch **Cynodon dactylon* was seen in several rubbish piles. **Yucca aloifolia* was on the western firebreak of Lot 17. The Olive **Olea europaea* is becoming naturalised across the eastern boundary of Lot 17 and Lot 7. **Gaura lindheimeri*, a recent garden escape was recorded from the wetland containing site PK01.

3.2 Vegetation

3.2.1 Vegetation Communities

The primary division in the vegetation communities was between 1: Dune System and 2: Wetlands, Damplands and Depressions in Dune Swales. The PATN analysis indicated that this division coincides with FCT29B: *Acacia* Shrublands on Taller Dunes and FCT19: Sedgelands in Holocene Dune Swales (Gibson *et al.*, 1994).

The vegetation communities were defined as:

1. Dune System

1a Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests.

1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.

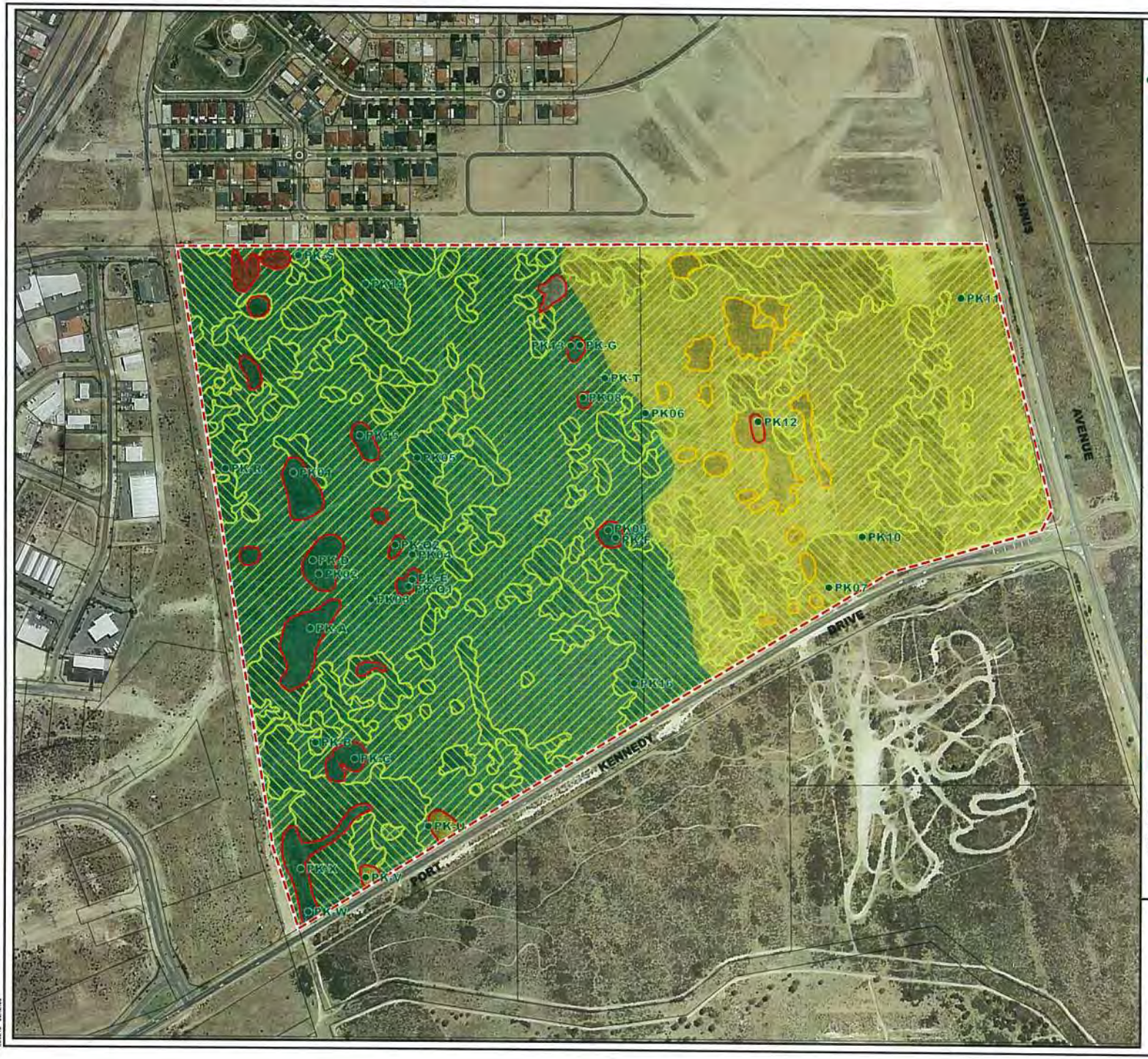
2. Wetlands, Damplands and Depressions in Dune Swales

2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.*

2b: Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa.*

2c: Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea.*

See Figure B1 for vegetation community and condition mapping.



LEGEND

- Site boundary
- Existing cadastre
- PK01 Flora site locations

N

0 50 150 250m

Scale 1: 5000

VEGETATION UNITS

DUNE SYSTEM

1a - Open Low Heath of *Acacia rostellifera*, *Melaleuca systena* on Dune Swales and Crests
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks.

1b - Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks

WETLANDS, DAMPLANDS AND DEPRESSIONS IN DUNE SWALES

2a - Closed Sedgeland of *Baumea juncea*, *B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*.
Condition: Excellent to Very Good with Degraded areas within 10m of tracks and firebreaks

2b - Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks

2c - Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks
(is equivalent to FCT 19: Sedgelands in Holocene Dune Swales)

Transitional vegetation between Community Units 1 and 2

VEGETATION CONDITION

- Very Good
- Good to Very Good
- Good
- Good to Degraded

NOTE:
Boundaries determined from 1: 5000 aerial photography and selective ground truthing.
Boundaries are indicative only.

Figure B1

Vegetation Units and Condition

RPS BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

L00215 09.12.08

Dune System

This is a mosaic of Open Low Heath (coastal) and *Acacia rostellifera* Open Heath to Closed Tall Scrub. The PATN analysis indicated that the sites within this community had the closest neighbours of FCT29b: *Acacia* Shrublands on Taller Dunes, and also FCT24: Northern Spearwood Shrublands and Woodlands. While the PATN analysis did not differentiate between the sites in communities 1a and 1b (as PATN is based on a floristic presence-absence analysis), these were split here on the basis of structure and density.

1a Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests

This community occurs on calcareous sands (Quindalup or Safety Bay Sands) in a parallel dune system. It is a Low Open Heath dominated by *Acacia rostellifera* and *Melaleuca systena*, with other typical low shrubs including *Adriana quadripartita* and *Acanthocarpus preissii.* There are occasional emergents *Hakea prostrata, Acacia saligna* and *Jacksonia furcellata*, up to three metres. In the ground layer there is typically an Open Herbland dominated by **Euphorbia terracina, Opercularia vaginata, Lomandra maritima* and *Conostylis aculeata* var. *preissii.* There is an Open to Very Open Sedgeland of *Lepidosperma squamatum* and *Desmocladus asper*, with occasional dense patches of *Lepidosperma gladiatum* and scattered *Schoenus grandiflorus*. There is an Open to Very Open Grassland typically of *Austrostipa flavescens, Bromus arenarius, *Avena barbata* and **Lagurus ovatus*.

This community formed a mosaic with community 1b.

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT29B: *Acacia* shrublands on Taller Dunes; and FCT24: Northern Spearwood Shrublands and Woodlands.

There were five detailed flora sites (PK03, PK04, PK06, PK10, PK11) and one releve PK-T within this community. The detailed flora sites had a mean species richness of 23 ± 4 (FCT29B has a mean species richness of 35.6 and FCT24 has 41.8). There was a mean weed frequency of seven species per site (FCT29B has 3.4 and FCT24 has 14.2). The condition varied from Good in Lot 4 to Very Good in Lot 17. There were Degraded areas which were generally limited to within 20m of tracks and firebreaks. The main

impacts have been from weed invasion, which may have been exacerbated by too frequent fires and fragmentation. There was also soil disturbance from trail bikes and dumping of household, industrial and garden rubbish.

See Figure B1 and Plate B1.

1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes

This association was on calcareous sand (Quindalup or Safety Bay Sands), both in swales and dune slopes. *Acacia rostellifera* formed an Open Heath to Closed Tall Scrub over Very Open Sedgeland to Sedgeland of *Lepidosperma squamatum*. Within lower lying areas there were occasional tall shrubs to four metres of *Hakea prostrata* or *Acacia saligna*. The understorey was often sparse where there were unburnt *Acacia rostellifera* thickets. There was a Low Open to Open Shrubland which typically included *Melaleuca systena, Rhagodia baccata* subsp. *baccata, Acacia lasiocarpa* var. *bracteolata* and *Adriana quadripartita*. There was a Very Open to Open Grassland typically including *Poa porphyroclados, Austrostipa flavescens, *Lagurus ovatus* and **Avena barbata*. In lower lying areas there was occasionally the sedge *Ficinia nodosa* present and in the lee of dunes there was occasionally dense but localised patches of sedge *Lepidosperma gladiatum*.

This community forms a mosaic and intergrades with community 1a.

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT29B: *Acacia* shrublands on taller dunes and FCT24: Northern Spearwood shrublands and woodlands.

There were four detailed flora sites within this community, PK05, PK07, PK14 and PK16, with an average of 20 ± 3 species per site. (FCT29B has a mean species richness of 35.6 and FCT24 has 41.8). There was a mean weed frequency of 5.5 species per site (FCT29B has 3.4 and FCT24 has 14.2).

The condition of this community varied from Very Good to Good with some Degraded areas near tracks and firebreaks. The main impacts have been from weed invasion, which may have been exacerbated by too frequent fires and fragmentation.

See Figure B1 and Plates B2 to B4.

Plate B1:: Community 1a: Open Low Heath of *Acacia rostellifera, Melaleuca systena* Site PK03. Lot 17.

Plate B2: Community 1b: Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes. Mature, not recently burnt. Lot 4.

Plate B3: Community 1b: Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes. Regrowth after fire (ca. 2 years ago). Site PK16. Lot 17.

Plate B4: Community 1b: Patches of *Lepidosperma gladiatum.* SW of Site PK16. Lot 4.

Wetlands, Damplands and Depressions in Dune Swales

This 'community' is equivalent to FCT19 and therefore TEC19: Sedgelands in Holocene Dune Swales, however it actually has a number of different communities within it. According to English *et al.,* (2002), the floristic composition of TEC19 appears to *'vary according to the age of the dunes and the depth to the water table'.* In the study area, there were four series of wetlands, each series running north to south along the dune swales of approximately five dune ridges. The wetlands got 'drier' progressively to the east. The most eastern site (PK12) intergraded with the surrounding dune swale vegetation, with only a couple of typical wetland species present to indicate that it was

still a wetland. These drier wetlands had *Xanthorrhoea preissii* as a dominant species within the wetland itself, while the wetter ones often had it as a fringing species.
These communities are all mapped as one unit but are described separately below. This is because the changes are fine scale, often change numerous times within each wetland and are unable to be accurately determined using aerial photography.

2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.*

This community occurred in wetlands with discrete boundaries in depressions in dune swales. The soil was a damp, dark brown peaty calcareous sand. The wetlands were often surrounded by a dense ring of *Xanthorrhoea preissii* (Plates A.7 and A.8) or *Acacia rostellifera.*

The wetlands themselves were a Closed Sedgeland, with *Baumea juncea* being the densest and most widespread sedge species. *Lepidosperma longitudinale* and *Ficinia nodosa* were also typical. Other sedges included *Lepidosperma gladiatum, Juncus pallidus, Baumea articulata, Isolepis cernua* var. *cernua* and *Gahnia trifida.* The shrubs *Logania vaginalis* and *Adriana quadripartita* were present as scattered individuals to Open Low Heath. There was a Very Open to Open Herbland typically dominated by the creeping herb *Centella asiatica* and often with *Lobelia alata.* Herb weeds were typically **Euphorbia terracina, *Conyza sumatrensis, *Carduus pycnocephalus* and **Sonchus oleraceus.*

Occasional emergent or overstorey species included *Xanthorrhoea preissii, Melaleuca teretifolia, M. rhaphiophylla, Acacia rostellifera* and *A. saligna.*

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT19, which is equivalent to TEC19: Sedgelands in Holocene Dune Swales. Site PK13, a very small wetland, had affiliations with FCT19 as well as FCT24 (Community 1a) which it is surrounded by. One of the of the DEC's Species and Community Branch sites (Wetland 103) came out as FCT19, while the remaining two (Wetlands 98 and 162) came out as close to both FCT17 and FCT19.

There were four detailed flora plots within this community: PK01, PK02, PK13 and PK15. These sites had a mean species richness of 25 species ± 7 (FCT19 has 22.6) with a mean weed frequency of 10 (FCT19 has 6.9). Additionally, there were four releves within this community PK-C, PK-D, PK-E and PK-U.

The condition within the wetlands was generally Very Good to Excellent. While there were weeds present, they were often in low densities. The exception to this were the wetlands in Lot 17 along the edge of Port Kennedy Drive on the southern boundary and the housing development on the northern boundary. These were in Good to Degraded condition as they had been impacted by clearing, drainage modification, exposure and weed invasion. Some wetlands had also been affected by a very patchy fire within the last two years that had enabled weeds to colonise and spread throughout the wetlands.

See Figure B1 and Plates B5 to B8.

2b: Scattered to Low Open Forest of *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*.

This community was in depressions in dune swales. The soil was a dark brown peaty sand. It appeared to be slightly drier than community 2a.

Melaleuca rhaphiophylla occured erratically in this community, as a Low Open Forest to scattered individuals or was occasionally absent. There was a Low Open to Open Shrubland of *Xanthorrhoea preissii* and/or *Adriana quadripartita*. The Open Sedgeland was most typically dominated by *Ficinia nodosa*, but also included *Baumea juncea* and *Gahnia trifida*. As a consequence there was often an Open Grassland dominated by weeds Couch **Cynodon dactylon* or Buffalo Grass **Stenotaphrum secundatum* and a Very Open Herbland of **Euphorbia terracina*. In areas that were in better condition, there were the native grasses *Sporobolus virginicus* and *Bromus arenarius*, and creeping herb *Centella asiatica*.

The PATN analysis indicated that this community is the closest to FCT19: Sedgelands in Holocene Dune Swales and FCT17: *Melaleuca rhaphiophylla – Gahnia trifida* Wetlands.

There was one detailed flora site in this community, PK09 and four releve's PK-A, PK-F, PK-V and PK-W. PK09 had a mean species richness of 20 (FCT19 has 22.6, FCT17 has 13.6) of which five were weeds (FCT19 has 6.9 and FCT17 has 1.7 weeds).

The condition of these wetlands was Very Good to Good. The examples along Port Kennedy Drive had been heavily impacted by weeds and more than likely drainage modification. The wetland indicated by site PK09 was affected by weeds due to kangaroos using it for protection. The Olive **Olea europaea* was establishing itself in some of the wetlands in this community.

See Figure B1 and Plate B9.

2c: Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

This community occurred in the east of the survey area in Lot 4 and in two wetlands at the west boundary of Lot 17. They were drier than wetlands in communities 2a and 2b. This community was also present in dune swales but on broader, shallower depressions. The soil was calcareous sand but more consolidated than the surrounding sand dunes and was probably sand with some clay or organic matter.

This community typically had mature *Xanthorrhoea preissii* up to three metres that formed a Shrubland to Tall Open Scrub. Other occasional tall shrubs included *Hakea prostrata* and *Acacia saligna.* Scattered shrubs under one metre included *Logania vaginalis* and *Adriana quadripartita* and the creeper *Kennedia prostrata.* The understorey was very sparse. There are scattered sedges to Open Sedgelands of *Ficinia nodosa. Baumea juncea* occurred at low density, indicating that they were still wetlands. There was a Very Open Grassland of *Poa porphyroclados* and *Austrostipa flavescens* and a Very Open Herbland of **Euphorbia terracina.* As the wetlands were smaller and drier, they were influenced by the floristics of Communities 1a and 1b, which surrounded them.

The PATN analysis indicated that the closest neighbour for the detailed flora sites in this community was both FCT19: Sedgelands in Holocene Dune Swales and FCT24: Northern Spearwood Shrublands and Woodlands.

There were two detailed flora sites in this community, PK08 and PK12. These sites had a mean species richness of 22.5 species ± 2 (FCT19 has 22.6 and 41.8 for FCT24) with a mean weed frequency of five species (FCT19 has 6.9 and FCT24 has 14.2).

The condition of this community was Good. Kangaroos used these areas for the shade provided by *X. preissii*, and the understorey was dominated by weed species, particularly **Lagurus ovatus* and **Euphorbia terracina.*

See Figure B1 and Plate B10.

Plate B5: **Community 2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.* Near Site PK01. Lot 17.**

Plate B6: **Community 2a: Closed Sedgeland of Baumea juncea, B. articulata and/or Ficinia nodosa and Lepidosperma longitudinale. Site PK15. Lot 17.**

Plate B7: **Community 2a: Closed Sedgeland surrounded by *Xanthorrhoea preissii.* Site PK13. Lot 17.**

Plate B8: **Community 2a: Closed Sedgeland surrounded by *Xanthorrhoea preissii.* Lot 17.**

Plate B9: **Community 2b: Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland. Site PK09. Lot 17.**

Plate B10: **Community 2c: Shrubland to Tall Open Scrub *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea.* Near Site PK12. Lot 4.**

3.2.2 PATN Analysis

The following text was taken from the PATN analysis results completed by E.A. Griffin and Associates (see Appendix B4 for full report).

It is common for the nearest neighbour analysis to be less conclusive than the dendrogram classification. This is more a product of the classification process than any inconsistency of the analyses. The message from the nearest neighbour is probably clearer in this instance. Table B5 is the product of the attempt to reconcile these differences. Some uncertainty exists in this assignment as indicated.

The conclusions were very difficult to derive in some cases given the low level of similarities between the Port Kennedy sites and the SCP or TEC sites. Why there is a low level of similarity is unknown. From the species richness point of view (a common reason for low similarities) there is a mixed picture. The richness of sites apparently related to FCT19, values are similar. However, of the others values (largely related to 29b) are low. The latter may be suggestive that these sites are partly transitional.

In the conclusion, it was considered that few sites would be related to FCT 24 as Port Kennedy is Quindalup rather than Spearwood landscapes.

Table B5: Summary of FCT Assignment

Site Number	Dendrogram	Nearest Neighbour	Conclusion
TEC98	19	17/19	?19
TEC103	19	19	19
TEC162	19	19/17	19
PK01	19	19(T)	19
PK02	19	19(T)	19
PK03	?19	29b/24	29b
PK04	?19	24/29b	29b
PK05	?19	29b	29b
PK06	?19	29b/24	29b
PK07	?19	24	?24?19
PK08	19	24	?24
PK09	19	?19/?24	?19
PK10	?19	29b/24	29b

Site Number	Dendrogram	Nearest Neighbour	Conclusion
PK11	?19	29b/29a/24	29b
PK12	?19	19/24/29a	19/24/29a
PK13	19	24/19(T)	24/19(T)
PK14	?19	24/29b	?29b
PK15	19	19(T)	19
PK16	?19	24/29b	?29b
PKA	19	19(T)/?17	19
PKB	?19	29b	29b
PKC	?19	?19	?19
PKD	19	19(T)/17	?19
PKE	?19	?19	?19
PKF	?19	?19/?17	?19/?17
PKG	?19	?29b/?19	?29b/?19
PKQ	?19	?19/?29b	?19/?29b
PKR	?19	29b	29b
PKS	?19	?24?29b	?29b
PKT	?19	29b	29b
PKU	?19	?19	?19
PKV	?19	?17/?19	?17/?19
PKW	?19	?17	?17
PKX	?19	?24/?19	?19

(T) is by reference to a TEC site rather than a SCP site.

3.3 Wetlands

Using vegetation as an indicator, the wetlands were mapped in Figure B1 (Community 2). The mapping was based on field observations, detailed flora and releve sites and the results of the PATN analysis. Previous mapping of the wetlands at the site was also taken into consideration.

4.0 DISCUSSION

4.1 Flora

No Declared Rare (DRF) as defined by the Wildlife Conservation Act, 1950 (as amended) or Priority Flora were recorded for either Lot 17 or Lot 4.

No Threatened Species as defined by the *Environmental Protection Biodiversity Conservation Act, 1999* (EPBC Act, 1999) were recorded for either Lot 17 or Lot 4.

No flora species was recorded for either Lot 17 or Lot 4 that was deemed to be conservation significant under Guidance Statement 51.

It is estimated that the flora inventory of the site (Appendix B1) represents an estimated greater than 80% of the potential flora for the survey area.

A search of the EPBC protected matters database identified the presence of suitable habitat for three flora species listed under the EPBC Act, orchid *Drakaea micrantha* ms (Vulnerable) and *Lasiopetalum pterocarpum* ms and the sedge *Lepidosperma rostratum* (Endangered), however none of these species were recorded from either Lot 17 or 4.

A search of the Department of Conservation and Land Management (CALM) Declared Rare (DRF) and Priority flora databases showed three records of Priority 4 species, *Jacksonia sericea* and one record of Priority 2 species *Acacia benthamii*. This search covered an area within a 10km radius from the site. None of these existing records were from within in the study area. Neither species was recorded from either Lot 17 or 4.

4.2 Vegetation

At a very broad scale, the site is in Quindalup Vegetation Complex (Heddle *et al.*, 1980) of which there is 48% remaining in the metropolitan region of the Swan Coastal Plain, of which 20% is protected or proposed for protection (Western Australian Planning Commission, 2000).

The two dominant Floristic Community Types (FCT's)(Keighery *et al.*, 1994) in the survey area according to the PATN analysis were FCT19: Sedgelands in Holocene Dune Swales (Unreserved, Endangered) and FCT29b: *Acacia* Shrublands on Taller Dunes (Poorly Reserved, Susceptible). Some sites, particularly the drier wetlands, were transitional. The floristics appeared to be secondarily influenced by FCT17: *Melaleuca rhaphiophylla – Gahnia trifida* Seasonal Wetlands (Well Reserved, Low Risk) and FCT24: Northern Spearwood Shrublands and Woodlands (Well Reserved, Susceptible).

FCT19: Sedgelands in Holocene Dune Swales (TEC19) was found to be present on both Lot 17 and in a single wetland on Lot 4. This is listed as a Threatened Ecological Community (TEC)(Critically Endangered) by the Department of Conservation and Land Management. It is listed under the *EPBC Act, 1999* as an Endangered Ecological Community. The Critical Habitat for this community is the *'system of dunes and swales in which they occur, the fresh superficial groundwater that provides water to the swale wetlands and the catchment for this groundwater'* (English *et al.*, 2002).

A Critically Endangered TEC (DEC) is a community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. An Endangered Ecological Community (EPBC Act, 1999) is a community that is facing a very high risk of extinction in the wild in the near future.

TEC19 includes not a single plant community but an association of communities. The structure, densities and floristics vary and *'sub-groupings appear to relate to variations in depth to groundwater and in age of the dunes'* (English *et al.*, 2002). It was found that the smaller, drier wetlands, which were mainly in the eastern portion of Lot 17 and the single wetland in Lot 4, were influenced by the FCT surrounding them. Under the precautionary principal (Environmental Protection Authority, 2004), all these communities were included within TEC19 (Figure B1).

The map of the current known distribution of TEC 19 (deh.gov.au/biodiversity/threatened/communities/maps/pubs/southern-swan-sedgelands-map.pdf) covers an area from Point Becher eastwards, covering the study area and then north in a ring surrounding Rockingham. It indicates that the Rockingham – Point Becher site represents the largest remnant of this community and its critical habitat. It is also known from Yanchep and three small wetlands at Preston Beach.

Lots 17 and 4 are both listed as an Environmentally Sensitive Area, under the Environmental Protection Act, 1996 (Vegetation Clearing Regulations, 2004).

4.3 Site Condition

Lot 17 was in Excellent to Very Good condition, with Degraded to Completely Degraded areas along tracks and firebreaks. Lot 4 was in Good condition with Degraded to Completely Degraded areas along tracks and firebreaks (Figure B1)

Both lots are undergoing rapid decline from trail bike users and rubbish dumping, particularly garden waste which is introducing serious weeds. There was a marked increase of both activities between September and November 2006, with new tracks and more waste appearing in the intervening period.

4.4 EPBC Act, 1999

A search of the Department of Environment and Heritage (DEH) protected matters database identified the following issues under the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act).

The study area is within the boundaries of Site 17282: Lakes Cooloongup and Walyungup and Surrounds, (listed on the Register of the National Estate 30.06.1992). These sites have protection under the EPBC Act, however it states that *'although some places may be legally registered because they are within a larger registered area they may not necessarily possess intrinsic significance'*. In terms of the vegetation, Site 17282 is listed as being significant because:

> *'The surrounding heathlands, shrublands, woodlands and forests are important as a representation of the now restricted communities which covered the Swan Coastal Plain prior to urban development'.*
>
> *'It has considerable animal and plant association diversity, with thirteen vegetation associations being found within the area'*

Discussion with DEC (December 2006) indicates that the boundary of Site 17282: Lakes Cooloongup and Walyungup and Surrounds will be added to RAMSAR Site 54: Becher Point Wetlands, within an estimated timeframe of a year. RAMSAR sites are internationally significant wetland sites and are protected under the *EPBC Act.* The wetlands currently protected within RAMSAR site 54 are a few hundred to 4500 years old. One of the reasons given for the extension of the site is to include sections of the Becher Plain that support older wetlands. The wetlands within Lots 17 and 4 occur within a section of the plain that was formed between 4500 and 7500 years ago. (English *et al.,* 2002).

Endangered Ecological Community: Sedgelands in Holocene Dune Swales occurs on both Lots 17 and the western end of Lot 4, and these are protected under the *EPBC Act.*

The dune and swale community within which the Endangered Ecological Community occurs is considered critical habitat (English *et al.,* 2002). There is potential in the future for this to be listed as Critical Habitat under the *EPBC Act,* which would give it specific protection. Even as the legislation currently stands, habitat critical to the survival of an Endangered Ecological Community is considered to be covered under the *EPBC Act.*

4.5 Survey Limitations

2006 was an extremely dry year and this may have affected the flora inventory. Additionally, winter rains were late and the growing season very short.

5.0 REFERENCES

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APPENDIX B1

Species List

020 **TYPHACEAE**
Typha domingensis

031 **POACEAE**
Austrodanthonia occidentalis
Austrostipa elegantissima
Austrostipa flavescens
**Avena barbata*
**Avena fatua*
**Briza maxima*
**Briza minor*
Bromus arenarius
**Bromus diandrus*
**Cynodon dactylon*
**Desmazeria rigida*
**Ehrharta calycina*
**Ehrharta longiflora*
* *Eragrostis curvula*
**Holcus lanatus*
Lachnagrostis filiformis
* *Lagurus ovatus*
**Lolium perenne*
**Lolium rigidum*
Poa porphyroclados
* *Polypogon monspeliensis*
**Stenotaphrum secundatum*
* *Vulpia bromoides*
Sporobolus virginicus

032 **CYPERACEAE**
Baumea articulata
Baumea juncea
Carex preissii
Cyperus polystachyos
**Cyperus tenuiflorus*
Ficinia nodosa
Gahnia trifida
Isolepis cernua var. *cernua*
Isolepis cernua var. *setiformis*
Lepidosperma gladiatum
Lepidosperma longitudinale
Lepidosperma squamatum
Schoenus grandiflorus

039 **RESTIONACEAE**
Desmocladus asper

052 **JUNCACEAE**
Juncus kraussii

054C **DASYPOGONACEAE**
Acanthocarpus preissii
Lomandra maritima

054D **XANTHORRHOEACEAE**
Xanthorrhoea preissii

054E **PHORMIACEAE**
Dianella revoluta var. *divaricata*

054F **ANTHERICACEAE**
Thysanotus dichotomus
Tricoryne elatior

054G **ASPHODELACEAE**
**Asphodelus fistulosus*
**Trachyandra divaricata*

056B **AGAVACEAE**
**Yucca aloifolia*

055 **HAEMODORACEAE**
Conostylis aculeata subsp. *preissii*

060 **IRIDACEAE**
**Romulea rosea* var. *australis*

090 **PROTEACEAE**
**Grevillea* sp. Hybrid Ornamental
Hakea prostrata

092 **SANTALACEAE**
Exocarpos sparteus

103 **POLYGONACEAE**
**Acetosella vulgaris*
* *Rumex crispus*

105 **CHENOPODIACEAE**
**Atriplex prostrata*
Rhagodia baccata subsp. *baccata*

113 **CARYOPHYLLACEAE**
**Cerastium glomeratum*
Petrorhagia dubia
**Silene gallica* var?

119 **RANUNCULACEAE**
Clematis linearifolia

131 **LAURACEAE**
Cassytha racemosa forma. *racemosa*

138 **BRASSICACEAE**
**Brassica tournefortii*

149 **CRASSULACEAE**
**Crassula glomerata*

163 **MIMOSACEAE**
Acacia lasiocarpa var. *lasiocarpa*
Acacia rostellifera
Acacia saligna

165 **PAPILLIONACEAE**
Gompholobium tomentosum
Hardenbergia comptoniana
Jacksonia furcellata
Kennedia prostrata
**Medicago polymorpha*
**Melilotus indicus*
**Trifolium campestre* var. *campestre*
**Trifolium repens* var. *repens*

167 **GERANIACEAE**
**Erodium botrys*
**Pelargonium capitatum*
**Pelargonium littorale* subsp. *littorale*

185 **EUPHORBIACEAE**
Adriana quadripartita
**Euphorbia terracina*
Phyllanthus calycinus

194 **ANACARDIACEAE**
**Schinus terebinthifolius*

223 **STERCULIACEAE**
Thomasia cognata

273 **MYRTACEAE**
**Melaleuca huegelii (planted)*
Melaleuca rhaphiophylla
Melaleuca systena
Melaleuca teretifolia

275 **ONAGRACEAE**
**Gaura lindheimeri*
Epilobium billardiereanum subsp. *billardiereanum*

281 **APIACEAE**
Apium prostratum var. *prostratum*
Centella asiatica

288 **EPACRIDACEAE**
Leucopogon parviflorus

293 **PRIMULACEAE**
**Anagallis arvensis* var. *arvensis*
**Anagallis arvensis* var. *caerulea*

301 **OLEACEAE**
**Olea europaea* subsp. *europaea*

302 **LOGANIACEAE**
Logania vaginalis

303 **GENTIANACEAE**
**Centaurium pulchellum*

311 **VERBENACEAE**
**Phyla nodiflora* var.*nodiflora*

313 **LAMIACEAE**
Hemiandra glabra subsp. *glabra*

315 **SOLANACEAE**
Anthocercis littorea
**Solanum nigrum*

316 **SCROPHULARIACEAE**
**Dischisma arenarium*
**Verbascum virgatum*

320 **OROBANCHACEAE**
Orobanche minor

326 **MYOPORACEAE**
Eremophila glabra subsp. *albicans*

331 **RUBIACEAE**
Opercularia vaginata

336 **DIPSACACEAE**
**Scabiosa atropurpurea*

340 **LOBELIACEAE**
Lobelia alata

341 **GOODENIACEAE**
Scaevola anchusifolia

345 **ASTERACEAE**
**Carduus pycnocephalus*
**Conyza bonariensis*
**Conyza sumatrensis*
*?*Hedypnois rhagadioloides* subsp. *cretica*
**Hypochaeris glabra*
Olearia axillaris
Senecio pinnatifolius var.*latilobus*
**Sonchus oleraceus*
**Symphyotrichum squamatum*

APPENDIX B2

Species by Site Table

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
*Acetosella vulgaris				<0.1																													
*Anagallis arvensis var. arvensis												<0.1		<0.1	<0.1					< 0.1		0.1		0.5		0.5		<.1	0.3				
*Anagallis arvensis var. caerulea																																	
*Asphodelus fistulosus	PK11																												0.2				
*Atriplex prostrata																																	
*Avena barbata				15		5		1				5		2		10	2	30		3		1		1		<0.1	3		1		2		
*Avena fatua																																	
*Brassica tournefortii						<0.1		<0.1						<0.1														<.1					
*Briza maxima															<0.1														0.1				
*Briza minor																<0.1										<0.1							
*Bromus diandrus				15																													
*Carduus pycnocephalus		<0.1		1																									1			1	
*Centaurium pulchellum															<0.1											<0.1							
*Cerastium glomeratum																																	
*Conyza bonariensis																																	
*Conyza sumatrensis				<0.1											0.2		<0.1								3	0.5	0.2		1			<0.1	
*Crassula glomerata						<0.1		<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1					0.2		<0.1		<0.1						<0.1			
*Cynodon dactylon																																	
*Cyperus tenuiflorus																													2				
*Desmazeria rigida																<0.1																	
*Dischisma arenarium										1																							
*Ehrharta calycina																	1				0.3												
*Ehrharta longiflora								<0.1																			<.1						
*Eragrostis curvula	PK11																									2							
*Erodium botrys						<0.1		<0.1	<0.1																								
*Euphorbia terracina	PK01			2		2		5		<0.1		35		35		###		2		4		3		4		0.2		0.5		3		2		3	
*Gaura lindheimeri																																	
*Grevillea sp. Hybrid Ornamental	PK11																																
?*Hedypnois rhagadioloides subsp. cretica																										0.1							
*Holcus lanatus		<0.1		<0.1																													
*Hypochaeris glabra		<0.1										<0.1	<0.1	<0.1		0.1						<0.1				<0.1							
*Lagurus ovatus								17				5	5	10--35			5				3		10		12		0.1		1		0.1	0.5		
*Lolium perenne						<0.1		<0.1	<0.1			<0.1			<0.1		<0.1			< 0.1			<0.1			<0.1			0.1	0.1				
*Lolium rigidum		<0.1																						<0.1									

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
**Medicago polymorpha*		<0.1										<0.1																							
**Melaleuca huegelii* (planted)	PK11																																		
**Melilotus indicus*				<0.1													<0.1							<0.1											
**Olea europaea* subsp. *europaea*																		2		1 plant															
**Orobanche minor*																														<0.1					
**Pelargonium capitatum*																0.1						0.5													
**Pelargonium littorale* subsp. *littorale*																																			
**Phyla nodiflora var nodiflora*																																			
**Polypogon monspeliensis*																																			
**Romulea rosea var. australis*	PK01					1		1				1	1	3	3		<0.1				< 0.1		0.1		0.5		<0.1			0.1			1		
**Rumex crispus*																																			
**Scabiosa atropurpurea*	PK10 PK11													<0.1																					
**Schinus terebinthifolius*																																		<0.1	
**Silene gallica* var?																0.5																			
**Solanum nigrum*																																			
**Sonchus oleraceus*		<0.1				<0.1								<0.1	<0.1									<0.1		<0.1		0.2		<0.1				<0.1	
**Stenotaphrum secundatum*																																			
**Symphyotrichum squamatum*				<0.1																															
**Trachyandra divaricata*						1		5																											
**Trifolium campestre* var. *campestre*																									0.1	0.3									
**Trifolium repens* var. *repens*				70									<0.1	<0.1	<0.1														2				50		
**Verbascum virgatum*	PK11																												<0.1						
**Vulpia bromoides*																				< 0.1															
**Yucca aloifolia*																																			
Acacia lasiocarpa var. *lasiocarpa*										4												0.2						0.2							
Acacia rostellifera	PK15					40				60		10--1	2	1						45		4	2	<0.1				40	30			35	8		
Acacia saligna	PK01, 02, 04, 11, 16			<0.1				<0.1								5		0.1								4				4					
Acanthocarpus preissii	PK16					5														4		5													
Adriana quadripartita	PK01			<0.1				<0.1		0.1		1		<0.1				0.5		0.5		1		<0.1		60		1		1		1		1	
Anthocercis littorea				2																															
Apium prostratum var. *prostratum*				2																														1	
Austrodanthonia occidentalis	PK03, PK14						0.5																									<0.1			
Austrostipa elegantissima				<0.1																															
Austrostipa flavescens						4		5--12		0.3		5--10		<0.1	<0.1			<0.1		4		4		<0.1		<0.1		1				5			

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Baumea articulata		7	5																														
Baumea juncea		20-30		15												0.5		0.3						<0.1	80			40				1	
Bromus arenarius	PK03 PK04			<0.1	<.1		0.1	0.1			0.1		2		<0.1		<0.1	0.2	2	2			<0.1	0.5			<0.1	1		<0.1		2	<0.1	
Carex preissii	PK13															0.1																	
Cassytha racemosa forma *racemosa*				20																													
Centella asiatica		2		50																					10			25				60	
Clematis linearifolia	PK14, PK10																														0.1		
Conostylis aculeata subsp. *preissii*	PK04					2		0.1		0.1										0.1		4									1		
Cyperus polystachyos																																	
Desmocladus asper						<0.1		1				1								0.5		0.1			0.3						1		
Dianella revoluta var. *divaricata*	RV01											<0.1		0.5				<0.1		0.1		0.3						0.2			0.1		
Epilobium billardiereanum subsp. *billardiereanum*				<0.1																												<0.1	
Eremophila glabra subsp. *albicans*	RV04																																
Exocarpos sparteus	PK11 PK15			0.5														<0.1										0.2					
Ficinia nodosa				2						2						3		1						2		1		1		50			<0.1	
Gahnia trifida	PK13			1														3															
Gompholobium tomentosum																0.1												<0.1					
Hakea prostrata	PK12 PK15									1		2	1							1								1						
Hardenbergia comptoniana	RV02 PK16					1																											
Hemiandra glabra subsp. *glabra*														2						0.5													
Isolepis cernua var. *cernua*				<0.1																													
Isolepis cernua var *setiformis*						<0.1	<.1			1	1																						
Jacksonia furcellata	RV01, PK11 PK16					<0.1														< 0.1													
Juncus kraussii	ADJ01																															60	
Kennedia prostrata	PK13							<0.1		1						0.5		<0.1													0.3		
Lachnagrostis filiformis																																	
Lepidosperma gladiatum		1	1	15										8						1													
Lepidosperma longitudinale		30-60	10	15-30																													
Lepidosperma squamatum						5		5--8		85		12--15		30		0.5				5		12		8				3				8		
Leucopogon parviflorus																		0.5		1		1				0.5							
Lobelia alata	PK13	<0.1																												<0.1			
Logania vaginalis	RV01			1												0.2										3				0.2			
Lomandra maritima						0.1		5				0.5		1						2		3		1				0.5					
Melaleuca rhaphiophylla																		15	5														

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Melaleuca systena						5		<0.1		3		3																1				4			
Melaleuca teretifolia				25																												<0.1	
Olearia axillaris																																	
Opercularia vaginata						<0.1		<0.1	<0.1	<0.1		<0.1								1		2								<0.1			
Petrorhagia dubia														<0.1										0.3									
Phyllanthus calycinus						0.3																											
Poa porphyroclados	PK15					<0.1	<0.1			2				0.3		0.2						1		2	1	<0.1						1			
Rhagodia baccata subsp. *baccata*	PK11 PK14			5		1				2								2															
Scaevola anchusifolia								<0.1	<0.1													0.2										<0.1	
Schoenus grandiflorus	PK03					0.1						1	1							0.3												1			
Senecio pinnatifolius var. *latilobus*																						<0.1		0.2								<0.1		<0.1	
Sporobolus virginicus	PK11																	1								0.2				2					
Thomasia cognata																																	
Thysanotus dichotomus						0.1																											
Tricoryne elatior						0.5																		<0.1									
Typha domingensis																																	
Xanthorrhoea preissii	RV01, PK09													5		55								40		2								

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		© PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
*Acetosella vulgaris												<0.1																							
*Anagallis arvensis var. arvensis																																			
*Anagallis arvensis var. caerulea																																			
*Asphodelus fistulosus	PK11																																		
*Atriplex prostrata																																			
*Avena barbata		<0.1																																	
*Avena fatua																						<0.1		5		35		3		<0.1		1		<0.1		2	
*Brassica tournefortii																																			
*Briza maxima																																			
*Briza minor																																			
*Bromus diandrus																																			
*Carduus pycnocephalus																																			
*Centaurium pulchellum																																			
*Cerastium glomeratum																																			
*Conyza bonariensis																																			
*Conyza sumatrensis														<0.1																					
*Crassula glomerata																														<0.1					
*Cynodon dactylon																																			
*Cyperus tenuiflorus																																			
*Desmazeria rigida																																			
*Dischisma arenarium																																			
*Ehrharta calycina																																			
*Ehrharta longiflora																										5									
*Eragrostis curvula	PK11																																		
*Erodium botrys																																			
*Euphorbia terracina	PK01	1				7		10						20		<0.1		5		3		2		15		15		5		10		5				3	
*Gaura lindheimeri																																			
*Grevillea sp. Hybrid Ornamental	PK11																																		
?*Hedypnois rhagadioloides subsp. cretica																																			
*Holcus lanatus				60		60		20																											
*Hypochaeris glabra																																			
*Lagurus ovatus																																			
*Lolium perenne																										15		8						10	
*Lolium rigidum																																			

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		© PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
**Medicago polymorpha*																		<0.1																	
**Melaleuca huegelii* (planted)	PK11																																		
**Melilotus indicus*																																			
**Olea europaea* subsp. *europaea*																		10																	
**Orobanche minor*																																			
**Pelargonium capitatum*																<0.1																			
**Pelargonium littorale* subsp. *littorale*																				<0.1															
**Phyla nodiflora var nodiflora*												20																							
**Polypogon monspeliensis*																																			
**Romulea rosea var. australis*	PK01																	<0.1				<0.1						<0.1							
**Rumex crispus*																																			
**Scabiosa atropurpurea*	PK10 PK11																																		
**Schinus terebinthifolius*																																			
**Silene gallica* var?																																			
**Solanum nigrum*												<0.1																							
**Sonchus oleraceus*																																			
**Stenotaphrum secundatum*																																85			
**Symphyotrichum squamatum*												<0.1						<0.1																	
**Trachyandra divaricata*																																			
**Trifolium campestre* var. *campestre*																																			
**Trifolium repens* var. *repens*												<0.1																							
**Verbascum virgatum*	PK11																																		
**Vulpia bromoides*																																			
**Yucca aloifolia*																																		<0.1	
Acacia lasiocarpa var. *lasiocarpa*																						<0.1				<0.1								<0.1	
Acacia rostellifera	PK15	70								60								3						50		<0.1		15		30				5	
Acacia saligna	PK01, 02, 04, 11, 16																			1		<0.1		1				3		<0.1		1		5	
Acanthocarpus preissii	PK16																											0.5							
Adriana quadripartita	PK01							10		1						40		3		5		3						<0.1		5		1			<0.1	
Anthocercis littorea										20																									
Apium prostratum var. *prostratum*												20																		1		0.5			
Austrodanthonia occidentalis	PK03, PK14																											<0.1							
Austrostipa elegantissima																																			
Austrostipa flavescens																				<0.1				1				2				<0.1		2	

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		® PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Baumea articulata																																			
Baumea juncea																																			
Bromus arenarius	PK03 PK04															2		5				5								15				<0.1	
Carex preissii	PK13																					5						<0.1			10	45		<0.1		2
Cassytha racemosa forma *racemosa*																		<0.1																	
Centella asiatica												50																							
Clematis linearifolia	PK14, PK10	<0.1		60		60		20				50										20													
Conostylis aculeata subsp. *preissii*	PK04																											<0.1							
Cyperus polystachyos																																			
Desmocladus asper																																			
Dianella revoluta var. *divaricata*	RV01																																		
Epilobium billardiereanum subsp. *billardiereanum*												<0.1																<0.1							
Eremophila glabra subsp. *albicans*	RV04																																		
Exocarpos sparteus	PK11 PK15																											<0.1							
Ficinia nodosa						7		10								50		5				70								30		20			
Gahnia trifida	PK13											5						10																	
Gompholobium tomentosum																																			
Hakea prostrata	PK12 PK15	10								10												1	15	1						2				<0.1	
Hardenbergia comptoniana	RV02 PK16																																	<0.1	
Hemiandra glabra subsp. *glabra*																																			
Isolepis cernua var. *cernua*																																			
Isolepis cernua var *setiformis*																																			
Jacksonia furcellata	RV01, PK11 PK16																																		
Juncus kraussii	ADJ01																											<0.1							
Kennedia prostrata	PK13	<0.1																<0.1		1		<0.1													
Lachnagrostis filiformis												<0.1																		<0.1		<0.1		1	
Lepidosperma gladiatum												80												<0.1											
Lepidosperma longitudinale												5																							
Lepidosperma squamatum		5																		8				<0.1				10						20	
Leucopogon parviflorus																				1								<0.1							
Lobelia alata	PK13																																		
Logania vaginalis	RV01							10								5						3								5					
Lomandra maritima																																			
Melaleuca rhaphiophylla																		30	70													3		5	30

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		® PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Melaleuca systena																								2		<0.1		5							<0.1	
Melaleuca teretifolia												60																							
Olearia axillaris																												<0.1		<0.1					
Opercularia vaginata																												<0.1							
Petrorhagia dubia																																			
Phyllanthus calycinus																												0.5							
Poa porphyroclados	PK15	<0.1																		<0.1		<0.1		0.5						<0.1				1	
Rhagodia baccata subsp. *baccata*	PK11 PK14	<0.1								1								3				<0.1								1					
Scaevola anchusifolia																												<0.1							
Schoenus grandiflorus	PK03																											<0.1							
Senecio pinnatifolius var. *latilobus*																																			
Sporobolus virginicus	PK11											1														15					5		5		
Thomasia cognata																																		<0.1	
Thysanotus dichotomus																																			
Tricoryne elatior																																			
Typha domingensis																																			
Xanthorrhoea preissii	RV01, PK09																			90				<0.1							1		2		20	

APPENDIX B3

Vegetation Site Descriptions

Detailed Flora Site: PK01
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383678 **Northing**: 6418353 **Accuracy:** 5m
Photo: KM031
Topography: damp land in coastal swale.
Soil: Dark brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years (Surrounding dunes to the east have been recently burnt).
Litter: 80% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Excellent. **Disturbance:** Level low - weeds and rubbish.
Vegetation Description:
Lepidosperma longitudinale, Baumea juncea and *Baumea articulata* Sedgeland over *Centella asiatica* Very Open Herbland.
Species List:
**Carduus pycnocephalus, *Holcus lanatus, *Hypochaeris glabra, *Lolium rigidum, *Medicago polymorpha, *Sonchus oleraceus, Baumea articulata, Baumea juncea, Centella asiatica, Lepidosperma gladiatum, Lepidosperma longitudinale, Lobelia alata.*
Notes: An existing Threatened Ecological Community plot (TEC98) mapped by The Department of Environment and Conservation (DEC) is present within this site.

Detailed Flora Site: PK02
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383712 **Northing**: 6418220 **Accuracy:** 5m
Photo: KM 038 & 039.
Topography: dampland.
Soil: Dark brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** approx 2 years (50% of plot is unburnt)
Litter: 50% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Good. **Disturbance:** Level medium – weeds (>70% cover in herb layer).
Vegetation Description:
Melaleuca teretifolia Tall Shrubland over *Lepidosperma longitudinale, Lepidosperma gladiatum* and *Baumea juncea* Open Sedgeland over **Trifolium repens* var. *repens, Centella asiatica* Herbland and **Avena barbata* Open Grassland.
Species List:
**Avena barbata, *Bromus diandrus, *Carduus pycnocephalus, *Conyza sumatrensis, *Euphorbia terracina, *Holcus lanatus, *Melilotus indicus, *Symphyotrichum squamatum, *Trifolium repens* var. *repens, *Acetosella vulgaris, Acacia saligna, Adriana quadripartite, Anthocercis littorea, Apium prostratum* var. *prostratum, Austrostipa elegantissima, Baumea juncea, Bromus arenarius, Cassytha racemosa* forma. *racemosa, Centella asiatica, Epilobium billardiereanum* subsp. *billardiereanum, Exocarpos sparteus, Ficinia nodosa, Gahnia trifida, Isolepis cernua* var.*cernua, Lepidosperma gladiatum, Lepidosperma longitudinale, Logania vaginalis, Melaleuca teretifolia, Rhagodia baccata* subsp.*baccata* and sterile herb.

Notes: An existing Threatened Ecological Community plot (TEC Pm35) mapped by The Department of Environment and Conservation (DEC) is present within this site.

Detailed Flora Site: PK03
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383781 **Northing**: 6418187 **Accuracy:** 5m
Photo: KM41.
Topography: dune crest.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: crest slightly NE. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 20%.
Condition: Very Good. **Disturbance:** Level medium - weeds (approx 25% cover).
Vegetation Description:
Acacia rostellifera, Melaleuca systena and *Acanthocarpus preissii* Open Low Heath to Low Shrubland over **Trachyandra divaricata* and *Conostylis aculeata* subsp.*preissii* Very Open Herbland and *Lepidosperma squamatum* Very Open Sedgeland.
Species List:
**Avena barbata, *Brassica tournefortii, *Crassula glomerata, *Erodium botrys, *Euphorbia terracina, *Lolium perenne, *Romulea rosea* var. *australis, *Sonchus oleraceus, *Trachyandra divaricata, Acacia rostellifera, Acanthocarpus preissii, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp.*preissii, Desmocladus asper, Hardenbergia comptoniana, Isolepis cernua* var.*setiformis, Jacksonia furcellata, Lepidosperma squamatum, Lomandra maritima, Melaleuca systena, Opercularia vaginata, Phyllanthus calycinus, Poa porphyroclados, Rhagodia baccata* subsp.*baccata, Schoenus grandiflorus, Thysanotus dichotomus, Tricoryne elatior* and sterile herb

Detailed Flora Site: PK04
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383836 **Northing**: 6418246 **Accuracy:** 5m
Photo: KM 43 & 43.
Topography: on flat in a swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly NE. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 20%.
Condition: Degraded. **Disturbance:** Level High - weeds and fire.
Vegetation Description:
**Euphorbia terracina, *Trachyandra divaricata* and *Lomandra maritima* Open Herbland over *Austrostipa flavescens* and weedy sterile grasses over *Lepidosperma squamatum* Very Open Sedgeland
Species List:
**Avena barbata, *Brassica tournefortii, *Crassula glomerata, *Ehrharta longiflora, *Erodium botrys, *Euphorbia terracina, *Lagurus ovatus, *Lolium perenne, *Romulea rosea* var. *australis, *Trachyandra divaricata, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp. *preissii, Desmocladus asper, Kennedia prostrata, Lepidosperma sqaamatum, Lomondra maritima, Melaleuca systena, Opercularia vaginata, Scaevola anchusifolia* and sterile herb & weedy grasses.

Detailed Flora Site: PK05
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383842 **Northing**: 6418374 **Accuracy:** 5m
Photo: KM 44 & 45.
Topography: dampland.
Soil: grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Very Good. **Disturbance:** Level medium - weeds.
Vegetation Description:
Acacia rostellifera and *Hakea prostrata* Open Low Heath over *Lepidosperma squamatum* Closed Sedgeland and *Austrostipa flavescens* and sterile weedy grasses Very Open Grassland.
Species List:
**Crassula glomerata, *Dischisma arenarium, *Euphorbia terracina, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conastylis aculeata* subsp. *preissii, Ficinia nodosa, Hakea prostrata, Isalepis cernua* var. *setiformis, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Opercularia vaginata, Poa porphyroclados, Rhagodia baccata* subsp. *baccata* and sterile weedy grasses.
Notes: The *Acacia rostellifera* and *Hakea prostrata* were both less than 1m, if the site had not been burnt they may have been >3m.

Detailed Flora Site: PK06
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384144 **Northing**: 6418435 **Accuracy:** 5m
Photo: KM 46.
Topography: dune swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly NE. **Age Since Fire:** more than 2 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level High - weeds.
Vegetation Description:
Acacia rostellifera Shrubland (with scattered *Hakea prostrata*) over *Acacia rostellifera* (regrowth) and *Melaleuca systena* Low Shrubland over *Lepidosperma squamatum* Open to Very Open Sedgeland, *Austrostipa flavescens* Very Open Grassland and **Euphorbia terracina* Herbland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Hypochaeris glabra, *Lagurus ovatus, *Lolium perenne, *Medicago polymorpha, *Romulea rosea* var. *australis, *Trifolium repens* var. *repens, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Desmocladus asper, Dianella revoluta* var. *divaricata, Hakea prostrata, Lepidosperma squamatum, Lomandra maritima, Melaleuca systena, Opercularia vaginata* and *Schoenus grandiflorus.*

Detailed Flora Site: PK07
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384387 **Northing**: 6418207 **Accuracy:** 5m
Photo: KM 47, 48 & 49.
Topography: dune swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly SW. **Age Since Fire:** more than 2 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** 5%.
Condition: Degraded. **Disturbance:** Level High - weeds (80%).
Vegetation Description:
Xanthorrhoea preissii Open Shrubland over *Lepidosperma gladiatum* and *Lepidosperma squamatum* Open Sedgeland over **Euphorbia terracina* Herbland and mixed annual weedy Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis*, **Avena barbata*, **Brassico tournefortii*, **Briza maxima*, **Crassula glomerata*, **Euphorbia terracina*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Romulea rosea* var. *australis*, **Scabiosa atropurpurea*, **Sonchus oleraceus*, **Trifolium repens* var. *repens*, *Acacia rostellifera*, *Adriana quadripartita*, *Austrostipa flavescens*, *Bromus arenarius*, *Dianella revoluta* var. *divaricata*, *Hemiandra glabra subsp. glabra*, *Lepidosperma gladiatum*, *Lepidasperma squamatum*, *Lomandra maritima*, *Petrorhagia dubia*, *Poa porphyroclados*, *Xanthorrhoea preissii* and sterile herb

Detailed Flora Site: PK08
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384061 **Northing**: 6418455 **Accuracy:** 4.1m
Photo: RPS 1039-1041.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: W-SW. **Age Since Fire:** more than 5 years.
Litter: 3% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level medium to high – graffiti, weeds and fire.
Vegetation Description:
Xanthorrhoea preissii and *Acacia saligna* Tall Shrubland/ Shrubland over *Ficinia nodosa* Open Sedgeland over **Avena barbata* and **Lagurus ovatus* Very Open Grassland.
Species List:
**Avena barbata*, **Briza minor*, **Centaurium pulchellum*, **Conyza sumatrensis*, **Desmazeria rigida*, **Euphorbia terracina*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Melilotus indicus*, **Pelargonium capitatum*, **Romulea rosea* var. *australis*, **Silene gallica* var?, *Acacia saligna*, *Baumea juncea*, *Carex preissii*, *Ficinia nodosa*, *Gompholobium tamentosum*, *Kennedia prostrata*, *Lepidosperma squamatum*, *Logania vaginalis*, *Poa porphyroclados* and *Xanthorrhoea preissii*.

Detailed Flora Site: PK09
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384095 **Northing**: 6418280 **Accuracy:** 6.3m
Photo: RPS 1043-1046.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Degraded - Good. **Disturbance:** Level medium - weeds.
Vegetation Description:
Melaleuca rhaphiophylla Low Woodland over *Gahnia trifida*, *Ficinia nodosa* Open Sedgeland and **Olea europaea* subsp. *europaea* Low Open Shrubland over **Avena barbata* and *Bromus arenarius* Grassland.
Species List:
**Avena barbata*, **Conyza sumatrensis*, **Ehrharta calycina*, **Euphorbia terracina*, **Olea europaea* subsp. *europaea*, *Acacia saligna*, *Adriana quadripartita*, *Austrostipa flavescens*, *Baumea juncea*, *Bromus arenarius*, *Dianella revoluta* var. *divaricata*, *Exocarpos sparteus*, *Ficinia nodosa*, *Gahnia trifida*, *Kennedia prostrata*, *Leucopogon parviflorus*, *Melaleuca rhaphiophylla*, *Rhagodia baccata* subsp. *baccata* and *Sporobolus virginicus*

Detailed Flora Site: PK10
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384431 **Northing**: 6418274 **Accuracy:** 4m
Photo: RPS 989-992.
Topography: upper slope of dune.
Soil: Light brown sand. **Rock Type:** limestone.

Aspect: NW. **Age Since Fire:** more than 5 years.
Litter: 80% dead grasses. **Bare Ground:** 5%.
Condition: Good. **Disturbance:** Level High – weeds, rubbish and vehicle tracks.
Vegetation Description:
Acacia rostellifera Open Heath over *Acanthocarpus preissii* and **Euphorbia terracina* Low Open Shrubland and *Lepidosperma squamatum* Very Open Sedgeland over *Lomandra maritima* Very Open Herbland and *Austrostipa flavescens, Bromus arenarius* and **Lagurus ovatus* Very Open Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Lolium perenne, *Olea europaea* subsp. *europaea, *Romulea rosea* var. *australis, *Vulpia bromoides, Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Canostylis aculeata* subsp. *preissii, Desmocladus asper, Dianella revaluta* var. *divaricata, Hakea prostrata, Hemiandra glabra* subsp. *glabra, Jacksonia furcellata, Lepidasperma gladiatum, Lepidosperma squamatum, Leucopogon parviflorus, Lomandra maritima, Opercularia vaginata* and *Schoenus grandiflorus,*

Detailed Flora Site: PK11
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384561 **Northing**: 6418590 **Accuracy:** 5m
Photo: RPS 993 & 994.
Topography: hill top on a coastal dune crest.
Soil: Light brown sand. **Rock Type:** limestone.
Aspect: E. **Age Since Fire:** < 2 years.
Litter: 80% dead weeds and grass. **Bare Ground:** 10%.
Condition: Good – Very Good. **Disturbance:** Level medium - weeds and fire.
Vegetation Description:
Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita and *Leucopogon parviflorus* Low Open Shrubland over *Lepidosperma squamatum* Open Sedgeland over *Lomandra maritima, Conostylis aculeata* subsp.*preissii* and **Euphorbia terracina* Very Open Herbland and **Lagurus ovatus* and *Austrostipa flavescens* Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis, *Avena barbata, *Crassula glomerata, *Ehrharta calycina, *Euphorbia terracina, *Hypochaeris glabra, *Lagurus ovatus, *Lolium perenne, *Pelargonium capitatum, *Romulea rosea* var. *australis, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp. *preissii, Desmocladus asper, Dianella revoluta* var. *divaricata, Lepidosperma squamatum, Leucopogon parviflorus, Lomandra maritima, Opercularia vaginata, Poa porphyroclados, Scaevola anchusifolia* and *Senecio pinnatifolius* var.*latilobus,*

Detailed Flora Site: PK12
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384293 **Northing**: 6418425 **Accuracy:** 4.3m
Photo: RPS 995-998.
Topography: Prominent dip in dune swale
Soil: Light brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 80% dead weeds and grasses. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level medium - weeds and rubbish.
Vegetation Description:
Xanthorrhaea preissii Open Heath over *Ficinia nodosa* and *Lepidosperma squamatum* Open Sedgeland over **Lagurus ovatus* Open Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Lolium rigidum, *Melilotus indicus, *Romulea rosea* var. *australis, *Sonchus oleraceus, *Trifolium campestre* var. *campestre, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Desmocladus asper, Ficinia nodosa, Lepidosperma squamatum, Lomandra maritima, Petrorhagia dubia, Poa porphyroclados, Senecio pinnatifolius* var.*latilobus, Tricoryne elatior, Xanthorrhoea preissii* and sterile herb.

Detailed Flora Site: PK13
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384045 **Northing**: 6418523 **Accuracy:** 3.8m
Photo: RPS 999-1001.
Topography: damp land in a prominent dip.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance:** Level medium - weeds.

Vegetation Description:
Adriana quadripartita, Acacia saligna, Logania vaginalis and *Xanthorrhoea preissii* Open Heath over *Baumea juncea* Closed Sedgeland over *Centello asiatica* and **Conyza sumatrensis* Open Herbland and **Eragrostis curvula* Very Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Avena barbata*, **Briza minor*, **Centaurium pulchellum*, **Conyza sumatrensis*, **Eragrostis curvula*, **Euphorbia terracina*, *?*Hedypnois rhagadioloides ssp. Cretica*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Romulea rosea* var. *australis*, **Sonchus oleraceus*, **Trifolium campestre* var. *campestre*, *Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Leucopogon parviflorus, Logania vaginalis, Poa porphyrocladas, Sporobolus virginicus* and *Xanthorrhoea preissii*
Notes: Around the wetland is a dense ring of *Xanthorrhoea preissii* up to 3m tall with a density of approx 85%.

Detailed Flora Site: PK14
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383773 **Northing**: 6418602 **Accuracy:** 5.3m
Photo: RPS 1047 & 1048.
Topography: Flat.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 80% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Good – Very Good. **Disturbance:** Level Low- weeds.
Vegetation Description:
Acacia rostellifera Closed Heath over *Lepidosperma squamatum* Very Open Sedgeland and **Avena barbata* Very Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Avena barbata*, **Brassica tournefortii*, **Briza maxima*, **Conyza sumatrensis*, **Ehrharta longiflora*, **Euphorbia terracina*, **Lagurus ovatus*, **Lolium perenne*, **Sonchus oleraceus*, *Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Dianella revoluta* var. *divaricata, Exocarpos sparteus, Ficinia nodosa, Gompholobium tomentosum, Hakea prostrata, Lepidosperma squamatum, Lomandra maritima* and *Melaleuca systena.*

DETAILED FLORA SITE: PK15
Date: 23.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383766 **Northing**: 6418403 **Accuracy:** 4.8m
Photo: RPS 1095 - 1097.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 10% humus layer over wetland. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance:** Level medium – trampled vegetation, weeds and rubbish.
Vegetation Description:
*Adriana quadripartita, *Carduus pycnocephalus* and **Euphorbia terracina* Low Open Shrubland over *Ficinia nodosa, Baumea juncea* and *Juncus pallidus* Closed Sedgeland and *Centella asiatica* Herbland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Asphodelus fistulosus*, **Avena barbata*, **Carduus pycnocephalus*, **Conyza sumatrensis*, **Cyperus tenuiflorus*, **Euphorbia terracina*, **Lagurus ovatus*, **Lolium perenne*, **Orobanche minor*, **Romulea rosea* var. *australis*, **Sonchus oleraceus*, **Trifolium repens* var. *repens*, **Verbascum virgatum*, *Acacia saligna, Adriana quadripartita, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Juncus pallidus, Lobelia alata, Logania vaginalis* and *Sporobolus virginicus.*

Notes: *Acacia rostellifera* and *Acacia saligna* Low Woodland surrounds the edge of the wetland

Detailed Flora Site: PK16
Date: 23.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384130 **Northing**: 6418078 **Accuracy:** 4.5m
Photo: RPS 1098 - 1100.
Topography: flat
Soil: Light brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** less than 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 3%.
Condition: Good – Very Good. **Disturbance:** Level medium - weeds and fire.

Vegetation Description:
Acacia rostellifera Melaleuca systena Open Shrubland to Low Open Shrubland over *Lepidosperma squamatum* Very Open Sedgeland and *Austrostipa flavescens, *Avena barbata* and *Bromus arenarius* Very Open Grassland
Species List:
**Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Romulea rosea* var. *australis, Acacia rostellifera, Adriana quadripartita, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Clematis linearifolia, Conostylis aculeata, Desmocladus asper, Dianella revoluta* var. *divaricata, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Opercularia vaginata, Poa porphyroclados, Scaevola anchusifolia, Schoenus grandiflorus* and *Senecio pinnatifolius* var.*latilobus*

Notes: Large *Acacia rostellifera* trees (1.8m tall) are dead due to fire, live *Acacia rostellifera* shrubs are 60cm in height.

RELEVE: PKA
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383701 **Northing**: 6418148 **Accuracy:** 5m
Photo: KM032
Topography: Dampland.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years
Litter: 2%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Juncus pallidus and *Baumea juncea* Sedgeland, over *Centella asiatica* and **Trifolium repens* var. *repens* Herbland.
Species List:
**Carduus pycnocephalus, *Conyza sumatrensis, *Euphorbia terracina, *Schinus terebinthifolius, *Sonchus oleraceus, *Trifolium repens* var. *repens, Adriana quadripartita, Apium prostratum* var. *prostratum, Baumea juncea, Bromus arenarius, Centella asiatica, Epilobium billardiereanum* subsp. *billardiereanum, Ficinia nodosa, Juncus pallidus, Melaleuca teretifolia* and *Senecio pinnatifolius* var.*latilobus.*

Notes: A Department Environment and Conservation (DEC) Threatened Ecological Community (TEC 103) is located in this area.

RELEVE: PKB
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383708 **Northing**: 6417997 **Accuracy:** 5m
Photo: KM033
Topography: Depression in a swale
Soil: brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 30%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Acacia rostellifera and *Hakea prostrata* Tall Open Scrub, over *Lepidosperma squamatum* Very Open Sedgeland and Grassland of annual sterile weed.
Species List:
**Avena barbata, *Euphorbia terracina, Acacia rostellifera, Clematis linearifolia, Hakea prostrata, Kennedia prostrata, Lepidosperma squamatum, Poa porphyroclados, Rhagodia baccata* subsp. *baccata* and annual sterile grass.

RELEVE: PKC1-PKC4
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383760 **Northing**: 6417976 **Accuracy:** 6m
Photo: KM034
Topography: Depression
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 30%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium/ High- weeds
Vegetation Description:
Anthocercis littorea and *Hakea prostrata* Shrubland, with *Acacia rostellifera* and *Adriana quadripartita* Low Open Heath, over *Ficinia nodosa* Very Open Sedgeland, with *Holcus lanatus* and *Centella asiatica* Herbland.
PKC1 Species List:
**Holcus lanatus* and *Centella asiatica,*

PKC2 Species List:
**Euphorbia terracina, *Holcus lanatus, Centella asiatica* and *Ficinia nodosa,*
PKC3 Species List:
**Euphorbia terracina, *Holcus lanatus, Adriana quadripartita, Centella asiatica, Ficinia nodosa* and *Logania vaginalis*
PKC4 Species List:
Acacia rostellifera, Adriana quadripartita, Anthacercis littorea, Hakea prostrata, Rhagodia baccata subsp. *baccata* and annual sterile grass.
Notes: PKC1 is the lowest part of the depression followed by PKC2, PKC3, and the high point of the depression is PKC4.

RELEVE: PKD
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383704 **Northing**: 6418238 **Accuracy:** 5m
Photo: KM036 & 037 (KM035 is from dune looking into the wetland)
Topography: Wetland/ Dampland.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 80%. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance Level:** Low- weeds
Vegetation Description:
Melaleuca teretifolia Tall Open Scrub, over *Lepidosperma gladiatum* Closed Sedgeland, with *Cassytha racemosa Nees forma racemosa, Centella asiatica, Apium prostratum* and **Phyla nodiflora* var.*nodiflora* Herbland
Species List:
**Acetasella vulgaris, *Phyla nodiflora* var.*nodiflora, *Solanum nigrum, *Symphyotrichum squamatum, *Trifolium repens* var. *repens, Apium prostratum Vent.* var. *prostratum, Cassytha racemosa Nees forma racemosa, Centella asiatica, Epilobium billardiereanum* Ser. subsp. *billardiereanum, Gahnia trifida, Lachnagrostis filiformis, Lepidosperma gladiatum, Lepidosperma langitudinale, Melaleuca teretifolia* and *Sporobolus virginicus*
Notes: A Department Environment and Conservation (DEC) Threatened Ecological Community (TEC PM35) is located in this area. Vegetation was too thick to put a plot in. Borehole 62-3 is also present.

RELEVE: PKE1 AND PKE2
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383836 **Northing**: 6418213 **Accuracy:** 5m
Photo: KM040
Topography: Dampland in dune swale.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 50%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** Medium- > 70% weeds in herb layer
Vegetation Description:
Adriana quadripartita Low Shrubland, over *Ficinia nodosa* Sedgeland and *Baumea juncea* Very Open Sedgeland, with annual sterile grass Closed Grassland
PKE1 Species List:
**Conyza sumatrensis, *Eupharbia terracina* and sterile annual grass.
PKE2 Species List:
**Euphorbia terracina, *Pelargonium capitatum, Adriana quadripartita, Baumea juncea, Ficinia nodosa, Logania vaginalis* and annual sterile grass.
Notes: PKE1 is the lowest, and PKE2 is the highest section of the dampland.

RELEVE: PKF
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384105 **Northing**: 6418270 **Accuracy:** 5m
Photo: no photo
Topography: flat
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Melaleuca rhaphiophylla Low Open Forest, over **Olea europaea* subsp. *europaea, Acacia rostellifera, Rhagodia baccata* subsp.*baccata* and *Adriana quadripartita* Open– Low Open Shrubland, over *Gahnia trifida, Ficinia nodosa* and *Baumea juncea* Very Open Sedgeland, with annual sterile grass Grassland

Species List:
**Euphorbia terracina, *Medicago polymorpha, *Olea europaea* subsp. *europaea, *Romulea rosea* var. *australis, *Symphyotrichum squamatum, Acacia rostellifera, Adriana quadripartita, Baumea juncea, Carex preissii, Ficinia nodosa, Gahnia trifida, Kennedia prostrata, Melaleuca rhaphiophylla, Rhagodia baccata* subsp. *baccata* and annual sterile grass.

RELEVE: PKG
Date: 18.11.06
Botanist: K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384057 **Northing**: 6418524 **Accuracy:** 5.8m
Photo: KM023
Topography: Depression on dune swale
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 85%. **Bare Ground:** 10%.
Condition: Very Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Xanthorrhoea preissii Closed Tall Scrub, with *Adriana quadripartita* and **Eupharbia terracina* Low Open Shrubland, over *Lepidosperma squamatum* Very Open Sedgeland.
Species List:
**Euphorbia terracina, *Pelargonium littorale* subsp. *littorale, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Kennedia prostrata, Lepidosperma squamatum, Leucopogan parviflorus, Poa porphyroclados* and *Xanthorrhoea preissii*
Notes: Area mapped surrounds PK13.

RELEVE: PKQ
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383831 **Northing**: 6418204 **Accuracy:** 5m
Photo: RPS 1054- 1056
Topography: Wetland basin in dune swale
Soil: Dark brown sandy loam. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 90%. **Bare Ground:** 5%.
Condition: Very Good. **Disturbance Level:** Low- 20% weeds
Vegetation Description:
Hakea prostrata (mostly burnt) Tall Shrubland, with *Adriana quadripartita, Logania vaginalis* and **Euphorbia terracina* Low Open Shrubland, over *Ficinia nodosa* and *Baumea juncea* Sedgeland, with *Centella asiatica* Open Herbland.
Species List:
**Avena barbata, *Euphorbia terracina, *Romulea rosea* var. *australis, Acacia lasiocarpa* var. *lasiocarpa, Acacia saligna, Adriana quadripartita, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Hakea prostrata* (mostly burnt), *Kennedia prostrata, Lagania vaginalis, Poa porphyroclados* and *Rhagodia baccata* subsp.*baccata.*

RELEVE: PKR
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383588 **Northing**: 6418358 **Accuracy:** 5m
Photo: RPS 1068
Topography: Dunes.
Soil: Grey sandy. **Rock Type:** limestone.
Aspect: West. **Age Since Fire:** < 2 years
Litter: 85%. **Bare Ground:** 3%.
Condition: Good-Very Good. **Disturbance Level:** High- weeds
Vegetation Description:
Acacia rostellifera Open Heath, over a Closed Grassland of dead grasses.
Species List:
**Avena barbata, *Euphorbia terracina, Acacia rostellifera, Acacia saligna, Austrostipa flavescens, Hakea prostrata, Lepidosperma gladiatum, Lepidosperma squamatum, Melaleuca systena, Poa porphyroclados* and *Xanthorrhoea preissii.*

RELEVE: PKS
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383684 **Northing**: 6418639 **Accuracy:** 5m
Photo: RPS 1069
Topography: Flat

Soil: Grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 90%- weedy hay. **Bare Ground:** 5%.
Condition: Degraded- Completely Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
**Euphorbia terracina* Low Shrubland, over **Avena barbata, *Lagurus ovatus, Sparobolus virginicus* and **Ehrharta calycina* Open Grassland
Species List:
**Avena barbata, *Ehrharta calycina, *Euphorbia terracina, *Lagurus ovatus, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Melaleuca systena* and *Sporobolus virginicus.*

RELEVE: PKT
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384090 **Northing**: 6418481 **Accuracy:** 5m
Photo: RPS 1070
Topography: Dune crest
Soil: Light grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 80%- dead grasses. **Bare Ground:** 10%.
Condition: Good-Very Good. **Disturbance Level:** Medium- weeds (5-15%)
Vegetation Description:
Acacia rostellifera and *Melaleuca systena* Low Shrubland, over *Lepidosperma squamatum* Very Open Sedgeland, with **Lagurus ovatus, *Avena barbata* and *Austrostipa flavescens* Very Open Grassland.
Species List:
**Avena barbata, *Euphorbia terracina, *Lagurus ovatus, *Romulea rosea* var. *australis, Acacia rostellifera, Acacia saligna, Acanthocarpus preissii, Adriana quadripartita, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp.*preissii, Dianella revoluta* var. *divaricata, Exocarpos sparteus, Jacksonia furcellata,, Lepidosperma squamatum, Leucopogon parviflorus, Melaleuca systena, Olearia axillaris, Opercularia vaginata, Phyllanthus calycinus, Scaevola anchusifolia* and *Schoenus grandiflorus.*

RELEVE: PKU
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383858 **Northing**: 6417888 **Accuracy:** 5m
Photo: RPS 1082 & 1083
Topography: Depression on dampland
Soil: Light grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 10%. **Bare Ground:** 5%.
Condition: Good. **Disturbance Level:** Medium
Vegetation Description:
Acacia rostellifera Tall Shrubland, with **Euphorbia terracina, Adriana quadripartita* and *Logania vaginalis* Low Open Shrubland, over *Ficinia nodosa* and *Baumea juncea* Open Sedgeland.
Species List:
**Avena barbata, *Conyza sumatrensis, *Euphorbia terracina, Acacia rostellifera, Acacia saligna, Adriana quadripartita, Anthocercis littorea, Baumea juncea, Bromus arenarius, Ficinia nodosa, Hakea prostrata, Kennedia prostrata, Lagania vaginalis, Olearia axillaris, Poa porphyroclados* and *Rhagodia baccata* subsp.*baccata.*

RELEVE: PKV
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383775 **Northing**: 6417820 **Accuracy:** 5m
Photo: RPS 1084
Topography: Wetland depression in dune swale.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 90%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Melaleuca rhaphiophylla Tall Open Shrubland, over *Ficinia nodosa* Open Sedgeland, with *Bromus arenarius* Grassland
Species List:
**Avena barbata, *Euphorbia terracina, Acacia saligna, Adriana quadripartita, Anthocercis littorea, Bromus arenarius, Ficinia nodosa, Kennedia prostrata, Melaleuca rhaphiophylla, Sporobolus virginicus* and *Xanthorrhoea preissii.*
RELEVE: PKW
Date: 22.11.06

Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383699 **Northing**: 6417774 **Accuracy:** 5m
Photo: RPS 1085 & 1086
Topography: Depression in dune swale.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Melaleuca rhaphiophylla Tall Shrubland (mostly dead), over **Stenotaphrum secundatum* Closed Grassland.
Species List:
**Avena barbata, *Stenotaphrum secundatum, Acacia rostellifera, Austrostipa flavescens, Bromus arenarius, Melaleuca rhaphiophylla, Sporobolus virginicus* and *Xanthorrhoea preissii.*

RELEVE: PKX
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383689 **Northing**: 6417831 **Accuracy:** 5m
Photo: RPS 1088
Topography: Wetland.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Xanthorrhoea preissii Tall Shrubland, with *Acacia rostellifera* and *Acacia saligna* Open Shrubland, over *Lepidosperma squamatum* Open Sedgeland.
Species List:
**Avena barbata, *Euphorbia terracina, *Lagurus ovatus, *Yucca aloifolia, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Gompholobium tomentosum, Hakea prostrata, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Poa porphyroclados, Thomasia cognata* and *Xanthorrhoea preissii.*

APPENDIX B4

PATN Analysis Results

1.0 INTRODUCTION

1.1 Purpose of this report

The current report is intended to help clarify the assignment of Floristic Community type (FCT) designation to vegetation community (site) data. FCTs were defined by Gibson et al (1994) based on site data collected from vegetation on the Swan Coastal Plain. In particular, the potential that a Threatened Ecological Community (English and Blyth 1997) is represented by the data collected needs to be clarified.

1.2 Location of Port Kennedy Sites

The sites were in the beach ridge plain in the Port Kennedy area.

1.3 Brief background to floristic analysis of vegetation on the Swan Coastal Plain

Floristic analysis (ie., analysis of variation in vegetation based on the species present, rather than description of structural variation and dominance) as a significant component of the understanding of the variation present in the native vegetation of the Swan Coastal Plain dates to Gibson *et al* (1994 – all references to the SCP survey in the current report refer to this publication), the first publication to document the floristics of the vegetation of a large part of the Swan Coastal Plain. While the SCP survey is based on a very significant amount of work, it must be viewed as a "first pass" survey, limited, in the context of the great variety of vegetation present in the very large area surveyed, by the relatively limited number (509) of sites (quadrats) it is based on. To a limited degree, this limitation has subsequently been addressed in an "update" to the work of the SCP survey (which describes additional units). However, there is no detailed publication of the results of this update available and the additional data used are not readily available in an appropriate form (ie., one that would enable ready comparison of new data to the overall data set).

The units described by the SCP survey are a series of "floristic community types", a "unit" whose rank is defined by the use within a study. The SCP survey surveyed a very large survey area and defined a relatively small number of floristic community types. Consequently, the floristic community types they have described are of a very high order (see Trudgen 1999, volume 1, for further discussion of this point). This is an extremely important point to fully grasp in interpreting the analysis presented by the SCP survey and in understanding the meaning of analysis of other data sets when they are compared to the floristic community types of the SCP survey.

The important effects of the limited size data set used by the SCP survey and of the relatively small number of floristic community types defined by them, can be summarised by the following points:

1. the definition of all but two of the Threatened Ecological Communities for vegetation on the Swan Coastal Plain (English and Blyth 1997) has been based on the floristic community types of the SCP survey. It therefore follows, that with two exceptions, only vegetation units from one study that are different at a very high order of floristics are treated as rare by Government. No account is taken of other important differences, such as differences in structure and dominance;

2. for the definition of floristic community types to be robust, a sufficient sized database is needed to give adequate precision in their definition. About half of the floristics community types (or sub types) of the SCP survey are based on less than 10 sites. It is likely that with a larger data set there would be significant alteration in the classification of those floristic community types from the SCP survey based on small numbers of sites.

3. as noted above, many (if not most) of the floristic community types defined by the SCP survey are very broad. They contain very significant variation in floristics, structure and

dominance. Some (or in more highly cleared parts of the Swan Coastal Plain much) of this variation may be rare by any reasonable definition, but it is currently "buried" within larger groups;

4. there is likely to be significant variation not sampled by the SCP survey. This includes some variation at a high level of floristic difference (see Trudgen 1999, volume 1, for an example of this) and undoubtedly quite significant (large!) amounts of variation at "medium" and "low" levels.

5. the document, and its use by Government, has focussed attention in the environmental impact assessment process on the high level of units described, deflecting attention from the layers of variation beneath these units that also have significant conservation value.

From these points it is obvious that there is a need for a major "upgrade" to the floristic analysis of the vegetation of the Swan Coastal Plain to provide a more detailed floristic classification that considers not only more of the variation present, but explicitly recognises more of the variation present in formally described units.

Obviously, such a reworking would have some effect on what vegetation is considered rare on the Swan Coastal Plain. It needs to be stressed that it would be very unlikely to find that any of the vegetation currently considered to be rare on the basis of the SCP survey *'s* classification was not rare. On the other hand, it is likely that such a review would very probably consider to be rare some vegetation which is not currently considered rare.

1.4 Data provided

It is very important in comparing different sets of floristic data that they are comparable in the application of names, in the intensity of the survey (ie., the effort of searching resulting in similar proportion of the flora at sites being recorded) and in the size of the site recorded. If the data from different data sets is not comparable in these ways, it reduces the clarity of the results of the analyses carried out. If the discrepancy in the comparability of the data sets is large, the results may become meaningless.

Superficial scanning suggested that the quadrats appeared to have a reasonable number of species for the expected Floristic Community Type (19) but releves were low in species compared to FCTs 29b.

2.0 METHODS

2.1 Data Preparation

The data from the Port Kennedy sites were provided in a spreadsheet. These were incorporated into a standard MS Access based database designed for this type of data. One virtue of the database is that the species recorded at each site are stored against standard codes (numbers, those used by the Western Australian Herbarium) for each species. This facilitates ready comparison of data from different surveys stored in the same system.

After the data were incorporated into the database, a process of reconciliation of flora species names with those used in the SCP survey was undertaken. This step was necessary at least because of changes in nomenclature over the last ten years and the potential of survey specific variations in the application of names. The reconciliation involved:

- reducing some infra-specific names to the relevant species name, and
- combining some taxa where confusion is known to have occurred in field observations and identifications.

The reconciliation process was relatively straightforward as most of the names had already been standardised. Most reconciliation was to conform with the methods that the SCP survey used to manage confusing taxa plus some nomenclatural changes (Appendix).

2.2 Comparability of datasets

It was concluded that the quadrat datasets were probably reasonably compatible in nomenclature. The richness of sites are moderate (see extract of dendrogram in results.) The number of species from families often overlooked (eg Orchidaceae) is comparable to that of quadrats in SCP dataset for similar vegetation (see Data Provided section).

2.3 Comparisons made

The data therefore from the ten quadrats plus the 509 sites from the SCP survey of the southern part of the Swan Coastal Plain (south of Gingin) were combined. This enabled various analyses to be performed.

The main purpose was intended to assign the individual sites to the Floristic Community Types (FCTs) defined in the SCP survey. These data are provided in BBG_Port Kennedy.mdb.)

2.4 Analyses carried out

The approach was the use of numerical classification techniques (PATN) based on the similarity of the floristic composition of the Port Kennedy quadrats to sites in the SCP survey data set.

2.4.1 PATN

Several modules of the numerical classification package PATN (Belbin 1987) were used for the analyses. The parameter values were the same as used by the SCP survey to ensure consistency of analysis with that study.

The PATN modules used were ASO (calculation of similarity matrix), FUSE (classification based on the results of ASO), DEND (representation of classification) and NNB (determination of sites most similar to each site – nearest neighbours). The results of the analyses were imported into a database (BBG_ Med_Springs.mdb) so that site characteristics and previous classifications (eg., Floristic Community Types derived in earlier classifications) could be associated and various analyses based on these data could be performed.

The attempted assignment of floristic community types to the Port Kennedy quadrats was made by summarising the results of two different methods:

- the classification, and
- the ten nearest neighbours.

Experience demonstrates that the results of these are likely to vary, but that from nearest neighbours is likely to make more sense for it is not directly influenced by group membership. On the other hand the nearest neighbour analysis often is ambiquous as it provides several options.

To the classification dendrogram of the combined dataset, the FCT assigned by the SCP survey was associated with the SCP survey sites. The apparent FCTs were assigned to the Port Kennedy quadrats by interpreting the position of these sites in the dendrogram (particularly by the way they joined to the SCP sites).

The 10 sites in the combined data set that were most similar to each of the Port Kennedy quadrats were obtained from the nearest neighbour method (NNB). By associating those nearest neighbours from the SCP survey, the most likely FCTs from this method for each of the Port Kennedy quadrats were determined.

It is common for there to appear tob inconsistencies in the affinietie indicated by these methods. Classification can be strongly influenced by the membership of groups which can "draw" a site "away" from another that it appears similar to. An attempt was then made to reconcile these different assignments of a Floristic Community Type. The relevant portion of the site by species matrix was examined to seek clarity in some cases.

3.0 LIMITATIONS

It has been found in earlier projects that the addition of new sites to the SCP survey data set to produce a combined classification disrupts the original classification. The more data added, the higher the level of the disruption. This is particularly the case with wetland sites, partly because there are relatively few of these in the SCP data set and these communities are often very distinctive. This problem can make it difficult to assign Floristic Community Types to new sites using this method.

Secondly, it is common for new data to group to their cohorts. In some cases this has proven to result from common deficiencies in the data, ie. whole groups of species missing. This absence tends to draw them together. The more sites in the added batch, the tighter they draw together. This is probably what has happened more than "deficiencies" in the data.

The analyses are conducted without personal knowledge of the sites. No data was provided on the condition of the sites.

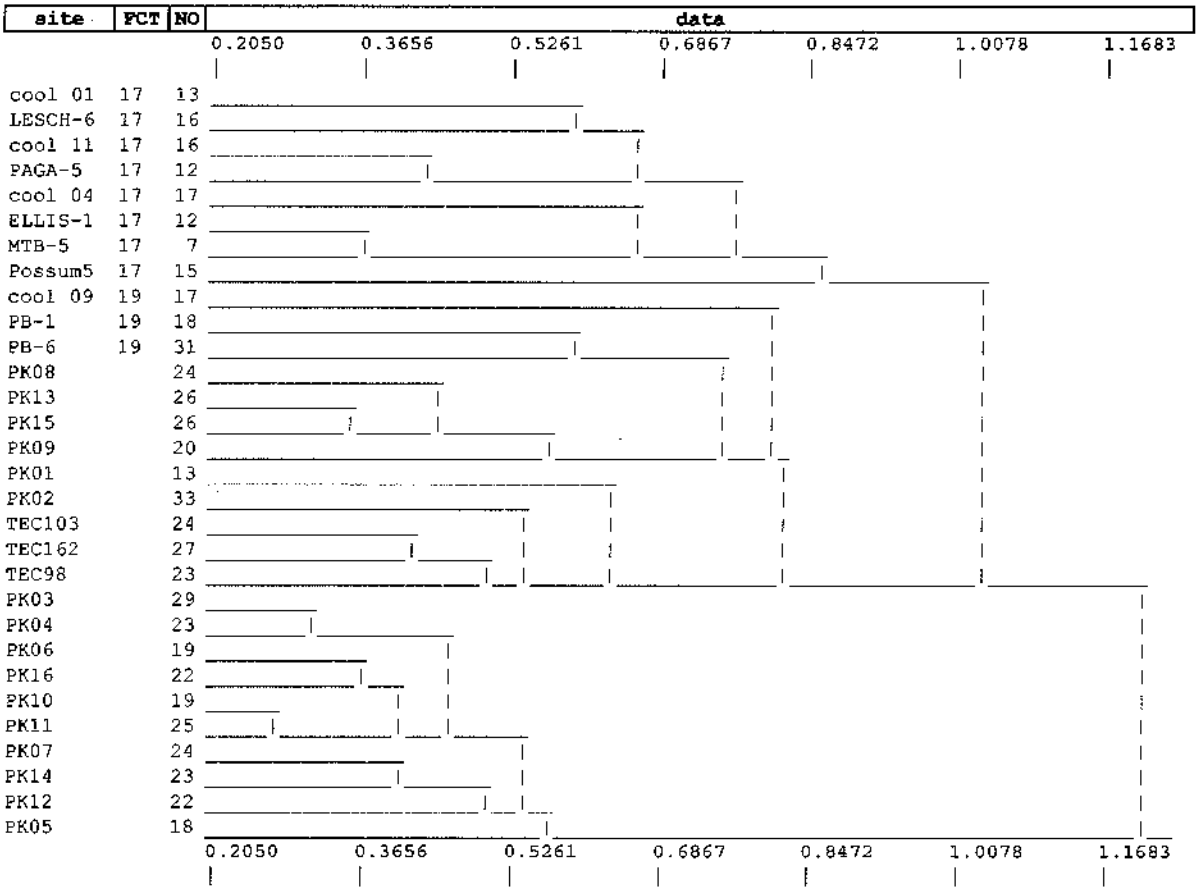
4.0 RESULTS

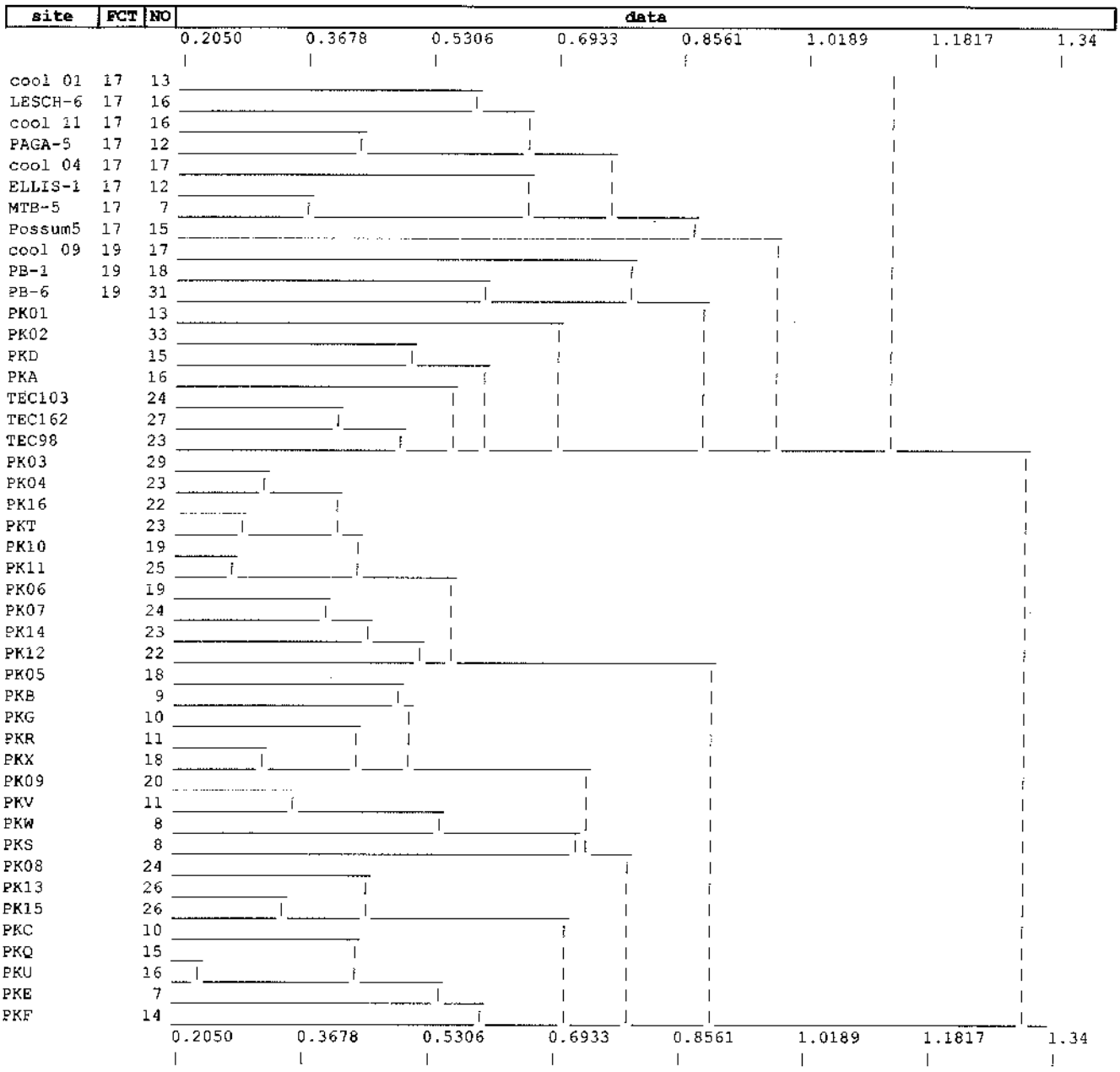
4.1 Determination of floristic community type by classification

The Port Kennedy sites were clustered in four different parts of the dendrogram. On the face of it this is encouraging in that the tendancies which sometimes occur for the new sites to aggregate with each other rather than the SCP sites has not happened. This is interpreted as an indication that, collectively, the data collected does not have significant survey dependant bias.

Most of the new sites joined with other sites from the Port Kennedy area in the SCP dataset. They were from apparently one FCT (19). The dendrograms, by their structure indicate that there are several communities.

Figure 1. Relevant portions of Dendrogram




site FCT NO data
0.2050 0.3678 0.5306 0.6933 0.8561 1.0189 1.1817 1.34
cool 01 17 13
LESCH-6 17 16
cool 11 17 16
PAGA-5 17 12
cool 04 17 17
ELLIS-1 17 12
MTB-5 17 7
Possum5 17 15
cool 09 19 17
PB-1 19 18
PB-6 19 31
PK01 13
PK02 33
PKD 15
PKA 16
TEC103 24
TEC162 27
TEC98 23
PK03 29
PK04 23
PK16 22
PKT 23
PK10 19
PK11 25
PK06 19
PK07 24
PK14 23
PK12 22
PK05 18
PKB 9
PKG 10
PKR 11
PKX 18
PK09 20
PKV 11
PKW 8
PKS 8
PK08 24
PK13 26
PK15 26
PKC 10
PKQ 15
PKU 16
PKE 7
PKF 14
0.2050 0.3678 0.5306 0.6933 0.8561 1.0189 1.1817 1.34

4.2 Determination of floristic community type using Nearest Neighbour method

The nearest neighbour analysis suggested that the quadrats have affinities with a number of different communities even though they were more similar to each other than any SCP sites by a modest amount. Some of the similarity values for sites from the SCP data sets were low enough (values less than about 0.55) to give confidence in this method being useful (Table 1).

Most Port Kennedy sites were more similar to sites in the new data set than those in the SCP sites. This indicates a reasonably strong geographic basis to the floristic composition.

By this analysis many of the new sites were related to sites from FCT 19 but also 29a, 24 and 17.

Table 1. Results of Nearest Neighbour analysis

s	s1	fct1	v1	s2	fct2	v2	s3	fct3	v3	s4	fct4	v4	s5	fct5	v5
PK01	TEC103		0.5135	TEC98		0.6111	PK15		0.641	TEC162		0.65	PK02		0.6522
PK02	TEC162		0.4333	TEC103		0.5439	PK15		0.5593	TEC98		0.6071	PK09		0.6226
PK03	PK04		0.3077	PK11		0.4074	PK16		0.4118	PK10		0.4167	cool 08	24	0.4603
PK04	PK03		0.3077	PK16		0.3333	PK11		0.375	PK10		0.4286	PK06		0.4762
PK05	PK16		0.4	PK11		0.4884	PK03		0.4894	PK14		0.5122	PK04		0.5122
PK06	PK16		0.3659	PK07		0.3953	PK11		0.4091	PK10		0.4211	PK14		0.4762
PK07	PK10		0.3953	PK06		0.3953	PK14		0.4043	PK12		0.4222	PK11		0.4286
PK08	PK13		0.36	PK12		0.5111	PK15		0.52	PK09		0.5909	PK14		0.617
PK09	PK13		0.4783	PK15		0.5652	PK14		0.5814	PK08		0.5909	PK02		0.6226
PK10	PK11		0.2727	PK07		0.3953	PK03		0.4167	PK06		0.4211	PK04		0.4286
PK11	PK10		0.2727	PK16		0.2766	PK04		0.375	PK03		0.4074	PK06		0.4091
PK12	PK07		0.4222	PK11		0.4348	PK10		0.45	PK16		0.4884	PK13		0.4894
PK13	PK15		0.3462	PK08		0.36	PK09		0.4783	PK12		0.4894	PK07		0.52
PK14	PK07		0.4043	PK11		0.4583	PK06		0.4762	PK05		0.5122	PK04		0.5217
PK15	PK13		0.3462	TEC98		0.5102	PK08		0.52	PK14		0.551	PK02		0.5593
PK16	PK11		0.2766	PK04		0.3333	PK06		0.3659	PK05		0.4	PK03		0.4118
TEC98	TEC162		0.48	TEC103		0.4894	PK15		0.5102	PK02		0.6071	PK01		0.6111
TEC103	TEC162		0.4118	TEC98		0.4894	PK01		0.5135	PK02		0.5439	PK15		0.56
TEC162	TEC103		0.4118	PK02		0.4333	TEC98		0.48	PK15		0.6226	PK01		0.65

Table 1 (cont)

s	s6	fct6	v6	s7	fct7	v7	s8	fct8	v8	s9	fct9	v9	s10	fct10	v10
PK01	PAGA-5	17	0.68	PK13		0.6923	cool 11	17	0.7241	LESCH-6	17	0.7241	PB-6	19	0.7273
PK02	PK01		0.6522	PK13		0.661	cool 09	19	0.66	PK08		0.6842	ELLIS-1	17	0.7333
PK03	PK05		0.4894	PK07		0.5094	PK12		0.52	PK14		0.5385	PK06		0.5417
PK04	PK05		0.5122	PK14		0.5217	PK07		0.5319	PB-3	29b	0.551	PK12		0.5909
PK05	PK06		0.5135	PB-3	29b	0.5909	PK07		0.619	PK10		0.6216	PK09		0.6316
PK06	PK04		0.4762	PK05		0.5135	PK03		0.5417	PK12		0.55	cool 08	24	0.6226
PK07	PK03		0.5094	PK13		0.52	PK16		0.5217	PK04		0.5319	cool 06	24	0.5862
PK08	PK04		0.617	PK07		0.625	PK11		0.6327	PB-6	19	0.6364	PK16		0.6522
PK09	PK05		0.6316	PK11		0.6444	cool 11	17	0.6667	PK16		0.6667	PK04		0.6744
PK10	PK12		0.45	PK16		0.4634	cool 08	24	0.5094	PK14		0.5238	PK13		0.6
PK11	PK07		0.4286	PK12		0.4348	cool 08	24	0.4576	PK14		0.4583	PK05		0.4884
PK12	PK08		0.5111	PK03		0.52	PK14		0.5455	PK06		0.55	PK15		0.5745
PK13	PB-6	19	0.5439	PK14		0.551	PK11		0.5686	PK10		0.6	TEC98		0.6327
PK14	PK10		0.5238	PK03		0.5385	PK12		0.5455	PK13		0.551	PK15		0.551
PK15	TEC103		0.56	PK09		0.5652	PK12		0.5745	PB-6	19	0.5789	PK07		0.6
PK16	PK10		0.4634	PK12		0.4884	PK07		0.5217	PB-3	29b	0.5417	PK14		0.5556
TEC98	PK13		0.6327	cool 11	17	0.6923	PB-6	19	0.7037	cool 01	17	0.7222	Possum2	16	0.7333
TEC103	PK13		0.64	PK12		0.6444	PB-1	19	0.6667	PB-6	19	0.6727	cool 11	17	0.7
TEC162	PK13		0.6604	PB-6	19	0.6897	PK12		0.7083	cool 11	17	0.7209	cool 09	19	0.7273

Table 1 (cont)

s	S11	Fct1 1	V11	S12	Fct1 2	V12	S13	Fct1 3	V13	S14	Fct1 4	V14	S15	Fct1 5	V15
PK01	cool 04	17	0.7333	ELLIS-1	17	0.76	PK12		0.7647	McLART-1	13	0.7692	PK07		0.7838
PK02	cool 01	17	0.7391	PK12		0.7407	PK14		0.75	PB-6	19	0.75	cool 11	17	0.7551
PK03	TRIG-1	29b	0.5926	PB-3	29b	0.6	PB-4	29b	0.6271	NWIL-3	29b	0.6364	CHIDPT-1	24	0.6452
PK04	cool 08	24	0.614	PK08		0.617	PK13		0.6327	PK15		0.6735	PK09		0.6744
PK05	PK12		0.641	PB-4	29b	0.6667	PB-5	29b	0.6744	NWIL-1	29b	0.7037	PB-2	29b	0.7083
PK06	PB-3	29b	0.6444	cool 02	24	0.6735	PK13		0.6889	BOLD-4	24	0.6897	MTB-2	24	0.6897
PK07	PK15		0.6	PK05		0.619	PK08		0.625	CHIDPT-1	24	0.6491	cool 02	24	0.6667
PK08	PK10		0.6744	PK02		0.6842	cool 08	24	0.6897	PK03		0.6981	TRIG-6	24	0.7097
PK09	cool 09	19	0.6757	PB-6	19	0.6863	cool 08	24	0.7037	PK12		0.7073	PK07		0.7273
PK10	PK05		0.6216	PB-3	29b	0.6444	PB-4	29b	0.6735	cool 02	24	0.6735	PB-2	29b	0.6735
PK11	PB-3	29b	0.5294	PK13		0.5686	PK08		0.6327	PB-4	29b	0.6364	BURN-1	29a	0.6364
PK12	PB-1	19	0.5897	PK04		0.5909	cool 08	24	0.6	NAVB-2	29a	0.6056	PB-6	19	0.6154
PK13	PK04		0.6327	cool 08	24	0.6333	TEC103		0.64	TEC162		0.6604	PK02		0.661
PK14	PK16		0.5556	cool 08	24	0.5789	PK09		0.5814	PK08		0.617	TRIG-1	29b	0.625
PK15	TEC162		0.6226	PK01		0.641	PK11		0.6471	PK04		0.6735	PK10		0.6889
PK16	cool 08	24	0.6429	PK08		0.6522	TRIG-1	29b	0.6596	PK09		0.6667	PK13		0.6667
TEC98	cool 04	17	0.75	PK09		0.7674	PK12		0.7727	PK08		0.7872	PK07		0.7872
TEC103	LESCH-6	17	0.7	cool 09	19	0.7073	cool 04	17	0.7073	low10b	11	0.7083	ELLIS-1	17	0.7222
TEC162	PB-1	19	0.7333	NAVB-2	29a	0.7403	PK09		0.7447	cool 01	17	0.75	Possum2	16	0.7551

Table 1 (cont)

s	S16	Fct1 6	V16	S17	Fct1	V17	S18	Fct1 8	V18	S1	Fct1 9	V19	S20	Fct2 0	V20
PK01	PK08		0.7838	low10b	11	0.7838	cool 09	19	0.8	brick4	9	0.8	PB-1	19	0.8065
PK02	NAVB-2	29a	0.759	cool 04	17	0.76	TRIG-6	24	0.7746	NAVB-4	24	0.7778	PAGA-5	17	0.7778
PK03	BURN-1	29a	0.6571	NWIL-1	29b	0.6615	SEAB-5	29a	0.6706	PK13		0.6727	WHILL-2	29b	0.68
PK04	NWIL-1	29b	0.7627	TRIG-6	24	0.7705	PB-2	29b	0.7736	NAVB-4	24	0.7742	MTB-2	24	0.7742
PK05	NWIL-3	29b	0.7091	PK08		0.7143	PB-6	19	0.7143	TRIG-1	29b	0.7209	PK13		0.7273
PK06	NAVB-3	24	0.7049	PB-4	29b	0.7143	TRIG-5	24	0.7188	BOLD-1	24	0.7231	NAVB-4	24	0.7241
PK07	TRIG-5	24	0.6812	BOLD-4	24	0.7143	PB-1	19	0.7143	TRIG-1	29b	0.7143	NAVB-4	24	0.7143
PK08	cool 03	24	0.7143	PK05		0.7143	TEC103		0.75	PB-1	19	0.7619	TEC162		0.7647
PK09	PB-3	29b	0.7391	PK10		0.7436	TEC162		0.7447	PAGA-5	17	0.75	cool 01	17	0.7576
PK10	PK08		0.6744	PK15		0.6889	CHIDPT-1	24	0.6923	BURN-1	29a	0.7	BOLD-3	24	0.7015
PK11	BOLD-3	24	0.6438	PK09		0.6444	PK15		0.6471	CHIDPT-1	24	0.6552	PB-2	29b	0.6727
PK12	PK05		0.641	TEC103		0.6444	CHIDPT-1	24	0.6667	BURN-1	29a	0.6774	cool 02	24	0.6863
PK13	PK16		0.6667	PK03		0.6727	PK06		0.6889	PK01		0.6923	NEER-1	24	0.6944
PK14	NEER-10	24	0.6712	TRIG-6	24	0.6721	NAVB-4	24	0.6774	CHIDPT-1	24	0.6786	BOLD-3	24	0.6901
PK15	cool 08	24	0.7	PK16		0.7083	PK03		0.7091	cool 11	17	0.7143	PB-1	19	0.7273
PK16	NWIL-1	29b	0.6897	PB-4	29b	0.6923	NWIL-3	29b	0.6949	PK15		0.7083	SEAB-3	29b	0.7313
TEC98	LESCH-6	17	0.7949	cool 09	19	0.8	PB-1	19	0.8049	PK14		0.8261	CARAB-2	7	0.8261
TEC103	Possum2	16	0.7391	PK08		0.75	PK07		0.75	NEER-1	24	0.7714	PK09		0.7727
TEC162	PK08		0.7647	PAGA-5	17	0.7949	ELLIS-1	17	0.7949	PK14		0.8	PK07		0.8039

s – the site being compared
s1 to s20 – the 1st to 20th most similar sites
f1 to f20 – the FCT of the similar sites (only for SCP sites)
v1 to v20 – the dissimilarity value between the site and the similar sites (values above 0.6 tend to indicate low similarity)

Table 2. Results of Nearest Neighbour analysis Releves (only PK sites)

s	s1	fct1	v1	s2	fct2	v2	s3	fct3	v3	s4	fct4	v4	s5	fct5	v5
PKA	TEC162		0.5349	TEC98		0.5385	TEC103		0.55	LESCH-6	17	0.75	cool 11	17	0.75
PKB	TRIG-1	29b	0.7647	WHILL-2	29b	0.8	PRES-1	29a	0.8125	PB-3	29b	0.8286	TRIG-6	24	0.8298
PKC	cool 09	19	0.7037	TEC98		0.8182	TEC162		0.8378	LESCH-4	30b	0.8667	WHILL-2	29b	0.871
PKD	TEC162		0.5238	ELLIS-1	17	0.6296	TEC98		0.6316	TEC103		0.641	cool 01	17	0.8429
PKE	TEC98		0.7333	cool 09	19	0.75	PB-1	19	0.76	TEC162		0.7647	MILT-2	13	0.7847
PKF	cool 09	19	0.6774	MTB-5	17	0.7143	Possum2	16	0.7222	cool 11	17	0.7333	TEC103		0.75
PKG	PB-3	29b	0.6667	PB-6	19	0.7073	PB-5	29b	0.7143	MTB-4	24	0.7297	cool 08	24	0.7727
PKQ	cool 09	19	0.6875	TEC103		0.6923	PB-3	29b	0.7073	PB-1	19	0.7578	TEC98		0.7895
PKR	TRIG-1	29b	0.7778	PB-5	29b	0.7778	PB-3	29b	0.7838	MTB-4	24	0.7895	TRIG-6	24	0.7959
PKS	cool 08	24	0.7619	TRIG-1	29b	0.8182	PB-4	29b	0.8421	PB-6	19	0.8462	NPRES-1	29b	0.8519
PKT	WHILL-2	29b	0.6818	PB-4	29b	0.6981	PB-2	29b	0.6981	PB-5	29b	0.7083	TRIG-1	29b	0.7083
PKU	cool 09	19	0.6364	PB-6	19	0.7021	TRIG-6	24	0.7407	MTB-4	24	0.7674	PB-2	29b	0.7826
PKV	cool 11	17	0.7037	cool 09	19	0.7143	PB-6	19	0.7619	TEC103		0.7714	TEC162		0.7895
PKW	cool 01	17	0.8095	cool 08	24	0.8095	cool 11	17	0.8333	cool 09	19	0.84	CHIDPT-1	24	0.8537
PKX	cool 08	24	0.6923	PB-6	19	0.7143	PB-5	29b	0.7209	TRIG-1	29b	0.7209	PB-3	29b	0.7273

Table 2 (cont)

s	s6	fct6	v6	s7	fct7	v7	s8	fct8	v8	s9	fct9	v9	s10	fct10	v10
PKA	cool 04	17	0.7576	PB-1	19	0.7647	PAGA-5	17	0.7857	Possum2	16	0.7895	cool 01	17	0.7931
PKB	PB-4	29b	0.8462	PB-2	29b	0.8482	cool 09	19	0.8462	GARDEN-4	30a	0.8519	CHIDPT-1	24	0.8571
PKC	PEPGRV-2	30a	0.8824	TRIG-1	29b	0.8857	PB-2	29b	0.9	PB-4	29b	0.9	PB-6	19	0.9024
PKD	cool 11	17	0.7419	FL-10	12	0.75	cool 04	17	0.75	PAGA-5	17	0.7778	ELLIS-3	18	0.8
PKE	PB-6	19	0.7895	TEC103		0.8065	cool 11	17	0.8261	MTB-5	17	0.8571	low10b	11	0.871
PKF	TEC162		0.7561	ELLIS-1	17	0.7692	PAGA-5	17	0.7692	PAGA-2	13	0.7778	cool 04	17	0.8065
PKG	cool 09	19	0.7778	yarl01	3c	0.8	PB-2	29b	0.8	cool 03	24	0.8286	ELLIS-3	18	0.8286
PKQ	cool 08	24	0.7959	PB-5	29b	0.8	cool 11	17	0.8065	TEC162		0.8095	TRIG-6	24	0.8113
PKR	PB-4	29b	0.8049	PB-2	29b	0.8049	WHILL-2	29b	0.8125	CHIDPT-1	24	0.8182	TEC103		0.8286
PKS	BOLD-1	24	0.8519	MHENRY-2	30c	0.8537	BOLD-3	24	0.8571	NEER-10	24	0.8621	WHILL-2	29b	0.8621
PKT	BOLD-4	24	0.7097	BOLD-3	24	0.7183	WHILL-1	29b	0.7231	cool 02	24	0.7358	NAVB-3	24	0.7538
PKU	WHILL-2	29b	0.7838	TEC98		0.7949	cool 08	24	0.8	TEC103		0.8	PB-5	29b	0.8049
PKV	cool 08	24	0.8222	TEC98		0.8235	PAGA-5	17	0.8261	cool 01	17	0.8333	PAGA-2	13	0.8333
PKW	KERO-1	24	0.8667	Possum2	16	0.8667	MTB-5	17	0.8667	TEC98		0.871	TEC103		0.875
PKX	PB-2	29b	0.75	TRIG-6	24	0.75	TEC103		0.7619	MTB-4	24	0.7778	NPRES-1	29b	0.7813

s – the site being compared
s1 to s20 – the 1st to 20th most similar sites from SCP or TEC
f1 to f20 – the FCT of the similar sites (only for SCP sites)
v1 to v20 – the dissimilarity value between the site and the similar sites (values above 0.6 tend to indicate low similarity)

4.3 Combining the results

It is common for the classification to indicate a simple result and the nearest neighbour analysis to be less conclusive. This is more a product of the classification process than of inconsistency of the analyses.

The different results are understandable, however, the message from the nearest neighbour is probably clearer. Table 3 is the product of the attempt to reconcile these differences. Some uncertainty exists in this assignment as indicated.

The conclusions were very difficult in some cases given the low level of similarities between the Port Kennedy sites and the SCP or TEC sites. Why there is a low level of similarity is unknown. From the species richness point of view (a common reason for low similarities) there is a mixed picture. The richness of sites apparently related to FCT19, values are similar. However, of the others values (largely related to 29b) are low. The latter may be suggestive that these sites are partly transitional.

In the conclusion, it was considered that few sites would be related to FCT 24 as Port Kennedy is Quindalup rather than Spearwood landscapes.

Table 3 Summary of FCT assignment

	Dendrogram	Nearest Neighbour	Conclusion
TEC98	19	17/19	?19
TEC103	19	19	19
TEC162	19	19/17	19
PK01	19	19(T)	19
PK02	19	19(T)	19
PK03	?19	29b/24	29b
PK04	?19	24/29b	29b
PK05	?19	29b	29b
PK06	?19	29b/24	29b
PK07	?19	24	?24?19
PK08	19	24	?24
PK09	19	?19/?24	?19
PK10	?19	29b/24	29b
PK11	?19	29b/29a/24	29b
PK12	?19	19/24/29a	19/24/29a
PK13	19	24/19(T)	24/19(T)
PK14	?19	24/29b	?29b
PK15	19	19(T)	19
PK16	?19	24/29b	?29b
PKA	19	19(T)/?17	19
PKB	?19	29b	29b
PKC	?19	?19	?19
PKD	19	19(T)/17	?19
PKE	?19	?19	?19
PKF	?19	?19/?17	?19/?17
PKG	?19	?29b/?19	?29b/?19
PKQ	?19	?19/?29b	?19/?29b
PKR	?19	29b	29b
PKS	?19	?24?29b	?29b
PKT	?19	29b	29b
PKU	?19	?19	?19
PKV	?19	?17/?19	?17/?19
PKW	?19	?17	?17
PKX	?19	?24/?19	?19

(T) is by reference to a TEC site rather than a SCP site.

5.0 REFERENCES

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APPENDIX1

Names combined for reconciliation

FCOD	Species_LUP.name	Species_LUP_1.name
031	Avena barbata	Avena barbata/fatua
031	Avena fatua	Avena barbata/fatua
031	Catapodium rigidum	Desmazeria rigida
031	Holcus lanatus	Holcus setiger
031	Poa porphyroclados	Poa poiformis/porphyroclados
032	Ficinia nodosa	Isolepis nodosa
032	Isolepis cernua	Isolepis cernua var. cernua
032	Isolepis setiformis	Isolepis cernua var. setiformis
039	Desmocladus asper	Desmocladus flexuosus
103	Rumex acetosella	Acetosella vulgaris
113	Petrorhagia dubia	Petrorhagia velutina
131	Cassytha racemosa var. racemosa	Cassytha racemosa
163	Acacia lasiocarpa var. bracteolata	Acacia lasiocarpa
165	Trifolium campestre var. campestre	Trifolium campestre
273	Melaleuca systena	Melaleuca acerosa
275	Epilobium billardiereanum subsp.	Epilobium billardierianum
281	Apium prostratum var. prostratum	Apium prostratum
281	Centella cordifolia	Centella asiatica
293	Anagallis arvensis var. avensis	Anagallis arvensis
313	Hemiandra glabra subsp. glabra	Hemiandra pungens/linearis
326	Eremophila glabra subsp. albicans	Eremophila glabra
345	Conyza albida	Conyza bonariensis
345	Conyza sumatrensis	Conyza bonariensis
345	Senecio pinnatifolius var. latilobus	Senecio lautus
345	Symphyotrichum squamatum	Aster subulatus

APPENDIX 7
PGV ENVIRONMENTAL AND RPS-BBG FLORA LIST

Port Kennedy Business Park Red = RPS only Blue = PGV Environmental only **MONOCOTYLEDONS**	**Inside Conservation Area**	**Outside Conservation Area**
ASPARAGACEAE		
Acanthocarpus preissii	✓	✓
Lomandra maritima	✓	✓
Thysanotus dichotomus	✓	
**Yucca aloifolia*	✓	
ASPHODELACEAE		
**Asphodelus fistulosus*	✓	✓
**Trachyandra divaricata*	✓	
CYPERACEAE		
Baumea articulata	✓	
Baumea juncea	✓	✓
Carex thecata		✓
**Cyperus polystachyus*	?	?
**Cyperus tenuiflorus*	✓	
Ficinia nodosa	✓	✓
Gahnia trifida	✓	✓
Isolepis cernua var. *cernua*	✓	
Isolepis cernua var. *setiformis*	✓	
Lepidosperma gladiatum	✓	✓
Lepidosperma longitudinale	✓	✓
Lepidosperma squamatum	✓	✓
Schoenus grandiflorus	✓	✓
HAEMODORACEAE		
Conostylis aculeata	✓	✓
HEMEROCALLIDACEAE		
Dianella revoluta var. *divaricata*	✓	✓
Tricoryne elatior	✓	✓
IRIDACEAE		
**Romulea rosea*	✓	✓
JUNCACEAE		
Juncus kraussii	✓	✓
Juncus pallidus	✓	
JUNCAGINACEAE		
Cycnogeton lineare	✓	
POACEAE		
Austrostipa elegantissima	✓	
Austrostipa flavescens	✓	✓

**Avena barbata*	✓	✓
**Avena fatua*	✓	✓
**Briza maxima*		✓
**Briza minor*		✓
Bromus arenarius	✓	✓
**Bromus diandrus*	✓	✓
**Catapodium rigidum*		✓
**Cynodon dactylon*		✓
**Ehrharta calycina*		✓
**Ehrharta longiflora*		✓
**Eragrostis curvula*		✓
**Holcus lanatus*	✓	
**Lachangrostis filiformis*	✓	
**Lagurus ovatus*	✓	✓
**Lolium perenne*	✓	✓
**Lolium rigidum*	✓	✓
Poa poiformis	✓	✓
**Polypogon monspeliensis*	?	?
Rhytidosperma occidentalis	✓	✓
Sporobolus virginicus	✓	
**Stenotaphrum secundatum*	?	?
**Vulpia bromoides*		✓
RESTIONACEAE		
Desmocladus flexuosus/asper	✓	✓
TYPHACEAE		
**Typha orientalis*	✓	
XANTHORRHOEACEAE		
Xanthorrhoea brunonis	✓	
Xanthorrhoea preissii	✓	✓
DICOTYLEDONS		
ANACARDIACEAE		
**Schinus terebinthifolius*	✓	
APIACEAE		
Apium prostratum var. *prostratum*	✓	
Centella asiatica	✓	✓
ASTERACEAE		
**Arctotheca calendula*	✓	
**Carduus pycnocephalus*	✓	
**Conyza bonariensis*	✓	✓
**Conyza sumartrensis*	✓	✓
**Hypochaeris glabra*	✓	✓
**?Leontodon rhagadioloides*		✓
Olearia axillaris	✓	✓

**Osteospermum ecklonis*	✓	
Senecio pinnatifolius	✓	✓
**Sonchus oleraceus*	✓	✓
**Symphyotrichum squamatum*	✓	
Asteraceae sp.	✓	✓
BRASSICACEAE		
**Brassica tournefortii*	✓	✓
**Diplotaxis muralis*	✓	
CAPRIFOLIACEAE		
**Scabiosa atropurpurea*	✓	✓
CARYOPHYLLACEAE		
**Cerastium glomeratum*	✓	
**Minuartia mediterranea*	✓	✓
**Petrorhagia dubia*	✓	✓
**Silene gallica*		✓
CHENOPODIACEAE		
**Atriplex prostrata*	✓	
Rhagodia baccata subsp. *baccata*	✓	✓
CRASSULACEAE		
**Crassula glomerata*	✓	✓
ERICACEAE		
Leucopogon parviflorus	✓	✓
EUPHORBIACEAE		
Adriana quadripartita	✓	✓
**Euphorbia terracina*	✓	✓
FABACEAE		
Acacia lasiocarpa var. *lasiocarpa*	✓	✓
Acacia rostellifera	✓	✓
Acacia saligna	✓	✓
Gompholobium tomentosum	✓	✓
Hardenbergia comptoniana	✓	✓
Jacksonia furcellata	✓	✓
Kennedia prostrata	✓	✓
**Medicago polymorpha*	✓	✓
**Melilotus indicus*	✓	✓
**Trifolium campestre* var. *campestre*	✓	✓
**Trifolium repens* var. *repens*	✓	✓
FUMARIACEAE		
**Fumaria capreolata*		✓

GENTIANACEAE		
**Centaurium pulchellum*		✓
GERANIACEAE		
**Erodium botrys*	✓	
**Pelargonium capitatum*	✓	✓
**Pelargonium littorale* subsp. *littorale*	?	?
GOODENIACEAE		
Scaevola anchusifolia	✓	✓
LAMIACEAE		
Hemiandra pungens/glabra		✓
LAURACEAE		
Cassytha racemosa	✓	
LOBELIACEAE		
Lobelia anceps	✓	
LOGANIACEAE		
Logania vaginalis	✓	✓
MALVACEAE		
**Malva parviflora*	✓	
Thomasia cognata	?	?
MORACEAE		
**Ficus carica*	✓	
MYRTACEAE		
Melaleuca huegelii Planted	?	?
Melaleuca rhaphiophylla	✓	✓
Melaeluca systena	✓	✓
Melaleuca teretifolia	✓	
OLEACEAE		
**Olea europea*		✓
ONAGRACEAE		
Epilobium billardiereanum	✓	
**Oenothera linheimeri*	✓	
OROBANCHACEAE		
**Orobanche minor*	✓	✓
PHYLLANTHACEAE		
Phyllanthus calycinus	✓	✓
POLYGONACEAE		

**Rumex acetosella*	✓	
**Rumex crispus*	✓	
PRIMULACEAE		
**Lysimachia arvensis* var. *arvensis*	✓	✓
**Lysimachia arvensis* var. *caerulea*	✓	
PROTEACEAE		
Grevillea sp. Hybrid Ornamental	?	?
Hakea prostrata	✓	✓
RANUNCULACEAE		
Clematis linearifolia	✓	✓
RHAMNACEAE		
Spyridium globulosum	✓	
RUBIACEAE		
Opercularia vaginata	✓	✓
SANTALACEAE		
Exocarpos sparteus	✓	✓
SCROPHULARIACEAE		
**Dischisma arenarium*	✓	
Eremophila glabra subsp. *albicans*	?	?
**Verbascum virgatum*	✓	✓
SOLANACEAE		
Anthocercis littorea	✓	
**Solanum nigrum*	?	?
Solanum symonii	✓	
VERBENACEAE		
**Phyla nodiflora* var. *nodiflora*	✓	

			Altogether	Known locations
Total species	**108**	**83**	**132**	**123**
native	58	44	63	60
introduced	50	39	69	63

APPENDIX 8

FAUNA REPORT

Port Kennedy Business Park Fauna Assessment – Survey Results

Prepared for: Strategen
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Prepared by: Jeff Turpin and Mike Bamford

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24th June 2011

EXECUTIVE SUMMARY

The Port Kennedy Business Park is a development proposed by LandCorp at Port Kennedy, Western Australia. The proposed project is situated approximately 45 km south of the Perth Central Business District and comprises Lot 4 Mandurah Rd and Lot 17 Port Kennedy Drive.

Bamford Consulting Ecologists was commissioned by Strategen on behalf of LandCorp to undertake a Level 1 Fauna Assessment of the proposed project covering the entire 67 hectare site.

The key objectives of this fauna study are:

- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the Project Area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify and describe general vegetation ("habitats") present including:
    - descriptions of vegetation and substrate associations (VSAs);
    - observations on the presence and distribution of rare VSAs;
- identify potential impacts of a development within the Project Area upon fauna values, and
- provide management recommendations to mitigate these impacts.

The desktop survey identified 204 fauna species potentially occurring in the Port Kennedy area. A total of 34 native fauna species was recorded during the site inspection. This comprised 25 bird, two native mammals, two introduced mammals, four reptile and one frog species. Conservation significant species recorded include the Quenda (Southern Brown Bandicoot) and a number of CS3 bird species listed as declining on the Swan Coastal Plain.

Forty-seven species of conservation significance are considered likely to occur in or utilise habitat within the proposed Port Kennedy Business Park. Of these, six are of high significance (Conservation Significance Level 1), being listed under legislation, five are of moderate conservation significance (Conservation Significance Level 2), being listed as priority species by the Department of Environment and Conservation (DEC), and thirty six are of local significance (Conservation Significance Level 3), because they have restricted distributions or are listed as declining species on the Swan Coastal Plain (DEP, 2000). The project area also supports a population of the conservation significant Graceful Sunmoth and habitats known to support short-range endemic fauna such seasonal wetlands.

Impacts upon fauna due to the construction and operation of the project are discussed in a separate report.

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CONTENTS

1. INTRODUCTION

1.1 Introduction

The Port Kennedy Business Park is a development proposed by LandCorp at Port Kennedy, Western Australia (see Figure 1). The proposed project is situated approximately 45 km south of the Perth Central Business District and comprises Lot 4 Mandurah Rd and Lot 17 Port Kennedy Drive.

The project lies within an area zoned as "Port Kennedy Business Enterprise". The 67 ha proposed project site s flanked by Port Kennedy Drive to the south and Ennis Avenue to the east. Rockingham Lakes Regional Park lies immediately adjacent to the east (see Figure 2), and the Rockingham Scientific Park a short way to the west.

Bamford Consulting Ecologists was commissioned by Strategen on behalf of LandCorp to undertake a Level 1 Fauna Assessment of the proposed project covering the entire 67 ha site. A level 1 Fauna Assessment is required to identify the fauna values of a site so that impacts upon these from any proposed development can be assessed and, where possible, minimised.

Figure 1. Location of the proposed Port Kennedy Business Park.

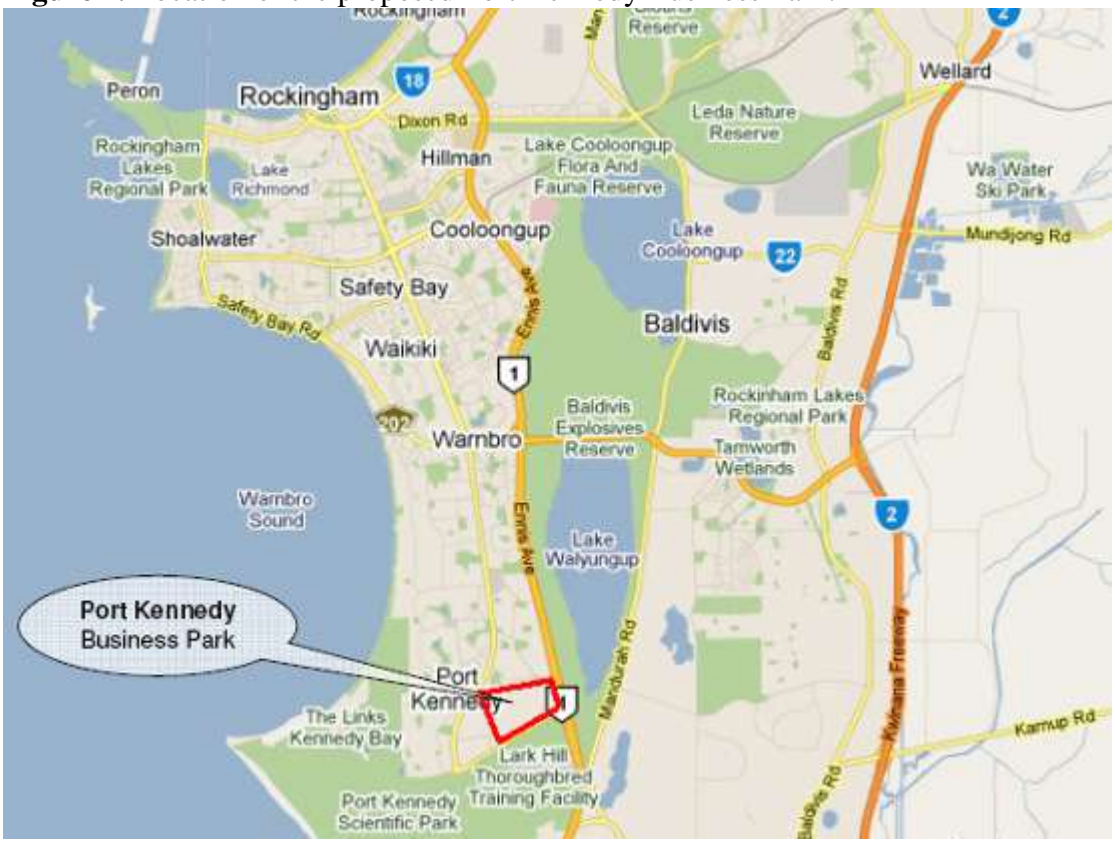


Figure 2. The location of the Proposed Project (shaded red).

1.2 Study Objectives

The objectives of fauna studies in the Environmental Impact Assessment (EIA) process are broadly to determine the fauna values of a site and the likely impacts of a proposed development. This provides government agencies with the information needed to assess the significance of impacts under state and government legislation. The key objectives of fauna studies are to:

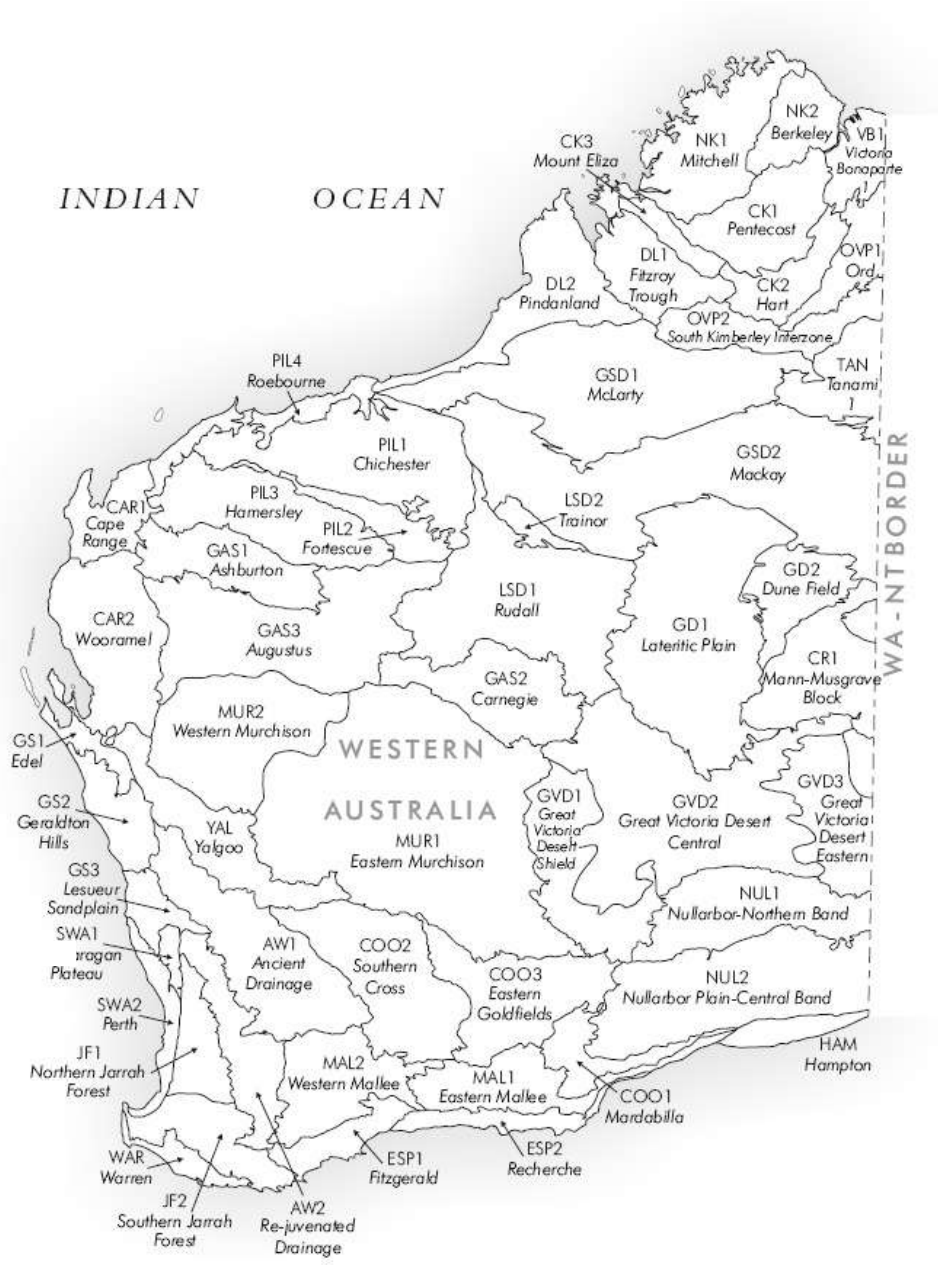
- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the Project Area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify and describe general vegetation ("habitats") present including:
  - descriptions of vegetation and substrate associations (VSAs);
  - observations on the presence and distribution of rare VSAs;
- identify potential impacts of a development within the Project Area upon fauna values, and
- provide management recommendations to mitigate these impacts.

2. BACKGROUND

2.1 Regional Description

The project area lies within the Swan Coastal Plain (SWA2) subregion of the Swan Coastal Plain Bioregion (Interim Biogeographical Regionalisation for Australia classification system, EA 2000; McKenzie *et al.* 2003, see Figure 3). The Swan Coastal Plain Bioregion falls within the Bioregion Group 1 classification of EPA (2004). Group 1 comprises the "bioregions of the South-West Botanical Province that are extensively cleared for agriculture."

Figure 3 **IBRA Subregions in Western Australia. Note the project lies in SWA2: Swan Coastal Plain.**



The general features of the Swan Coastal Plain subregion are summarised by Mitchell, Williams and Desmond (2002). The Swan Coastal Plain is a low-lying coastal plain, mainly covered with woodlands. It is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark (*Melaleuca* spp.) in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. The climate is Mediterranean with rainfall varying from 600 to 1000, depending on topography and elevation. Three phases of marine sand dune development provide relief.

The Swan Coastal Plain subregion is composed of:

"colluvial and aeolian sands, alluvial river flats and coastal limestone. Vegetation includes heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvial deposits. The subregion includes a complex series of seasonal wetlands and also includes Rottnest, Carnac and Garden Islands. The subregional area is 1,333, 901 ha. (Mitchell *et al.* 2002)."

The dominant land uses in this subregion are dry land agriculture, unallocated crown land and crown reserves, urban areas, rural residential, cultivation, forestry-plantations, conservation and grazing. There are smaller areas of mining and defence lands. The Perth Metropolitan Area makes up 20% of the entire subregion (Mitchell *et al.* 2002). The Swan Coastal Plain has undergone large scale development and as a result much of the native vegetation in the region has been cleared. The majority of the remaining remnant vegetation occurs in small and isolated remnants.

2.2 Vegetation

The vegetation of the Swan Coastal Plain has been extensively cleared and significantly altered by human activities. Native vegetation has been reduced and degraded to such an extent that much of the remaining remnant vegetation is regionally significant and in need of retention and some level of protection. The project area contains approximately 67ha of intact native vegetation comprising coastal and near-coastal heaths and shrublands generally in good condition (RPS, 2006). It falls within the Rockingham-Becher Plain that comprises a low sandplain featuring a distinctive landscape of parallel dune ridges alternating with linear swale depressions containing a series of wetlands at the lowest points in the landscape (RPS, 2006).

RPS conducted a flora and vegetation survey of the project area and mapped two major vegetation communities (RPS, 2006, see Figure 4). These comprise:

- Dune System
    a. Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests
    b. Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes
- Wetlands, Damplands and Depressions in Dune Swales
    a. Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.

b. Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
c. Shrubland to Tall Open Scrub of *Xanthorrhea preisii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

The Wetlands, Damplands and Depressions in Dune Swales vegetation community is equivalent to "FCT 19 : Sedgelands in Holocene Dune Swales of the southern Swan Coastal Plain". This community is listed under the EPBC Act as an endangered Ecological Community and listed as a threatened Ecological Community (TEC) in Western Australia. Due to large scale land clearance this vegetation community occurs in small and isolated remnants on the Swan Coastal Plain. It is restricted to the Rockingham and Yanchep areas plus a small area south of Mandurah (DEC, 2011).

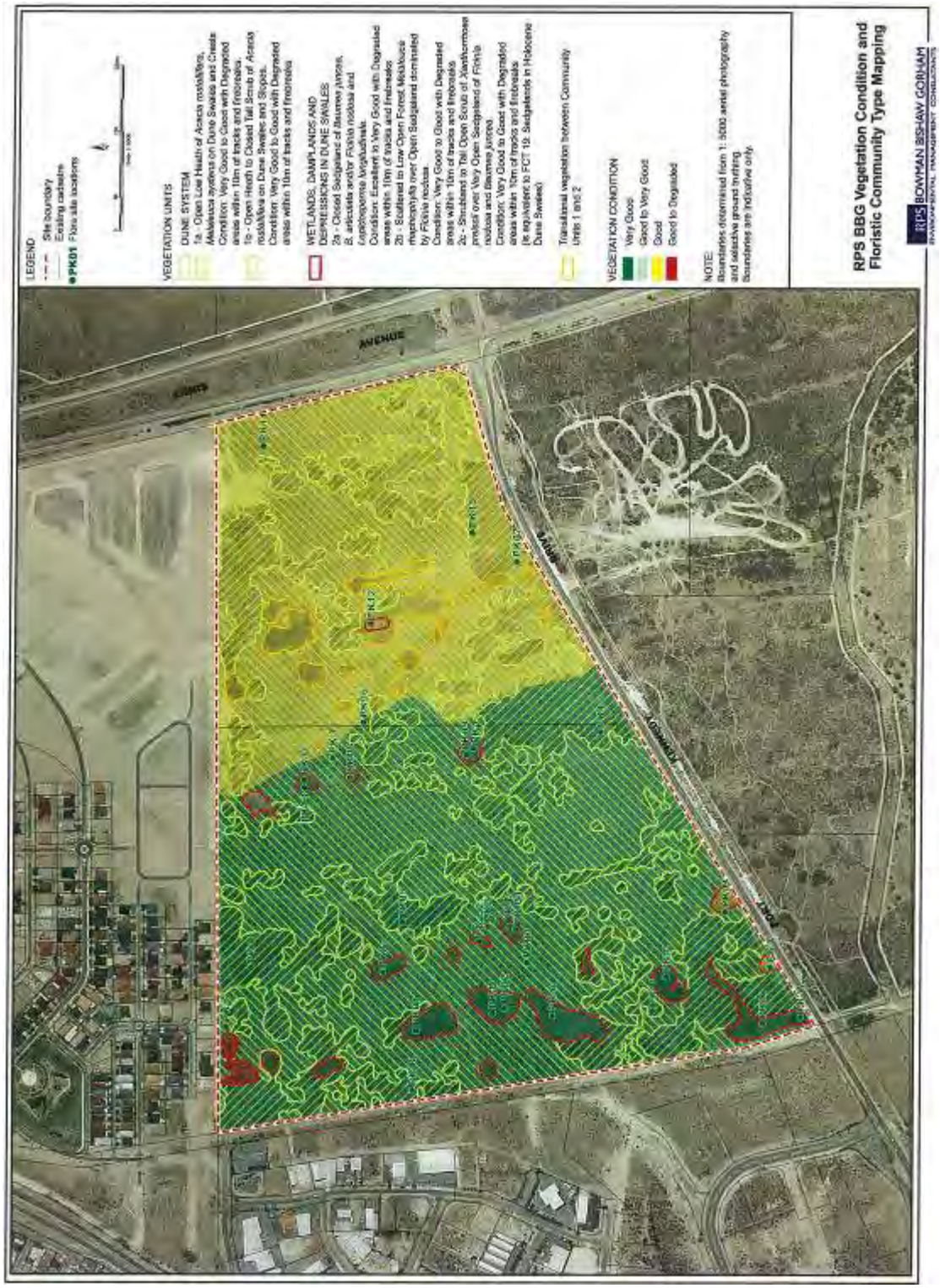


Figure 4. Vegetation of the Project Area.

2.3 Significant Wetlands

Several Wetland communities occurring within the project area have been mapped by RPS. The wetlands occur in the linear swale depressions where the ground surface approaches or meets the maximum elevation of the groundwater table during the wetter months of the year (RPS 2006). A total of 22 wetlands has been recorded from the project area comprising sumplands (seasonally inundated basin wetlands) and damplands (seasonally waterlogged basin wetlands) (see Figure 5, RPS, 2006).

Figure 5. Wetlands of the Project Area.

2.4 Previous Fauna Surveys

Bamford Consulting Ecologists has conducted several fauna assessments in the local area. This includes at Rockingham Lakes Regional Park (Site Inspection conducted in April 2011) adjacent to project area. A total of 40 species was recorded during the survey comprising 33 birds, 1 frog, 2 reptile, two native mammal and three introduced mammal species. Species of conservation significance recorded from the area include the DEC Priority Quenda and five locally significant bird species.

Species Lists are also available for the Rockingham area including fauna recorded at Point Peron (Western Australian Naturalists Club – Kwinana, Rockingham and Mandurah Branch, 1998), Port Kennedy Scientific Park (DEC, 2011) and Rockingham Lakes Regional Park (DEC, 2010). Point Peron lies approximately 10 km north-west of the project area, Port Kennedy Scientific Park lies immediately to the south-west of the project area and Rockingham Lakes Regional Park encompasses the lakes immediately to the east and also vegetation immediately to the south of the project area.

2.5 Assessment of Conservation Significance

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994). The Wildlife Conservation Act uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix One.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). In addition, the federal Department of Sustainability, Environment, Water, Population and Communities (SEWPC, formerly DEWHA and Environment Australia) has supported the publication of reports on the conservation status of most vertebrate fauna species e.g. fish (Wager and Jackson (1993), reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell et al. 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). These publications also use the IUCN categories, although those used by Cogger et al. (1993) and Wager and Jackson (1993) differ in some respects as these reports pre-date Mace and Stuart's review (1994).

In Western Australia, the Department of Environment and Conservation (DEC) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the *Wildlife Conservation Act* but for which the DEC feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN

Conservation Dependent category. Levels of Priority are described in Appendix One.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by DEC, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993) but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environmental Protection (2000, now DEC) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan.

On the basis of the above comments, three levels of conservation significance are recognised in this report:

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Conservation Significance (CS) 2: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by the DEC.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA 2002). For example, if a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3.

In addition to these conservation levels, species that have been introduced (INT) are indicated.

3. METHODS

3.1 Approach

This fauna assessment and report preparation were carried out with reference to guidance and position statements published by the WA Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (e.g. EPA 2002; EPA 2004). The level of fauna assessment required by the EPA is determined by the size and location of the proposed disturbance and the sensitivity of the surrounding environment in which the disturbance is planned.

Due to the scale and nature of the proposal, a Level 1 survey was deemed suitable (for this assessment) to satisfy the EPA guidelines, given the small area of proposed disturbance and the large extent of sampling in the region. For this assessment, a Level 1 survey involved a desktop study and reconnaissance survey (site inspection). The EPA describes a Level 1 survey as:

"Background research or 'desktop' study with the purpose to gather background information on the target area (usually at the locality scale). This involves a search of all sources for literature, data and map-based information (EPA, 2004)."

The purpose of a Reconnaissance Survey is to verify the accuracy of the background study; to further delineate and characterise the fauna and faunal assemblages present in the target area; and to identify potential impacts.

This involves:

"a target area visit by suitably qualified personnel to undertake selective, low intensity sampling of the fauna and faunal assemblages, and to provide habitat descriptions and habitat maps of the project area".

3.2 Personnel

The site inspection was conducted on 3rd June 2011 by:
Jeff Turpin: B.Sc. (Zoology)

This fauna assessment document was prepared by Mr Jeff Turpin and Dr Mike Bamford (B.Sc. Hons. Ph.D.).

3.3 Nomenclature and Taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's *Checklist of the Vertebrates of Western Australia*. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin and Smith 2001), birds (Christidis and Boles 1994; Johnstone 2001), and mammals (How *et al.* 2001).

3.4 Sources of Information for Desktop Assessment

Information for this fauna assessment was drawn primarily from the DEC NatureMap (2011), the Birds Australia Atlas Database, DEC Threatened Fauna Database and EPBC Protected Matters Search Tool. All databases were interrogated in June 2011 (see below). This information was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were: frogs (Tyler *et al.* 2000), reptiles (Storr *et al.* 1983, 1990, 1999 and 2002), birds (Blakers *et al.* 1984; Johnstone and Storr 1998; Johnstone and Storr, 2003; Storr, 1984), and mammals (Churchill 1998; Strahan 1995; Menkhorst and Knight 2001). Information was also available from some previous surveys in the region (Section 2.5 above).

Database	Type of records held on database	Area searched
NatureMap	Records of specimens held in the WA Museum. DEC records, Information and records on Threatened and Priority species in Western Australia. Includes historical data.	115.77125E, 32.36442S - plus 10km buffer
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	Species list for the 1 degree grid cell containing 115.77125E, 32.36442S
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	115.77125E, 32.36442S - plus 10km buffer

3.5 Site Inspection

The site inspection of the project area was conducted on the 3rd June 2011. During the site inspection, the project area was traversed on foot. All fauna habitats encountered were recorded as well as opportunistic fauna observations.

The aim of the site inspection was to develop an understanding of the fauna habitats occurring at the site, and to search for evidence of conservation significant species. Habitats present within the project area were assessed as to the likelihood of supporting species of conservation significance known to occur in the region. All fauna species observed during surveying were recorded.

Sampling consisted of:

- searching for evidence of significant species such as diggings and burrows, roost hollows, tracks, scats, shelters etc.;
- microhabitat searching for smaller vertebrate animals (e.g. reptiles and mammals) and invertebrates (specifically short-range endemic invertebrates e.g. land snails, millipedes);
- bird surveys;
- opportunistic observations;
- bat surveys;
- use of motion sensitive cameras;
- aural frog calls; and
- habitat assessment.

3.5.1 Searching for Significant Species

Significant species identified in the desktop assessment that may occur in the project area include several that can be found by searching for evidence of their activities. These include the Quenda or Southern Brown Bandicoot (tracks and diggings), Brush Wallaby (tracks), Carnaby's Black-Cockatoo (feeding sign), Forest Red-tailed Black-Cockatoo (feeding sign), Baudin's Black-Cockatoo (feeding sign), South-West Carpet Python (shed skin, tracks, scats), bat species (roosting hollows) and mygalomorph spiders (burrows, shelters). Searching for evidence of significant fauna was therefore undertaken by walking through habitat considered suitable for such species.

3.5.2 Micro-habitat Searching

Micro-habitat searching was carried out in any areas of interest found during the site visit. Searching involved searching through leaf-litter, looking under bark and turning over rocks, logs and rubbish.

3.5.3 Bird Surveys

Bird censusing was based on that of the Birds Australia Atlas (2 ha area search for 20 minutes). Bird surveys were conducted at least once in each habitat present within the project area. Opportunistic bird observations were recorded at all times during surveying.

3.5.4 Opportunistic Surveys

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while travelling through the site.

3.5.5 Aural Frog Calls

Frogs were active and calling in the late afternoon during the survey. Twelve wetland areas (mapped by RPS within the project area) were visited on dusk, and the presence (or absence) of calling frogs was noted.

3.5.6 Bat Surveys

An ANABAT detector was used to sample for bats for 1 hour after sunset on the 3rd June 2011. However no bats were active during this period.

3.5.7 Motion Sensitive Cameras

Three Motion Sensitive Cameras were established at three separate wetlands targeting small mammals. The cameras (Bushnell Trophy Cams) were set during the early morning, baited with universal bait (peanut butter, sardines, rolled oats) and sampled until dusk.

3.5.8 Habitat Assessment

Each habitat visited was assessed as to the suitability of supporting threatened fauna.

3.6 Limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are addressed below:

Limitation	Comment
Level of survey.	Level 1 (desktop study and reconnaissance survey). Survey intensity was deemed adequate due to the size of project and large number of fauna surveys previously conducted in the region
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and site inspections.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Birds were extensively sampled however due to the nature of the survey, low level sampling was conducted for reptiles, amphibians and mammals. Graceful Sun Moth Survey was previously conducted on site.
Proportion of fauna identified, recorded and/or collected.	No species collected, all fauna observed identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the local area (BCE database); databases (BA, DEC, WAM, EPBC); Rockingham Lakes Regional Park Management Plan (DEC, 2010).
The proportion of the task achieved and further work which might be needed.	Site Inspection completed.
Timing/weather/season/cycle.	Site Inspection conducted June 2011 which was suitable for most species but poor for recording bats and some migrants.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbances affected the survey.

Limitation	Comment
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was low (desktop study and site inspection) however was adequate to satisfy EPA guidelines.
Completeness (e.g. was relevant area fully surveyed).	Desktop study covered project area and adjacent habitats. Site inspection covered all areas of the project.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to taxon level.
Remoteness and/or access problems.	NA
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional (e.g. Swan Coastal Plain) information was available and was consulted.

4. RESULTS

4.1 Fauna Habitats / Vegetation and Substrate Associations

Two major VSAs were found within the project area. These can be further divided into sub-units reflecting a finer detail of vegetation, landform and soil:

1. Sand Dune Systems:
    a. Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes, sandplain and swales.
    b. Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
2. Wetlands, Damplands and Seasonal Drainage Depressions in Dune swales:
    a. Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.
    b. Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
    c. Shrubland to Tall Open Scrub of *Xanthorrhea preisii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

These VSAs are depicted below.

Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes and swales.

Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.

Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*

Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.

Shrubland to Tall Open Scrub of *Xanthorrhea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea* (above and below).

4.2 Vertebrate fauna

The desktop survey identified nearly 300 vertebrae species potentially occurring in the general region of the Port Kennedy area, but this was reviewed on the basis of available habitat (see below). A total of 34 native fauna species was recorded during the site inspection. This comprised 25 bird, two native mammals, two introduced mammals, four reptile and one frog species.

Upon completion of the site inspection a large number of species were removed from the expected species list after consideration of the limited fauna habitats present on the site. Excluded species appeared in databases but are obviously likely on the site only as vagrants, such as seabirds, or for which the site has no suitable habitat, such as marine mammals. As a result a total of 204 vertebrate fauna species are expected including 9 amphibian, 48 reptile, 122 bird and 25 mammals (Tables 1, 2, 3 and 4). Table 5 lists those species considered to be of conservation significance and details their respective conservation status.

The faunal assemblage expected is typical of a small vegetated remnant on the Swan Coastal Plain. Most fauna species occurring or expected to occur in the project area are widespread but some species may have restricted or habitat limited distributions, and some fauna species expected have declined in the region. Conservation significant fauna species occurring or likely to occur in the project area are discussed below.

The vertebrate fauna expected to occur within the project area has the following composition (see Tables 1, 2, 3 and 4 for species lists):

Taxon	Species Expected	Species Recorded (Site Inspection)	Significant Fauna Expected			
			CS1	CS2	CS3	Total
Frogs	9	1	0	0	0	0
Reptiles	48	4	1	3	6	10
Birds	122	25	10	3	34	47
Mammals	20 native 6 feral	2 2	1	4	6	11
Total	**205**	**34**	**12**	**10**	**46**	**68**

4.2.1 Freshwater Fish

There are no permanent freshwater habitats within the proposed project area. Seasonal freshwater wetlands occur although these dry out over summer.

4.2.2 Amphibians

Nine species of frogs may occur in the vicinity of the project (Table 1). Of the species expected, the *Litoria, Heleioporus, Limnodynastes* and *Pseudophryne* species rely on wetlands or damp areas for breeding but disperse widely as adults. The Turtle Frog

breeds terrestrially. All species are common in woodland on sandy soils on the northern parts of the Swan Coastal Plain. Additionally, the Motorbike Frog *Litoria moorei* and Slender Tree Frog *Litoria adelaidensis* require more or less permanent water so may be present in nearby wetlands or suburbs (in garden ponds).

One species, *Heleioporus eyrei* was recorded during the site inspection. Numerous individuals were heard calling during the late afternoon and on dusk from seasonal wetlands. During this time period of activity, 12 wetlands were visited and *H. eyrei* was calling at three of the largest and deepest wetlands. These three wetlands comprised a closed sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinal*, with thickets of *Melaleuca rhaphiophylla.* Other wetlands areas such as those containing Melaleuca or Lepidosperma appeared either too small in size or too dry (too high in the landscape) to support frogs.

No species of frog expected within the project area are of listed conservation significance. All frog species expected in the vicinity of the project area are widespread but the fact that *H. eyrei* was restricted to three of 12 wetlands suggest that some frog populations may be locally significant; ie the deeper wetlands within the project area may be locally important for frogs.

4.2.3 Reptiles

A total of 48 species of reptile may occur in the vicinity of the proposed Port Kennedy Business Park (Table 2). Due to its relative small size and homogeneity, the proposed project area is likely to support only a proportion of these species, however adjacent bushland may support a large number of additional species.

Few reptiles of conservation significance are expected to be present. These are described below and summarised in Table 5. The South-West Carpet Python is the only reptile species of high significance (CS1) recorded in the vicinity of the project.

Conservation Significance Level 1 (CS1)

Morelia spilota imbricata **South-west Carpet Python (Sch. 4)**

Listed as Schedule 4 (Specially Protected) under the WA Wildlife Conservation Act and also as Priority 4 by DEC, and is of concern because this subspecies has declined dramatically in the face of urban development and land clearing. *M. s. imbricata* occurs in the south-western of WA, south of a line that runs from approximately Geraldton in the north-west to Eyre in the south-east. It prefers undisturbed bushland and rocky outcrops and is often arboreal. It preys on birds, other reptiles and small to medium sized mammals and requires large areas of bushland to survive. Near Perth the South-west Carpet Python inhabits substantial undisturbed patches of bushland including around Neerabup, Yanchep and on Garden Island (Bush, *et al.* 1995). Large scale development on the Swan Coastal Plain has considerably reduced its numbers in the Perth area (Bush *et. al.* 1995). *Morelia spilota imbricata* is a slow-moving species and is susceptible to vehicle strikes (roadkill) and predation in an urban environment but Dogs, Cats and

Foxes. NatureMap has several records of this species within 10km of the project area, from the Point Peron and the Karnup areas. There is thus some potential for this species to persist in the project area.

Conservation Significance Level 2 (CS2)

Lerista lineata **Perth Lined Lerista (DEC Priority 3)**

Listed as Priority 3 by DEC, and is of concern because this species has a restricted distribution between Busselton and Perth and is virtually confined to the Perth area (DEP, 2000). *Lerista lineata* is found in the southern suburbs and dunes of the Swan coastal Plain, restricted to pale sands supporting heathlands and shrublands, particularly in association with Banksias (Bush, et al., 1995). *Lerista lineata* has been recorded within 5km from the project area from Point Peron and from the adjacent Port Kennedy Scientific Park (DEC, 2010). This species is likely to occur within the proposed project area.

Neelaps calonotos **Black-striped Snake (DEC Priority 3)**

The Black-striped Snake is listed as Priority 3 by the Department of Environment and Conservation. This species is restricted to the west coast region from Cataby south to Mandurah, with an apparently isolated population recorded near Dongara (Bush et al., 2007). *Neelaps calonotos* has been recorded from coastal dunes, sandplains with Heath and Banksia Woodland It is threatened by encroaching land development and appears to be uncommon on the Swan Coastal Plain.

Neelaps calonotos is fossorial and due to its patchy distribution can be difficult to find. The closely related snake *Neelaps bimaculatus* appears to be quite common in the project area with several recorded during the site inspection. *Neelaps calonotos* appears to have similar habitat requirements to more common *Neelaps bimaculatus* and as a result is also likely to occur within the project area.

Ctenotus gemmula **Jewelled Ctenotus (DEC Priority 3)**

The Swan coastal Plain population of the Jewelled Ctenotus is listed as Priority 3 by the Department of Environment and Conservation. This species is scarce on the Swan Coastal Plain, occurring in isolated populations at Cataby and from Wanneroo south to Medina (Storr *et al.,* 1999). *Ctenotus gemmula* inhabits pale soils supporting heathlands, usually in association with banksias (Bush *et al.* 1995) and has been recorded at the margins of damplands (J. Turpin, per obs). This species may occur in the Port Kennedy area and has been recorded from Medina, approximately 14km north of the project area.

Conservation Significance Level 3 (CS3)

Black-headed Tree Goanna	***Varanus tristis***
Gould's Sand Goanna	***Varanus gouldii***
Rosenberg's Goanna	***Varanus rosenbergi***

Species of *Varanus* (Varanids) and *Morelia* (Pythons) have been most severely affected by urban development in the Perth area (DEP, 2000). Varanids and Pythons are large predators that occur at low population densities and thus require large areas of intact vegetation; they are now restricted to a few larger bushland remnants in the Perth area. Perth also represents the northern limit of *Varanus rosenbergi's* distribution.

All three varanid species may occur in the vicinity of the Port Kennedy Business Park project area. *Varanus gouldi* and *V. tristis* have been recorded in the adjacent Rockingham Lakes Regional Park (DEC, 2011).

As a result there is potential for all three species to occur within the proposed project area. The Stimpson's Python (*Antaresia stimsoni*) is considered locally extinct on the Swan Coastal Plain in the Perth area (DEP, 2000).

Western Swamp Egernia	***Lissolepis luctuosa***
Beaked Blind Snake	***Ramphotyphlops waitii***
Keeled Legless-lizard	***Pletholax gracilis***

The above three species also occur in the region at the extremes of their range. The skink *Lissolepis luctuosa* is restricted to dense vegetation surrounding lakes, swamps and rivers, and has declined dramatically due to the draining and reduction of wetland habitat (DEP, 2000). Perth represents the northern limit of this species' range. *Lissolepis luctuosa* may occur within the wetland areas in the project area or may be associated with Lake Walyungup directly to the east of the proposed Port Kennedy Business Park.

Pletholax gracilis is uncommon in the Perth region, inhabiting coastal dunes and sandplain supporting heath and Banksia Woodland (Bush, *et. al.,* 1995). It has been recorded from bushland adjacent to the Rockingham Lakes Regional Park, approximately 10km north of the project area (DEC, 2010) and is likely to occur on site. *Ramphotyphlops waitii* occurs throughout the Darling Range and adjoining coastal plain south to the Armadale area (Bush, *et. al.,* 1995). This species is scarce on the Swan Coastal Plain and is unlikely to occur at Port Kennedy.

4.2.4 Birds

Twenty five bird species were recorded from the proposed project area during the site inspection (see Table 3).

A total of nearly 200 bird species are considered likely to occur in the general region, but due to the small size of the proposed project area and limited habitats present only 122 species are expected to occur as either residents, seasonal or irregular visitors (see Table 3). Several bird species listed under database searches have been excluded from the list of birds expected. Coastal species (such as the Osprey, Terns), Seabirds, Waders, Cormorants, Pelicans and birds requiring large areas of permanent water (such as many ducks, spoonbills) have been omitted from the expected species list. These birds may occasionally fly over the proposed project area but are unlikely to occur within the habitats present. Other birds such as the Emu require large areas of intact vegetation and are almost certainly locally extinct.

Waterbirds will also use seasonal wetlands and cleared areas and after flooding. However, the majority of the waterbirds expected in the area are likely to be restricted to habitats outside the proposed project area such as that associated with the adjacent Lake Walyungup.

Forty-seven of the bird species that may be present are considered to be of conservation significance. Conservation Significant species are described below, with summary information in Table 5. A suite of bird species have been identified as having declined in the Perth area (DEP 2000) and therefore listed as CS3 in this assessment. These species are not formally listed under national or state legalisation, however have been noted as conservation significant due to their local decline. This includes habitat specialists with a reduced distribution on the Swan Coastal Plain and wide-ranging species with reduced populations on the Swan coastal Plain (DEP, 2000). They are dependent upon more or less intact areas of native vegetation in the region. CS3 bird species are also discussed below.

Conservation Significance Level 1 (CS1)

Ardea alba	**Great Egret (EPBC Migratory)**
Ardea ibis	**Cattle Egret (EPBC Migratory)**
Plegadis falcinellus	**Glossy Ibis (EPBC Migratory)**

These three species are all large, Australian breeding waterbirds that are listed as Migratory under the EPBC Act. The Great and Cattle Egrets are also listed as Schedule 3 (JAMBA) under the WA Wildlife Conservation Act. The Great Egret has been recorded from Lake Walyungup and Lake Cooloongup (adjacent to the project area, Birds Australia, 2011). The Cattle Egret and Glossy Ibis may only be infrequent visitors to the

local area as they are uncommon in the South-West. None of the above three species is expected to occur regularly within the habitats present in the project area.

Botaurus poiciloptilus **Australasian Bittern (DEC Schedule 1)**

The Australasian Bittern is listed as Vulnerable under the WA Wildlife Conservation Act. This species frequents reedbeds and dense vegetation in wetlands including lignum and sedges. In Western Australia, the Australasian Bittern is confined to the far south-west. It is known from Thomsons Lake (approximately 25km north) however due to a lack of local records and suitable habitat, this species is unlikely to occur within the project area.

Falco peregrinus **Peregrine Falcon (DEC Schedule 4)**

The Peregrine Falcon is classified as "Specially Protected Fauna" under the Schedule 4 of the Wildlife Conservation Act. This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands. The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predates heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Birds Australia, 2008). The Peregrine Falcon mates for life with pairs maintaining a home range of about 20 -30 km square throughout the year. Blakers et al. (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world.

The Peregrine Falcon is a wide-ranging bird of prey that may be an occasional visitor to the project area. Due to the lack of large hollow-bearing trees this species is unlikely to breed in the proposed project area. This species has been recorded nearby from Point Peron (Birds Australia, 2011).

Calyptorhynchus banksii naso **Forest Red-tailed Black-Cockatoo (EPBC V.)**

Listed as Schedule 1 (Vulnerable) under the WA Wildlife Conservation Act and is of concern because clearing and forestry have reduced the available breeding and feeding habitat. Feral bees and Galahs also compete with *C. b. naso* for nesting hollows. *C. b. naso* occurs in the south-west of Western Australia, approximately south-west of a line between Gingin and the Green Range (near Wellstead, east of Albany). The range of this subspecies is closely tied to the distribution of Marri (*Corymbia calophylla*); the favoured nesting and food tree of *C. b. naso*. *C. b. naso* occurs occasionally on the Swan Coastal Plain, where it is associated with Marri or Pine Plantations (J. Turpin, pers. obs.). This species was recorded flying over the project area (two individuals). Due to the lack of Marri trees within the proposed project area, the Forest Red-tailed Black-Cockatoo is unlikely to breed or forage in the area.

Calyptorhynchus latirostris **Carnaby's (Short-billed) Cockatoo (EPBC E.)**

Listed as Endangered under the EPBC Act and Schedule 1 (Endangered) under the WA Wildlife Conservation Act. *C. latirostris* occurs in the south-west of Western Australia, approximately south-west of a line between the Murchison River (near Kalbarri) and Cape Arid National Park (east of Esperance). Carnaby's Cockatoo has been recorded in

the area from the Rockingham Lakes Regional Park (Birds Australia, 2011) and may be a rare visitor to the project area.

Carnaby's Cockatoo generally breeds in inland areas, moving to cooler, coastal areas for the non-breeding period (late spring to mid-winter). It has recently begun breeding on coastal areas due to loss of inland breeding habitat. Land clearing and degradation has reduced available breeding sites (tree hollows) and fragmented breeding and feeding sites. Feral bees, galahs and corellas out-compete *C. latirostris* for nesting hollows. Illegal trapping and smuggling also threaten this species.

Carnaby's Cockatoo has declined due to loss of breeding habitat in the wheatbelt and of non-breeding habitat along the west coast, partly due to urban expansion. While small areas of foraging habitat around the metropolitan area support only small numbers of birds for short periods of time, the progressive loss of such small areas is an ongoing concern for this species.

Carnaby's Cockatoo is known to feed on seeding *Banksia* and *Eucalyptus* as well as proteaceous heaths (Johnstone and Storr 1998). It will feed on scattered Proteaceae and has been observed extracting grubs from *Jacksonia* sp. (M. Bamford). Loss of feeding habitat is identified as an important contributing factor to the decline of Carnaby's Cockatoo in Garnett and Crowley (2000). Further loss of significant regional feeding habitat may constitute a trigger as a controlled action under the EPBC Act and may require assessment by the DEH. Some areas of feeding habitat (proteaceous heaths) occur including around the fringes of the wetlands however and no breeding habitat (Eucalypt trees) occurs in the project area.

Calyptorhynchus baudinii **Baudin's Cockatoo (EPBC Vulnerable)**

Listed as Vulnerable under the EPBC Act and as Schedule 1 (Endangered) under the WA Wildlife Conservation Act. *C. baudinii* occurs in the deep south-west of Western Australia, approximately south-west of a line between Morangup (near Bullsbrook, north of Perth) and Waychinicup National Park (east of Albany). Birds generally breed in the Karri, Marri and Wandoo forests in the southern parts of the species' range and move north to the Darling Range and Swan Coastal Plain during autumn and winter (non-breeding period). Clearing for agriculture and logging has removed nesting and feeding trees for this species. The species has been recorded in the region but appears to be a vagrant onto the Swan Coastal Plain in the Rockingham area. Baudin's Cockatoo is more frequently found in the Darling Range. It is unlikely to utilise the proposed project area.

Apus pacificus **Fork-tailed Swift (EPBC Migratory)**

Merops ornatus **Rainbow Bee-eater (EPBC Migratory)**

Both these species are listed as Migratory under the EPBC Act. *A. pacificus* breeds in Siberia and the Himalayas and migrates to arrive in Australia in October, returning to the breeding grounds by May or June. Movements within Australia are in response to weather patterns, with this species often following thunderstorms. It is a highly aerial

species that rarely comes to ground. The Fork-tailed Swift is not expected to utilise habitats within the proposed project area.

The Rainbow Bee-eater occurs year-around in the tropics of northern Australia, with a southward migration, to both south-eastern and south-western Australia, in early spring. Southern birds return north in autumn (Johnstone and Storr 1998). It occurs in the better watered parts of Western Australia, between the Kimberley and south-west, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr, 1998). It nests in burrows dug usually at a slight angle in flat ground, gently elevated slopes, sandy banks or cuttings, and often at the margins of roads or tracks. The Rainbow Bee-eater has a very widespread distribution over Australia, wintering in northern Australia and Indonesia, and migrating south during September and October (Johnstone & Storr, 1998).

The Rainbow Bee-eater has been previously recorded at Lake Walyungup (Birds Australia, 2011). When present, *M. ornatus* is common and prominent in natural and altered environments. Breeding is widespread on the Swan Coastal Plain and often occurs on the margins of paddocks. Although a species of high conservation significance, it is abundant and versatile in its selection of nest sites. This species is almost certainly a seasonal (late spring to late summer) breeding visitor to the proposed project area.

Conservation Significance Level 2 (CS2)

Ixobrychus minutus **Little Bittern (DEC Priority 4)**

Listed as Priority 4 by DEC and is of concern because of habitat loss due to salinisation, clearing, grazing, wetland drainage and altered fire regimes. *I. minutus* occurs in south-western Western Australia (south-west of a line between Perth and Albany), in the Kimberley, and along the eastern coast of Australia. This species does occur in the region, with records from the Rockingham Lakes Regional Park (DEC, 2010). However, It is unlikely to occur within the project area regularly because the wetlands are small are retain water for only short periods.

Ixobrychus flavicollis **Black Bittern (SW population, DEC P3)**

The south-west population of the Black Bittern is listed as Priority 3 by DEC. This species roosts and nests in trees and dense vegetation associated with wetlands. Except as a rare vagrant, the Black Bittern is unlikely to occur within the project area due to a lack of suitable habitat.

Tyto novaehollandiae novaehollandiae **Masked Owl (southern population, P3)**

Listed as Priority 3 by DEC and is of concern because the population and range of this subspecies has declined dramatically as a result of habitat clearing. *T. n. novaehollandiae* occurs in the deeper south-west of Western Australia, with recent surveys (see Garnett and Crowley 2000) recording birds only from the area between Margaret River and

Manjimup. The range of *T. n. novaehollandiae* formerly extended from Carnarvon to the Nullarbor. Three other subspecies are recognised within Australia, with only *T. n. kimberli* (listed as Vulnerable under the EPBC Act and as Priority 1 by DEC) occurring elsewhere in Western Australia (Kimberley region). There is a recent record of this species from near Mandurah (Birds Australia, 2011) and this species may be a rare visitor to the project area, but it is unlikely to be dependent on habitat within the proposed project area.

Ninox connivens connivens **Southern Barking Owl (DEC Priority 2)**

The southern population of the Barking Owl is listed as Priority 2 by DEC. The Barking Owl primarily occurs in dry sclerophyll woodland, particularly that associated with riparian vegetation in the south-west (Johnstone and Storr, 1998). The range of the Barking Owl has declined by over 50% (Garnett and Crowley, 200) as a result of land clearing. This species nests within hollows in large eucalypts (Garnett and Crowley, 2000). The Southern Barking Owl is restricted to the far south-west in Western Australia, with scattered records around the Perth region including from Pinjar, Wanneroo and Carmel (Birds Australia, 2010). This species may be a rare visitor to the project area, however is unlikely to be dependent on habitat within the proposed project area.

Conservation Significance Level 3 (CS3)

Declining Birds on the Swan Coastal Plain

A number of bird species have been identified by the WA Department of Environmental Protection (DEP, 2000) as having declined in the Perth area due to impacts associated with urban development. A few of these are birds of prey, but the majority are small birds that rely on woodlands and shrublands where they are either residents (eg. fairy-wrens and thornbills) or seasonal visitors (honeyeaters). The fairy-wrens and thornbills are particularly sensitive to habitat loss and fragmentation, whereas the honeyeaters have a greater ability to access suitable habitat even when it is fragmented by urban development. The majority of the species listed by the DEP (2000) are also noted as having declined Australia-wide by more than 20% in the New Atlas of Australian Birds (Barrett et al. 2003). The species listed as CS3 likely to occur in the project area are listed in Table A.

Seven of these CS3 species were recorded during the site inspection – Brown Goshawk, Common Bronzewing, Splendid Fairy-wren, White-browed Scrub-wren, Inland Thornbill, Western Thornbill and White-cheeked Honeyeater. The fairy-wren species, the White-browed Scrub-wren, Thornbills and the robins are all sedentary species that have poor powers of dispersal and thus rely upon continuity of habitat to persist. As a result the proposed project area may support some small but locally significant populations of these species.

Table A. Twenty-eight CS3 Bird species expected in the project area. These species are listed as declining in the Perth region by DEP (2000).

Species recorded at during the site inspection are listed with an asterisk. Species recorded in local area by Birds Australia (BA or at Rockingham Lakes Regional Park) are also listed.

Square-tailed Kite (RLRP)	Splendid Fairy-wren*	New Holland Honeyeater (RLRP)
Whistling Kite (RLRP)	Southern Emu-wren	Tawny-crowned Honeyeater (BA)
Brown Goshawk*	White-browed Scrub-wren*	Scarlet Robin (RLRP)
Collared Sparrowhawk (RLRP)	Inland Thornbill*	Hooded Robin (BA)
Wedge-tailed Eagle (RLRP)	Western Thornbill*	White-breasted Robin
Little Eagle (RLRP)	Yellow-rumped Thornbill (RLRP)	Golden Whistler (RLRP)
Brown Falcon (RLRP)	Western Wattlebird (RLRP)	Grey Shrike-thrush (RLRP)
Painted Button-quail (BA)	White-cheeked Honeyeater*	Black-faced Woodswallow (BA)
Common Bronzewing*	Western Spinebill (BA)	Dusky Woodswallow (BA)
Brush Bronzewing		

4.2.5 Mammals

A total of 26 mammal species is considered likely to occur in the general region, comprising 20 native and six introduced species. However, due to the extent of land clearance coupled with the small size of the proposed project area with limited habitats present many of these species may no longer occur in the Port Kennedy area bt have been included in the species list (see Table 4).

Several ground dwelling terrestrial mammal species found in the region have been recorded in the adjacent Rockingham Lakes Regional Park. These are:

1. Western Grey Kangaroo (*Macropus fuliginosus*);
2. Brush Wallaby (*Macropus irma*);
3. Southern Brown Bandicoot (*Isoodon obesulus*);
4. Bush Rat (*Rattus fuscipes*); and
5. Echidna (*Tachyglossus aculeatus*).

These species are expected to utilise the proposed project area. Additionally, the Common Brushtail Possum may occasionally move through the area from larger adjacent remnants of native vegetation.

Two native mammal species, the Quenda or Southern Brown Bandicoot and the Western Grey Kangaroo, were recorded during the site inspection. Three Western Grey Kangaroos were observed and Kangaroo tracks were commonly encountered throughout the project area. The Quenda was recorded from tracks, diggings and also one individual was recorded on the motion sensitive camera (see Plates 1 – 3). All evidence of the Quenda was within or on the margins of wetlands on the western side of the project area. It is likely that the local Quenda population is restricted to this area in the wetland habitats.

The Bush Rat is considered likely to occur within the project area. This species has been recorded in the adjacent Rockingham Lakes Regional Park and inhabits sedgeland of *Lepidosperma longitudinale* in dune swales on the Swan Coastal Plain (J. Turpin, pers obs.). Additionally two introduced species, the feral cat and dog were, recorded and are likely to be household pets from neighbouring residents.

Conservation significant mammal species that may be present are outlined below, with a summary of conservation status and impacts in Table 5. A number of other species are locally extinct and are not considered here (eg. Quokka, Common Ringtail Possum, Numbat).

Conservation Significance Level 1 (CS1)

Dasyurus geoffroii **Chuditch (EPBC Vulnerable)**

The Chuditch is listed as Vulnerable under the EPBC Act and Schedule 1 (Vulnerable) under the WA Wildlife Conservation Act. It currently survives only in south-western

Western Australia, in areas dominated by eucalypt forest or woodland and mallee shrubland (Strahan, 1995) and also persists amongst rocky outcrops. Habitat alteration through clearing, grazing and changed fire regimes, competition with foxes and cats for food, predation by foxes, hunting, and poisoning all threaten *D. geoffroii*. This species occupies large home ranges, is highly mobile and appears able to utilise bush remnants and corridors (DEC, 2008).

The Chuditch is effectively extinct on the Swan Costal Plain in the Perth area but vagrants occasionally occur. This species is unlikely to occur within the project area.

Conservation Significance Level 2 (CS2)

Isoodon obesulus fusciventer **Southern Brown Bandicoot/ Quenda, P5**

The Quenda is listed as Priority 5 by DEC and has declined on the Swan Coastal Plain. The Southern Brown Bandicoot occurs in the south-west of Western Australia north to Yanchep and Gingin, south to Albany and east to Esperance. This species previously occurred north to Moore River but like many mammals in the region has undergone a large range reduction (Maxwell *et al.* 1996). On the Swan Coastal Plain it is patchily distributed as a result of land clearance, habitat degradation and feral predators, and often occurs in small and fragmented populations (DEC, 2008). It is commonly associated with dense, low vegetation.

Plate 1: Quenda recorded from the proposed project area on a motion sensitive camera.

The Southern Brown Bandicoot was recorded from the project area. One individual was recorded on the motion sensitive camera (see Plate 1), from the edge of one of the larger wetland areas supporting dense sedgeland. Numerous Quenda diggings and tracks were also recorded within or on the margins of most wetlands on the western margin of the project area (see Plates 2 and 4). The Quenda may occur throughout the project area however the local population is likely to be concentrated within the wetland habitat. The Closed Sedgeland of *Baumea juncea, B. articulata* and / or *Ficinia nodosa* and

Lepidosperma longitudinale is a favoured habitat of this species and is expected to support the highest densities of Quenda in the project area.

Plate 2: Quenda diggings recorded from the proposed project area.

Plate 3: Quenda tracks recorded from the proposed project area.

Macropus irma **Brush Wallaby (DEC Priority 4)**

The Brush Wallaby is listed as Priority 4 by DEC. This species occurs in south-western Australia, from Kalbarri to Cape Arid. The Western Brush Wallaby formerly occurred over a much larger area however has suffered a large range reduction and fragmentation of populations due to clearing for agriculture and predation by introduced predators (DEC, 2008). The optimum habitat for the Western Brush Wallaby is open forest or

woodland, in which it favours open, seasonally wet flats with low grasses and open, scrubby thickets (Strahan, 1995), and areas of dense vegetation. It is also found in mallee and heathland (DEC, 2008). The Brush Wallaby occurs in native vegetation on the outskirts of Perth, including the Yanchep and Jandakot areas (BCE records). This species has also been recorded from Rockingham Lakes Regional Park, from Lake Cooloongup and the adjacent bushland (DEC, 2011) and individuals may occasionally move through the project area.

Falsistrellus mackenziei **Western False Pipistrelle (DEC P4)**

Listed as Priority 4 by DEC. *F. mackenziei* occurs in the wet sclerophyll and higher rainfall areas of dry sclerophyll forest in the south-west of Western Australia. Pipistrelle is normally associated with forest (Strahan 1995) but there is a recent record from woodland near Jandakot (Hosken and O'Shea 1994). This species is unlikely to be dependent on habitat within the project area.

Hydromys chrysogaster **Water Rat, Rakali (DEC Priority 4)**

Listed as Priority 4 by DEC and is of concern because the species' population is in decline, particularly along rivers affected by salinity or degradation. In Western Australia, *H. chrysogaster* occurs in the south-west, along parts of the Pilbara coast (including some islands) and in the Kimberley. It also occurs throughout northern and eastern Australia. The distribution of this species is very patchy on the Swan Coastal Plain with records from Kwinana, Thomsons Lake Nature Reserve, Medina and the Peel Inlet (DEC, 2008). At Port Kennedy this species may occur in and around adjacent wetlands and could be an occasional visitor to wetlands within the project area.

Conservation Significance Level 3 (CS3)

Sminthopsis griseoventer Grey-bellied Dunnart

S. griseoventer is not listed as a threatened or priority species and is moderately common in suitable habitat north of Perth, but it appears to be locally extinct on the Coastal Plain south of Perth (Bamford, 2008, unpublished), with no recent records from this area. Therefore, a surviving population would be locally significant. Studies from Port Kennedy Scientific Park recorded a Dunnart species which may have been *Sminthopsis griseoventer* (DEC, 2010).

Cercartetus concinnus Western Pygmy-Possum

C. concinnus is not listed as a threatened or priority species and is moderately common in suitable habitat throughout southern Australia. This species is listed as CS3, because the Swan Coastal Plain population has declined and is now fragmented.

There are no recent records of this species near the Port Kennedy area and as a result the Western Pygmy-possum is considered unlikely to occur within the project area. This species has been recorded from the Mandurah area (DEC, 2011).

Tarsipes rostratus Honey Possum

T. rostratus is not listed as a threatened or priority species and is common to abundant in suitable habitat in south-western Western Australia. This species is listed as CS3 because the Swan Coastal Plain population has declined and is now fragmented. *T. rostratus* is an obligate nectarivore and can only survive in areas that support a diverse range of nectar producing plants that ensure a year-around supply of food. There are no recent records of this species in the local area and due to a lack of suitable habitat this species is not expected to occur in the project area.

Rattus fuscipes Western Bush Rat (Moodit)

In Western Australia, the Bush Rat occurs in coastal and near coastal areas from Jurien Bay south-east to Point Dempster (WAM, 2008). This species inhabits forest, woodland, coastal thickets and sedgelands (Strahan, 1995). *R. fuscipes* is not listed as a threatened or priority species and is moderately common to common in suitable near-coastal habitat throughout southern and eastern Australia. This species is listed as CS3 because the Swan Coastal Plain population has declined and is now fragmented.

The Bush Rat is considered likely to occur within the project area. This species has been recorded in the adjacent Rockingham Lakes Regional Park, from Point Peron and also Port Kennedy Scientific Park (DEC, 2011). The Bush Rat inhabits sedgeland of *Lepidosperma longitudinale* in dune swales on the Swan Coastal Plain (J. Turpin, pers obs.), a habitat occurring within the project area.

Trichosurus vulpecula vulpecula Common Brushtail Possum

The Common Brushtail Possum has undergone a significant reduction in distribution in Western Australia, and the Midwest in particular (How and Hilcox 2000). In Western Australia it is now generally confined to the temperate south-west, Kimberley and Pilbara coast. This species inhabits a range of habitats including forests and woodlands containing large hollow bearing trees and ground refuges (such as hollow logs, DEC, 2008). The Common Brushtail Possum occurs patchily on the Swan Coastal Plain but due to the lack of hollow bearing trees is unlikely to rely on habitats within the project area. However, it may move through the project area as it occurs in adjacent bushland including from Rockingham DEC, (2011), and Paganoni Rd Bushland (DEC, 2011).

Pseudomys albocinereus Noodji or Ashy-grey Mouse

The Ash-grey Mouse has declined in the Perth region due to the loss of habitat and is now probably extinct south of the Gnangara region (M. Bamford pers. obs). There are no recent records of this species on the Swan Coastal Plain south of the Swan River. As a result the Ash-grey Mouse is considered unlikely to occur within the project area.

4.2.6 Short-range Endemic Invertebrates

Invertebrates in general are beyond the scope of assessment for environmental impact assessment because there are so many species and their taxonomy is so poorly understood, but it is possible to focus on a small range of taxa that are short-range endemics. Harvey (2002) notes that the majority of invertebrate species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Schizomida (schizomids; spider-like arachnids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish).

Significant species are discussed below:

Conservation Significance Level 1

- Graceful Sunmoth (*Symenon grantiosa*, Castniidae). **EPBC Endangered,** Schedule 1 (Endangered) of the WA Act. The Graceful Sun-Moth *Synemon gratiosa* (Castniidae) is noted as occurring in few locations from Yanchep south to Mandurah and to be threatened by land clearing. This species inhabits *Lomandra maritima* on coastal dunes and *Lomandra hermaphrodita* within Banksia Woodland and Heath. The Graceful Sunmoth has been recorded patchily on the Swam Coastal Plain from several areas of remnant vegetation. It was recorded in the project area during surveys conducted by Emerge Associates in March 2011.
- *Leioproctus douglasiellus* (Native Bee). Schedule 1. This species is known only from a few records on the Swan Coastal Plain including from Pearce, Forrestdale Lake Nature Reserve and Brixton Street Wetlands. It has been collected from flowers of *Goodenia filiformis* and *Anthotium junciforme*.

Conservation Significance Level 2

- *Austrosaga spinifer* (a cricket) Priority 3. Recorded from heathlands between Perth and Cervantes, but the nature of these heathlands is not known.
- *Hyaleus globuliferus* (Native Bee) Priority 3. Forages on the flowers of Woollybush *Adenanthos cygnorum* and some other species. No *Adenanthos* species were observed during the site inspection.
- *Leioproctus contrarius* (Native Bee) Priority 3. Apparently dependent upon flowers of Goodeniaceae and known from Banksia woodlands. Recent surveys have shown that it is more widespread that previously thought. This species has been recorded at Forrestdale and Murdoch however there are no local records near Port Kennedy.
- *Leioproctus bilobatus* (Native Bee) Priority 2. This species is known only from a few records on the Swan Coastal Plain however there are no local records near Port Kennedy.
- the cricket *Throscodectes xiphos* (Priority 1). Associated with Banksia Woodland which is absent from the proposed project area.

The Graceful Sunmoth (CS1) has been recorded within the project area and due the extensive amount of favourable habitat (coupled with land clearance in the region) a significant local population may occur. Liaison with the DEC is highly recommended.

While the Graceful Sunmoth has been recorded within the project area, no other threatened invertebrate species have been recorded on DEC's NatureMap database within 20km of the project area. However due to large scale clearing in the area remnant vegetation is small, isolated and fragmented within a regional context. As a result a number of invertebrate species occurring within the proposed Port Kennedy Business Park project area may exhibit restricted ranges.

5. DISCUSSION

Due to widespread vegetation clearing in the region, few areas of intact native vegetation remain. As a result, intact native vegetation in the Port Kennedy area is of local importance to fauna and provides habitat for some species of conservation significance. Significant habitats and species of conservation significance are summarized below (see also Table 5). Impacts upon fauna due to the construction and operation of the project are discussed in a separate report.

5.1 Habitat Types

Habitats of conservation significance tend to be those that are both rare across the landscape and that are important for significant species and/or for biodiversity. Due to the extensive clearing in the region, all remaining native vegetation is likely to be of value to fauna and support isolated and fragmented faunal populations. However, while two broad fauna habitats were recorded from the project area one habitat is considered of high conservation significance:

- Sedgelands in Holocene Dune Swales of the southern Swan Coastal Plain.

The Sedgelands in Holocene Dune Swales have a highly restricted distribution on the Swan Coastal Plain. Within the project area they are restricted to small areas mostly concentrated on the western margin of the site (see Figure 6). A total of 22 wetlands (equivalent to the sedgeland habitat) have been recorded from the project area comprising sumplands and damplands.

The sedgeland (wetland) areas are a highly significant fauna habitat supporting species of conservation significance, restricted fauna and breeding populations of amphibians. The conservation significant Quenda (DEC Priority 4) was recorded from several wetland areas. The Closed Sedgeland of *Baumea juncea, B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale* is a favoured habitat of this species and is expected to support the highest densities of Quenda in the project area.

Additionally several CS3 bird species are expected to be dependant on the wetland habitat including the White-browed Scrubwren and Splendid Fairy-wren. The conservation significant Carpet Python and *Ctenotus gemmula* may also occur within this habitat. The low lying wetland areas also contain some Proteaceae species which may also be suitable foraging habitat for the Short-billed Cockatoo.

Many additional fauna species (particularly invertebrates) may be restricted to this fauna habitat. As a result of the restricted range of the habitat, fauna dependant on the habitat may have very localised distributions.

Three of the largest wetland areas also support breeding populations *H. eyrei* (see Figure 6). These three wetlands comprised a closed sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*. The species was only recorded from the larger wetlands (and therefore largest areas of sedgeland) in the deepest swales with the densest sedgeland. These wetlands are likely to be better suited to the frog's ecology which requires seasonal inundation of burrows for breeding (WAM, 2011). Other wetlands areas such as those containing *Melaleuca* or *Lepidosperma* appeared either too small in size or too dry (too high in the landscape) to support frogs.

The Sedgelands in Holocene Dune Swales are listed as Endangered under the EPBC Act and are a significant fauna habitat. Disturbances to this habitat should be avoided. DEC policy recommends a minimum buffer of 50m around wetlands (RPS, 2006). Since several conservation significant fauna species occur in the wetland habitats (eg. Quenda, Bush Rat, Splendid Fairy-wren, White-browed Scrubwren) impacts to such fauna will be reduced if the wetland areas are retained.

Figure 6. Mapped Wetlands within the Project Area (circled green, source: RPS, 2006). Wetlands where the Quenda (Q) or *Heleioporus eyrei* (H) were recorded are noted.

5.2 Significant species

Forty-seven conservation significant species may occur within the proposed Port Kennedy Business Park Project Area. Eight Conservation Significant Fauna species were recorded and include:

1. Forest Red-tailed Black Cockatoo (CS1 – flying overhead, unlikely to depend on habitats within project area)
2. Quenda or Southern Brown Bandicoot (CS2 – DEC Priority listed)
3. Brown Goshawk (CS3 – DEP declining species)
4. Common Bronzewing (CS3 – DEP declining species)
5. Splendid Fairy-wren (CS3 – DEP declining species)
6. Inland Thornbill (CS3 – DEP declining species)
7. Western Thornbill (CS3 – DEP declining species)
8. White-browed Scrubwren (CS3 – DEP declining species)
9. White-cheeked Honeyeater (CS3 – DEP declining species)

An additional 28 species are considered likely to occur within the proposed Port Kennedy Business Park or utilise a home range that includes the Project Area. These include eight reptile, 18 bird and two mammal species as listed below. Species marked with an asterisk (*) have been recorded from adjacent remnant vegetation. The reptiles may all be resident species while several of the bird species would be expected as occasional visitors. Some CS3 species such as the White-breasted Robin and Bush Rat are likely to occur as a resident population.

<u>Reptiles</u>

1. *Carpet Python (*Morelia imbricata*, CS1, potential resident)
2. *Perth Lined Lerista (*Lerista lineata*, CS2, likely resident)
3. Black-striped Snake (*Neelaps calonotus*, CS2, likely resident)
4. Jewelled Ctenotus (*Ctenotus gemmula*, CS2, likely resident)
5. *Black-headed Tree Goanna (*Varanus tristis*, CS3, likely resident)
6. *Gould's Sand Goanna (*Varanus gouldii*, CS3, likely resident)
7. Rosenberg's Goanna (*Varanus rosenbergi*, CS3, likely resident)
8. Keeled Legless-lizard (*Pletholax gracilis*, CS3, likely resident)

<u>Birds</u>

1. *Carnaby's Cockatoo (*Calyptorhynchus latirostris*, CS1, likely visitor)
2. *Peregrine Falcon (*Falco peregrinus*, CS1, likely visitor)
3. *Rainbow Bee-eater (*Merops ornatus*, CS1, likely visitor)
4. Fork-tailed Swift (*Apus pacificus*, CS1: rare aerial visitor)
5. *Scarlet Robin (*Petroica multicolour*, CS3, likely visitor)
6. Golden Whistler (*Pachycephala pectoralis*, CS3, likely resident)
7. Grey Shrike-thrush (*Colluricincla harmonica*, CS3, likely resident)

8. Square-tailed Kite (*Lophoictinia isura*, CS3, occasional visitor)
9. Whistling Kite (*Haliastur sphenurus*, CS3, occasional visitor)
10. Collared Sparrowhawk (*Accipiter cirrhocephalus*, CC3, likely visitor)
11. Wedge-tailed Eagle (*Aquila audax*, CS3, occasional visitor)
12. Little Eagle (*Hieraaetus morphnoides*, CS3, occasional visitor)
13. *Brown Falcon (*Falco berigora*, CS3, occasional visitor)
14. Painted Button-quail (*Turnix varia*, CS3, occasional visitor)
15. Western Wattlebird (*Anthochaera lunulata*, CS3, likely visitor)
16. New Holland Honeyeater (*Phylidonyris novaehollandiae*, CS3, likely resident)
17. Tawny-crowned Honeyeater (*Phylidonyris melanops*, CS3, likely visitor)
18. Black-faced Woodswallow (*Artamus cinereus*, CS3, likely visitor)
19. Additionally conservation significant waterbird species may occur in adjacent habitats or during seasonal flooding of the site.

Mammals

1. Bush Rat (*Rattus fuscipes*, CS3, likely resident)
2. Brush Wallaby (*Macropus irma*, CS2, occasional visitor)

The majority of the CS3 species listed above are described as declining and surviving in small and fragmented populations on the Swan Coastal Plain (DEP, 2000).

The DEC Priority listed Quenda occurs within the project area. This species was recorded from wetland habitat (see Figure 6). The CS1 Carnaby's Black-Cockatoo may occasionally forage within wetland habitat and proteaceous heaths. This species is able to utilise even small remnants on the Swan Coastal Plain.

Several of the above conservation significant fauna occur in the wetland habitats (eg. Quenda, Bush Rat, Splendid Fairy-wren, White-browed Scrubwren). As a result, impacts to such fauna will be reduced if the wetland areas are retained.

Many of the conservation significant bird species likely to occur in the area occupy large home ranges, with the project area forming a small component of the overall foraging range of several species (such as the Peregrine Falcon, Carnaby's Cockatoo, Rainbow Bee-eater). Impacts to such species associated with the proposal are considered to be minimal.

Impacts are likely to be greater to those species residing within the project area. Such species include the Quenda, Bush Rat, possibly the Carpet Python, DEC Priority listed Perth Lined Lerista and Jewelled Ctenotus, Varanid species, Keeled Legless-lizard, Brush Wallaby and several resident CS3 bird species (Fairy-wrens, Thornbills, Honeyeaters and White-browed Scrubwren). The exact disturbance footprint is not known however should be minimised to minimise the disturbance on such species.

5.2.1 EPBC Species

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) the Short-billed Black Cockatoo (Carnaby's Black-Cockatoo) is listed as Endangered, the Forest Red-tailed Black-Cockatoo is listed as Vulnerable and the Rainbow Bee-eater is listed as Migratory. A number of EPBC Act Policy Statements have been released by the Federal Government including "Policy Statement 1.1: Significant Impact Guidelines" The purpose of this Policy Statement is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the Australian Government under the EPBC Act. The guidelines contain "Significant Impact Criteria" for each matter of national environmental significance.

The Forest Red-tailed Black-Cockatoo was recorded flying overhead during the site inspection. Due to a lack of suitable habitat this species is not expected to depend on habitats found within the project area. The Carnaby's Black-Cockatoo may be a rare visitor to the site as small areas of foraging habitat occur, mostly on the fringes of the wetlands. However there are no areas of breeding habitat (tree hollows in Eucalypts) for either Cockatoo species present within the project area. If the wetland areas are retained the impacts on the Carnaby's Black-Cockatoo is expected to be reduced.

TABLE 1. Frogs Recorded or Expected in the vicinity of the project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Species		Status	RLRP	PK SP	DEC	Port Kennedy BP
HYLIDAE (Tree frogs)						
Litoria adelaidensis	Slender Tree Frog		X		X	
Litoria moorei	Motorbike Frog		X		X	
MYOBATRACHIDAE (Ground frogs)						
Heleioporus eyrei	Moaning Frog		X		X	X
Heleioporus psammophilus	Sand Frog		X			
Limnodynastes dorsalis	Banjo Frog		X		X	
Crinia glauerti	Glauert's Froglet		X		X	
Crinia insignifera	Squelching Froglet		X		X	
Myobatrachus gouldii	Turtle Frog					
Pseudophryne guentheri	Günther's Toadlet					
Number of Species Expected: 9						
Number of Species Recorded: 1			**7**	**0**	**6**	**1**

TABLE 2. Reptiles Recorded or Expected in the vicinity of the project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Species		Status	RL RP	PK SP	DEC	Port Kennedy BP
Chelidae (freshwater tortoises)						
Long-necked Tortoise	*Chelodina oblonga*				**X**	
Gekkonidae (geckoes)						
Marbled Gecko	*Christinus marmoratus*		**X**		**X**	
White-spotted Ground Gecko	*Diplodactylus alboguttatus*					
Spiny-tailed Gecko	*Strophurus spinigerus*		**X**			
Pygopodidae (legless lizards)						
Sandplain Worm Lizard	*Aprasia repens*				**X**	
Fraser's Legless Lizard	*Delma fraseri*					
Grey's Legless Lizard	*Delma greyii*					
Burton's Legless Lizard	*Lialis burtonis*		**X**		**X**	
Keeled Legless-lizard	*Pletholax gracilis*	**CS3**				
Common Scaleyfoot	*Pygopus lepidopodus*					
Agamidae (dragon lizards)						
Sandhill Dragon	*Ctenophorus adelaidensis*			**X**		
Western Bearded Dragon	*Pogona minor*		**X**			
Varanidae (monitors or goannas)						
Gould's Sand Goanna	*Varanus gouldii*	**CS3**	**X**		**X**	
Rosenberg's Goanna	*Varanus rosenbergi*	**CS3**				
Black-headed Tree Goanna	*Varanus tristis*	**CS3**	**X**			
Scincidae (skink lizards)						
South-West Cool Skink	*Acritoscincus trilineatum*		**X**			
Fence Skink	*Cryptoblepharus buchananii*		**X**			
Western Ctenotus	*Ctenotus australis*				**X**	
West coast Ctenotus	*Ctenotus fallens*					
Jewelled Ctenotus	*Ctenotus gemmula*	**CS2**				
South-west Odd-striped Ctenotus	*Ctenotus impar*					
Western Slender Blue-tongue	*Cyclodomorphus celatus*					
King's Skink	*Egernia kingii*		**X**		**X**	
Western Swamp Egernia	*Lissolepis luctuosa*	**CS3**				
Salmon-bellied Skink	*Egernia napoleonis*					
Two-toed Earless Skink	*Hemiergis quadrilineata*		**X**		**X**	**X**
West Coast Four-toed Lerista	*Lerista elegans*				**X**	
Perth Lined Lerista	*Lerista lineata*	**CS2**	**X**	**X**	**X**	

Species	Status	RL RP	PK SP	DEC	Port Kennedy BP
Western Worm Lizard *Lerista praepedita*		X			
Dwarf Skink *Menetia greyii*		X		X	
Western pale-flecked Morethia *Morethia lineoocellata*		X			
Southern pale-flecked Morethia *Morethia obscura*		X			
Western Blue-tongue *Tiliqua occipitalis*					
Bobtail *Tiliqua rugosa*		X		X	
Typhlopidae (blind snakes)					
Southern Blind Snake *Ramphotyphlops australis*		X		X	
Beaked Blind Snake *Ramphotyphlops waitii*	**CS3**				
Boidae (pythons)					
South-West Carpet Python *Morelia spilota imbricata*	**CS1**	X	X	X	
Elapidae (front-fanged snakes)					
Narrow Banded Snake *Brachyurophis fasciolata*					
Southern Half-girdled Snake *Brachyurophis semifasciatus*		X		X	
Yellow-faced Whipsnake *Demansia psammophis*				X	
Bardick *Echiopsis curta*					
Crowned Snake *Elapognathus coronatus*				X	
Black-naped Snake *Neelaps bimaculatus*					X
Black-striped Snake *Neelaps calonotos*	**CS2**	X		X	
Tiger Snake *Notechis scutatus*		X		X	
Dugite *Pseudonaja affinis*		X		X	X
Gould's Snake *Parasuta(Rhinoplocephalus) gouldii*				X	
Jan's Bandy-Bandy *Simoselaps(Vermicella) bertholdi*				X	X
Total Number of species expected: 48		**22**	**3**	**22**	**4**

TABLE 3. Birds Recorded or Expected in the vicinity of the Project area.
Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer), BA (Birds Australia database - project area plus 10km buffer, denoted by B). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park). Species for which no suitable habitat is present are excluded.

Species		Status	DEC / BA	RLRP	PK SP	Port Kennedy BP
Phasianidae (pheasants and quails)						
Brown Quail	*Coturnix ypsilophora*		B			
Stubble Quail	*Coturnix pectoralis*		B			
Anatidae (ducks, geese and swans)						
Australian Shelduck	*Tadorna tadornoides* [w]		X			
Pacific Black Duck	*Anas superciliosus* [w]		X	X		
Grey Teal	*Anas gibberifrons* [w]		X	X		
Ardeidae (herons and egrets)						
White-faced Heron	*Egretta novaehollandiae* [w]		X	X		
Little Egret	*Egretta garzetta* [w]		B			
White-necked Heron	*Ardea pacifica* [w]		B			
Eastern Great Egret	*Egretta alba* [w]	CS1	X	X		
Cattle Egret	*Ardea ibis* [w]	CS1	B			
Nankeen Night Heron	*Nycticorax caledonicus* [w]	CS3	B			
Little Bittern	*Ixobrychus minutus* [w]	CS2	B	X		
Black Bittern	*Ixobrychus flavicollis* [w]	CS3				
Australasian Bittern	*Botaurus poiciloptilus* [w]	CS1		X		
Plataleidae (ibis and spoonbills)						
Glossy Ibis	*Plegadis falcinellus* [w]	CS1	B			
Australian White Ibis	*Threskiornis molucca*		B	X		
Straw-necked Ibis	*Threskiornis spinicollis*		B			
Accipitridae (kites, hawks and eagles)						
Black-shouldered Kite	*Elanus notatus*		B			
Square-tailed Kite	*Lophoictinia isura*	CS3	B			
Whistling Kite	*Haliastur sphenurus*	CS3	X			
Swamp Harrier	*Circus approximans*		X	X		
Spotted Harrier	*Circus assimilis*		B		X	
Brown Goshawk	*Accipiter fasciatus*	CS3	X			**X**
Collared Sparrowhawk	*Accipiter cirrhocephalus*	CS3	B			
Wedge-tailed Eagle	*Aquila audax*	CS3	X			
Little Eagle	*Hieraaetus morphnoides*	CS3	X			
Falconidae (falcons)						
Peregrine Falcon	*Falco peregrinus*	CS1	B	X		
Australian Hobby	*Falco longipennis*		B		X	

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Brown Falcon	*Falco berigora*	CS3	B			
Nankeen Kestrel	*Falco cenchroides*		X		X	
Turnicidae (button-quails)						
Painted Button-quail	*Turnix varia*	CS3				
Rallidae (crakes and rails)						
Buff-banded Rail	*Rallus philippensis* [w]		B			
Baillon's Crake	*Porzana pusilla* [w]		B			
Spotless Crake	*Porzana tabuensis* [w]		B			
Australian Crake	*Porzana fluminea* [w]		B			
Dusky Moorhen	*Gallinula tenebrosa* [w]	CS3				
Purple Swamphen	*Porphyrio porphyrio* [w]		B			
Eurasian Coot	*Fulica atra* [w]			X		
Charadriidae (lapwings and plovers)						
Banded Lapwing	*Vanellus tricolor*		X			
Laridae (Skuas, gulls, terns and allies)						
Silver Gull	*Larus novaehollandiae* [w]		X			**X**
Columbidae (pigeons and doves)						
Rock Dove	*Columba livia*	INT	B			**X**
Laughing Turtle-Dove	*Streptopelia senegalensis*	INT	B		X	**X**
Spotted Turtle-Dove	*Streptopelia chinensis*	INT	B			
Common Bronzewing	*Phaps chalcoptera*	CS3	X			**X**
Brush Bronzewing	*Phaps elegans*	CS3	B			
Crested Pigeon	*Ocyphaps lophotes*		B			
Cacatuidae (cockatoos)						
Forest Red-tailed Black-Cockatoo	*Calyptorhynchus banksia naso*	CS1	B			**X**
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	CS1	B	X		
Baudin's Black-Cockatoo	*Calyptorhynchus baudinii*	CS1	B			
Galah	*Cacatua roseicapilla*		X			
Little Corella	*Cacatua sanguinea*		B			**X**
Long-billed Corella	*Cacatua tenuirostris*	INT	B			
Psittacidae (lorikeets and parrots)						
Rainbow Lorikeet	*Trichoglossus haematodus*	INT	B			
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*		B			
Regent Parrot	*Polytelis anthopeplus*		B			
Red-capped Parrot	*Purpureicephalus spurius*		X		X	
Australian Ringneck	*Barnardius zonarius*		X			
Elegant Parrot	*Neophema elegans*		B			
Cuculidae (cuckoos)						
Pallid Cuckoo	*Cuculus pallidus*		B			
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*		X			**X**
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		B			
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		X			

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Strigidae (hawk-owls)						
Barking Owl	*Ninox connivens*	CS2				
Southern Boobook Owl	*Ninox novaeseelandiae*		B			
Tytonidae (barn owls)						
Masked Owl	*Tyto novaehollandiae*	CS2	B			
Barn Owl	*Tyto alba*		B			
Podargidae (frogmouths)						
Tawny Frogmouth	*Podargus strigoides*		B			
Caprimulgidae (nightjars)						
Spotted Nightjar	*Eurostopodus argus*		B			
Aegothelidae (owlet-nightjars)						
Australian Owlet-nightjar	*Aegotheles cristatus*		B			
Apodidae (swifts)						
Fork-tailed Swift	*Apus pacificus*	CS1	B			
Halcyonidae (forest kingfishers)						
Laughing Kookaburra	*Dacelo novaeguineae*	INT	X			
Sacred Kingfisher	*Todiramphus sanctus*		B			
Meropidae (bee-eaters)						
Rainbow Bee-eater	*Merops ornatus*	CS1	X			
Maluridae (fairy-wrens)						
Southern Emu-wren	*Stipiturus malachurus*	CS3	B			
Splendid Fairy-wren	*Malurus splendens*	CS3	X		X	**X**
Pardalotidae (pardalotes)						
Spotted Pardalote	*Pardalotus punctatus*		X			
Striated Pardalote	*Pardalotus striatus*		X			
White-browed Scrubwren	*Sericornis frontalis*	CS3	X		X	**X**
Western Gerygone	*Gerygone fusca*		X			**X**
Weebill	*Smicrornis brevirostris*	CS3	X			
Inland Thornbill	*Acanthiza apicalis*	CS3	X		X	**X**
Western Thornbill	*Acanthiza inornata*	CS3	B			**X**
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	CS3	B			
Meliphagidae (honeyeaters)						
Red Wattlebird	*Anthochaera carunculata*		X			
Western Wattlebird	*Anthochaera lunulata*		B			
Yellow-throated Miner	*Manorina flavigula*	CS3	B			
Singing Honeyeater	*Lichenostomus virescens*		X			**X**
Brown Honeyeater	*Lichmera indistincta*		X			**X**
New Holland Honeyeater	*Phylidonyris novaehollandiae*	CS3	B			
White-cheeked Honeyeater	*Phylidonyris nigra*	CS3	B			**X**
Tawny-crowned Honeyeater	*Phylidonyris melanops*	CS3	B			
Western Spinebill	*Acanthorhynchus superciliosus*		B			
White-fronted Chat	*Epthianura albifrons*		B			

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Petroicidae (Australian robins)						
Red-capped Robin	*Petroica goodenovii*		B			
Hooded Robin	*Melanodryas cucullata*	CS3	B			
Scarlet Robin	*Petroica multicolor*	CS3	X			
Western Yellow Robin	*Eopsaltria griseogularis*	CS3	B			
Neosittidae (sittellas)						
Varied Sittella	*Daphoenositta chrysoptera*	CS3	B			
Pachycephalidae (whistlers)						
Golden Whistler	*Pachycephala pectoralis*	CS3	X		X	
Rufous Whistler	*Pachycephala rufiventris*		X			
Grey Shrike-thrush	*Colluricincla harmonica*	CS3	X		X	
Dicruridae (flycatchers)						
Magpie-lark	*Grallina cyanoleuca*		X			**X**
Grey Fantail	*Rhipidura fuliginosa*		X		X	**X**
Willie Wagtail	*Rhipidura leucophrys*		B			**X**
Restless Flycatcher	*Myiagra inquieta*	CS3	B			
Campephagidae (cuckoo-shrikes)						
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X			
White-winged Triller	*Lalage sueurii*		B			
Artamidae (woodswallows)						
Black-faced Woodswallow	*Artamus cinereus*	CS3	B			
Dusky Woodswallow	*Artamus cyanopterus*	CS3	B			
Grey Butcherbird	*Cracticus torquatus*		X		X	**X**
Australian Magpie	*Gymnorhina tibicen*		X			**X**
Corvidae (ravens and crows)						
Grey Currawong	*Strepera versicolor*	CS3	B			
Australian Raven	*Corvus coronoides*		X		X	**X**
Motacillidae (pipits and true wagtails)						
Australasian (Richard's Pipit	*Anthus novaeseelandiae*		X			
Hirundinidae (swallows)						
White-backed Swallow	*Cheramoeca leucosternus*		B			
Welcome Swallow	*Hirundo neoxena*		X		X	**X**
Tree Martin	*Hirundo nigricans*		X		X	**X**
Dicaeidae (flower-peckers)						
Mistletoebird	*Dicaeum hirundinaceum*		B			
Sylviidae (old world warblers)						
Clamorous Reed-Warbler	*Acrocephalus stentoreus* [w]		B	X		
Little Grassbird	*Megalurus gramineus* [w]		X			
Rufous Songlark	*Cincloramphus mathewsi*		B			
Brown Songlark	*Cincloramphus cruralis*		B			
Zosteropidae (white-eyes)						
Silvereye	*Zosterops lateralis*		X		X	**X**
Total: (Number of Species Expected: 122)		56	136	14	15	**25**

TABLE 4. Mammals Recorded or Expected in the vicinity of the Project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Several mammals identified in the desktop review have been left on the expected list but are considered unlikely to reside in the project area (eg. Grey-bellied Dunnart, Western Pygmy-Possum, Rakali and Ash-grey Mouse). Locally extinct species are not listed. These are: Numbat *Myrmecobius fasciatus*, Quokka *Setonix brachyurus,* Brush-tailed Phascogale *Phascogale tapoatafa* and Chuditch *Dasyurus geoffroii*.

Species	Status	DEC	RL RP	PK SP	Port Kennedy BP
Tachyglossidae (echidnas)					
Echidna *Tachyglossus aculeatus*			X		
Dasyuridae					
Chuditch *Dasyurus geoffroii*	CS1	X			
Grey-bellied Dunnart *Sminthopsis griseoventer*	CS3		X		
Peramelidae (bandicoots)					
Quenda or Brown Bandicoot *Isoodon obesulus*	CS2	X	X	X	**X**
Phalangeridae (brushtail possums)					
Brush-tailed Possum *Trichosurus vulpecula*	CS3	X			
Tarsipedidae (honey possum)					
Honey Possum *Tarsipes rostratus*	CS3				
Burramyidae					
Western Pygmy-Possum *Cercartetus concinnus*	CS3				
Macropodidae (kangaroos and wallabies)					
Western Grey Kangaroo *Macropus fuliginosus*			X		**X**
Brush or Black-gloved Wallaby *Macropus irma*	CS2		X		
Mollosidae (mastiff bats)					
White-striped Bat *Tadarida australis*					
Western Freetail Bat *Mormopterus planiceps*	CS3				
Vespertilionidae (vesper bats)					
Southern Forest Bat *Vespadelus regulus*					
Gould's Wattled Bat *Chalinolobus gouldii*		X			
Chocolate Wattled Bat *Chalinolobus morio*					
Lesser Long-eared Bat *Nyctophilus geoffroyi*					
Greater Long-eared Bat *Nyctophilus timoriensis*					
Western False Pipistrelle *Falsistrellus mackenziei*	CS2				

Species	Status	DEC	RL RP	PK SP	Port Kennedy BP
Muridae (rats and mice)					
Water-rat, Rakali *Hydromys chrysogaster*	CS2				
Noodji or Ashy-grey Mouse *Pseudomys albocinereus*	CS3				
Moodit or Bush-Rat *Rattus fuscipes*	CS3		X		
INTRODUCED MAMMALS					
House Mouse *Mus musculus*		X			
Black Rat *Rattus rattus*		X			
Rabbit *Oryctolagus cuniculus*		X			
European Red Fox *Vulpes vulpes*					
Feral Cat *Felis catus*		X			**X**
Dog *Canis lupus*					**X**
Number of native mammal species expected:	20	4	6	1	**2**
Number of introduced mammal species expected:	6	4	-	-	**2**

TABLE 5. **Conservation status of significant fauna species expected to occur in the Port Kennedy area. See Appendix 1 for explanation of status codes. Species previously recorded in the project area are highlighted.**

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
CONSERVATION SIGNIFIANCE 1 (CS1)						
Morelia spilota imbricata	Carpet Python		Schedule 4 (Specially protected).	Priority 4.		**Yes**
Ardea alba	Great Egret	Migratory.	Schedule 3 (JAMBA).			No
Ardea ibis	Cattle Egret	Migratory.	Schedule 3 (JAMBA).			No
Plegadis falcinellus	Glossy Ibis	Migratory.				No
Falco peregrinus	Peregrine Falcon		Schedule 4 (Specially protected).			**Yes - visitor**
MIGRATORY WATERBIRDS		Migratory.	Schedule 3 (JAMBA).			No
Calyptorhynchus banksii naso			Schedule 1 (Vulnerable).			**RECORDED**
Calyptorhynchus latirostris	Carnaby's Cockatoo	Endangered.	Schedule 1 (Endangered).			**Yes**
Calyptorhynchus baudinii	Baudin's Cockatoo	Vulnerable.	Schedule 1 (Endangered).			**No**
Apus pacificus	Fork-tailed Swift	Migratory.				**Yes -Vagrant**
Merops ornatus	Rainbow Bee-eater	Migratory.				**Yes**
Dasyurus geoffroii	Chuditch	Vulnerable.	Schedule 1 (Vulnerable).			No
Synemon gratiosa	Graceful Sun-Moth		Schedule 1			Yes
Leioproctus bilobatus	Native Bee		Schedule 1			No
Leioproctus douglasiellus	Native Bee		Schedule 1			No
CONSERVATION SIGNIFIANCE 2 (CS2)						
Lerista lineata	Perth Lined Lerista			Priority 3.		**Yes**
Neelaps calonotos	Black-striped Snake			Priority 3.		**Yes**
Ctenotus gemmula	Jewelled Ctenotus			Priority 3.		**Yes**
Ixobrychus minutus	Little Bittern			Priority 4.		No
Thinornis rubricollis	Hooded Plover			Priority 4.		No
Tyto novaehollandiae novaehollandiae	Masked Owl			Priority 3.		No
Ninox connivens connivens	Southern Barking Owl			Priority 4.		**No**
Isoodon obesulus fusciventer	Quenda			Priority 5.		**RECORDED**
Macropus irma	Brush Wallaby			Priority 4.		**Yes**
Falsistrellus mackenziei	Western False Pipistrelle			Priority 4.		**No**
Hydromys chrysogaster	Water-Rat			Priority 4		**No**
Austrosaga spinifer	A Cricket			Priority 3		Unknown

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
Hyaleus globuliferus	A Native Bee			Priority 3		Unknown
Leioproctus contrarius	A Native Bee			Priority 3		Unknown
Throscodectes xiphos	A Cricket			Priority 1		Unknown
CONSERVATION SIGNIFIANCE 3 (CS3)						
Pletholax gracilis	Keeled Legless-lizard				Range edge	Yes
Varanus tristis	Black-headed Tree Goanna				Local Decline	Yes
Varanus gouldii	Gould's Sand Goanna				Local Decline	Yes
Varanus rosenbergi	Rosenberg's Goanna				Local Decline	Yes
Lissolepis luctuosa	Western Swamp Egernia				Local Decline	No
Ramphotyphlops waitii	Beaked Blind Snake				Range Edge	No
Lophoictinia isura	Square-tailed Kite				Local decline	Visitor
Haliastur sphenurus	Whistling Kite				Local decline	Visitor
Accipiter fasciatus	Brown Goshawk				Local decline	**RECORDED**
Accipiter cirrhocephalus	Collared Sparrowhawk				Local decline	Yes
Aquila audax	Wedge-tailed Eagle				Local decline	Yes
Hieraaetus morphnoides	Little Eagle				Local decline	Yes
Falco berigora	Brown Falcon				Local decline	Yes
Turnix varia	Painted Button-quail				Local decline	Yes
Phaps chalcoptera	Common Bronzewing				Local decline	**RECORDED**
Phaps elegans	Brush Bronzewing				Local decline	No
Platycercus icterotis	Western Rosella				Local decline	Vagrant
Neophema petrophila	Rock Parrot				Local decline	No
Malurus splendens	Splendid Fairy-wren				Local decline	**RECORDED**
Stipiturus malachurus	Southern Emu-wren				Local decline	No
Sericornis frontalis	White-browed Scrubwren				Local decline	**RECORDED**
Smicrornis brevirostris	Weebill				Local decline	No
Acanthiza apicalis	Inland Thornbill				Local decline	**RECORDED**
Acanthiza inornata	Western Thornbill				Local decline	**RECORDED**
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				Local decline	Yes
Anthochaera lunulata	Western Wattlebird				Local decline	Yes

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
Melithreptus lunatus	White-naped Honeyeater				Local decline	No
Phylidonyris novaehollandiae	New Holland H'eater				Local decline	Yes
Phylidonyris nigra	White-cheeked Honeyeater				Local decline	**RECORDED**
Phylidonyris melanops	Tawny-crowned Honeyeater				Local decline	Yes
Petroica multicolor	Scarlet Robin				Local decline	No
Eopsaltria georgiana	White-breasted Robin				Local decline	Yes
Daphoenositta chrysoptera	Varied Sittella				Local decline	Yes
Pachycephala pectoralis	Golden Whistler				Local decline	Yes
Colluricincla harmonica	Grey Shrike-thrush				Local decline	Yes
Myiagra inquieta	Restless Flycatcher				Local decline	No
Artamus cinereus	Black-faced Woodswallow				Local decline	Yes
Artamus cyanopterus	Dusky Woodswallow				Local decline	No
Strepera versicolor	Grey Currawong				Local decline	No
Cercartetus concinnus	Western Pygmy-possum				Local decline	No
Tarsipes rostratus	Honey Possum				Local decline	No
Rattus fuscipes	Western Bush Rat				Local decline	Yes
Pseudomys albocinereus	Ashy-grey Mouse				Local decline	No
Sminthopsis griseoventer	Grey-bellied Dunnart				Local decline	Potential Resident

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Appendix 1. ***Categories used in the assessment of conservation status***

IUCN categories (based on review by Mace and Stuart 1994) **as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act**.

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act.

Schedule 1. Rare and Likely to become Extinct.
Schedule 2. Extinct.
Schedule 3. Migratory species listed under international treaties.
Schedule 4. Other Specially Protected Fauna.

WA Department of Conservation and Land Management Priority species
(species not listed under the Conservation Act, but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

APPENDIX 9

CONCEPT PLAN

Concept Plan

Lot 4 & Lot 17, Port Kennedy Drive

Date: 07 December 2020 Scale: NTS @A1 Drawing No. **717-278** Staff: LR Checked: MR

0 20 40m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

D. Landscape Masterplan

TEC RATING:

- HIGH QUALITY
- MEDIUM QUALITY
- LOW QUALITY

LEGEND

01 ENTRY STATEMENT TO ESTATE WITH SIGNAGE WALL

02 EXISTING PEDESTRIAN ACCESS WAY

03 ENTRY TO BUSHLAND TRACK NETWORK INCLUDING EDUCATIONAL SIGNAGE AND ARTWORK/ INTERPRETATIVE ELEMENT (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

04 RETAINED VEGETATION IN EXISTING CONSERVATION AREA CEDED TO DBCA

05 OPEN MESH FENCE TO CONSERVATION AREA FOR VISUAL PERMEABILITY

06 *GRAVEL PATHWAYS ALONG EXISTING BUSH TRACKS

07 SEATING ON DECKING AT LOOKOUT POINTS WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19A- HOLOCENE SEDGELANDS (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

08 SCREENING NATIVE TREE AND SHRUB PLANTING ALONG BOUNDARY FENCE TO RESIDENCES

09 NEW *GRAVEL PATHWAY CONNECTION

10 VEGETATED SWALE WITH ENDEMIC WETLAND PLANTING AND MELALEUCA TREES WITH REFERENCE TO ADJACENT BUSHLAND SPECIES

11 PEDESTRIAN FOOTPATH NETWORK

12 STORMWATER MANAGEMENT INFRASTRUCTURE (INFILTRATION OR BIORETENTION) IN ROADSIDE TO BE PROVIDED AS PER THE INDICATIVE LOCATIONS SHOWN ON THE CONCEPT DRAINAGE PLAN (BY OTHERS)

13 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS

14 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)- SIGNAGE ENDORSED BY DBCA DESIGN STUDIO

15 *GRAVEL PATHWAYS TO TEC 19B- (HOLOCENE WOODLANDS) WITH REVEGETATION INCLUDING TREE PLANTING THROUGHOUT

16 ARTWORK/ INTERPRETIVE ELEMENT TO STREET CORNER AND DECKING OVER DRAINAGE BASIN

17 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS

18 VEGETATED DRAINAGE SWALE ALONG MEDIAN STRIP TO PORT KENNEDY DRIVE

19 VEGETATED DRAINAGE SWALE ALONG PORT KENNEDY DRIVE WITH BUFFER TREE AND SHRUB PLANTING. RETAIN EXISTING 3M WIDE BIKE PATH.

20 RETAIN EXISTING VERGE TREATMENT/ SWALES TO SOUTH SIDE OF PORT KENNEDY DRIVE

21 STREETSIDE PARKING ADJACENT TO CONSERVATION AREA INTERSPERSED WITH VERGE PLANTINGS - TOTAL 8 NO. PARKING BAYS

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

CONCEPT MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.101 REV N

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

STREET TREE PLANTING

EUCALYPTUS LEUCOXYLON 'ROSEA'

EUCALYPTUS UTILIS

MELALEUCA RHAPHIOPHYLLA

AGONIS FLEXUOSA

EUCALYPTUS TORQUATA

EUCALYPTUS VICTRIX

EUCALYPTUS GOMPHOCEPHALA

ENTERPRISE PARK, PORT KENNEDY

STREET TREE MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.102

REV F

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

LEGEND

01 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS -NON-IRRIGATED

02 PROTECT AND RETAIN EXISTING REMMANT VEGETATION CORE TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)

03 REVEGETATION AREA WITHIN 50M BUFFER ZONE, RETAINING REMNANT VEGETATION AND WITH NEW LOCALLY NATIVE TREE & SHRUB PLANTINGS. TEMPORARY IRRIGATION TO NEW PLANTINGS AND WEED MANAGEMENT THROUGHOUT

04 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO LOCAL ECOLOGY/ BOTANY OF THE AREA (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

05 INFORMAL *GRAVEL PATHWAYS THROUGH REGETATION AREA FOR BUSH WALKING

06 STREET TREES & LOW NATIVE GROUNDCOVER PLANTINGS TO VERGE- NON-IRRIGATED

09 ARTWORK/ INTERPRETIVE SHADE ELEMENT TO STREET CORNER WITH INFORMAL SEATING AND/OR TABLES WITH DECKING OVER DRAINAGE BASIN

10 SHORT BOARDWALK ELEMENT OVER DRAINAGE BASIN

11 SMALL LOOKOUT OVER DRAINAGE BASIN

12 CONCRETE FOOTPATHS

13 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS- NON-IRRIGATED

14 LANDSCAPE BATTER & ROCKWORK TO MEET EXISTING LEVELS

15 STORMWATER MANAGEMENT INFRASTRUCTURE THAT INCLUDES SUITABLE ENDEMIC VEGETATION

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

PRELIMINARY CONCEPT PLAN - POS 01
JULY 2024

JOB NO. 2011201
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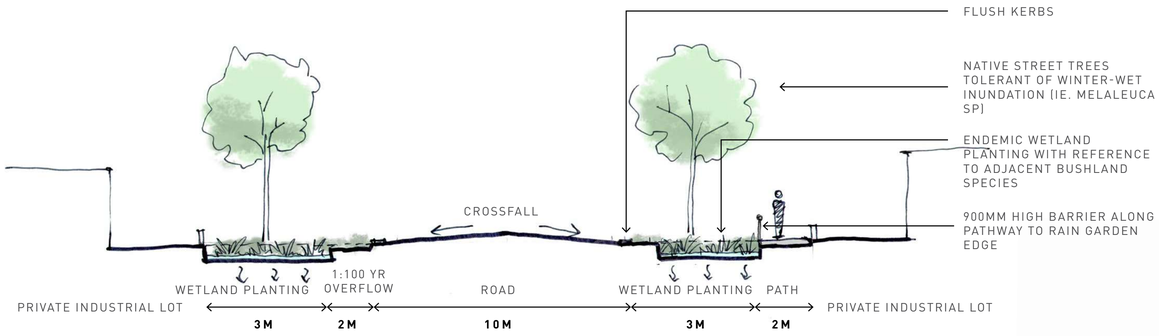
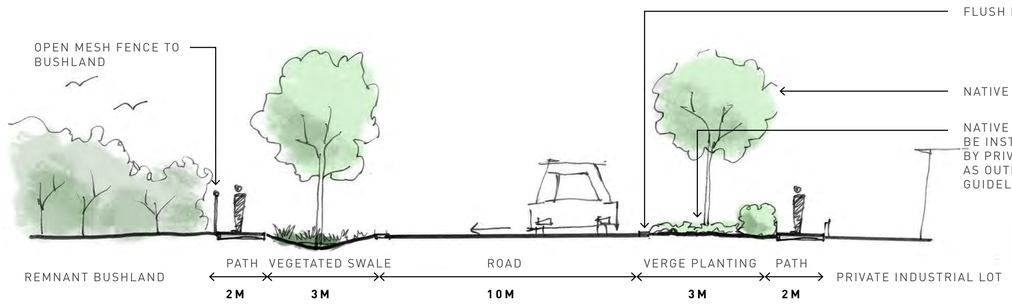
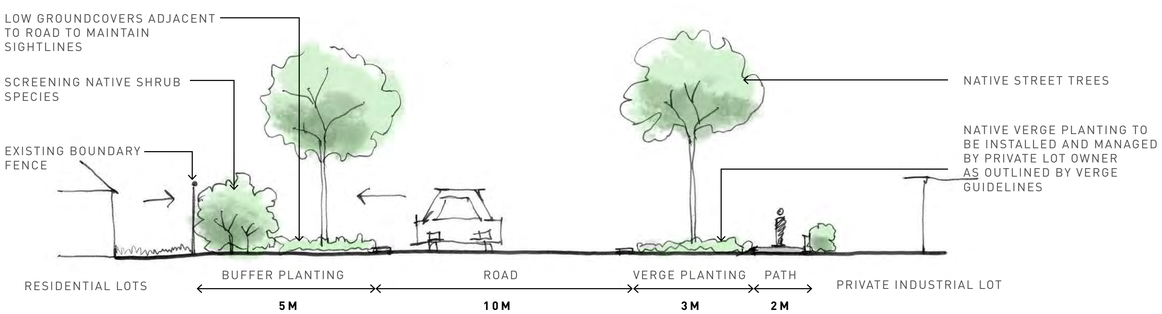


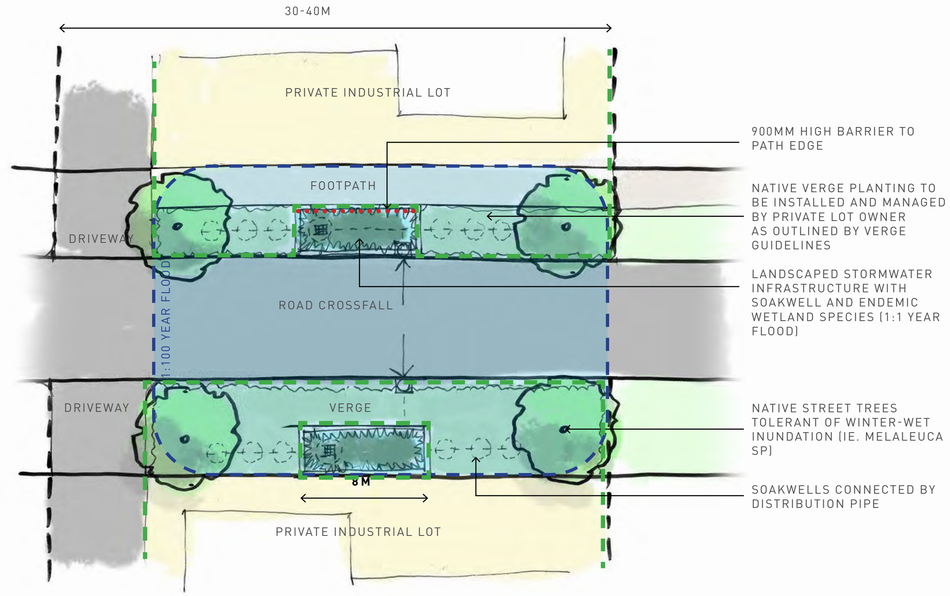
TYPICAL STREET SECTION- RAIN GARDENS



TYPICAL STREET SECTION- CONSERVATION AREA BOUNDARY



TYPICAL STREET SECTION - BUFFER TO RESIDENTIAL LOTS



TYPICAL STREET PLAN - STORMWATER INFRASTRUCTURE

ENTERPRISE PARK, PORT KENNEDY

TYPICAL SECTIONS
JULY 2024

JOB NO. 2011201
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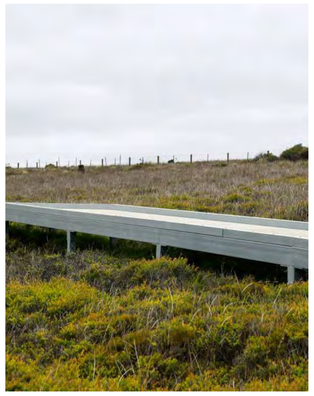
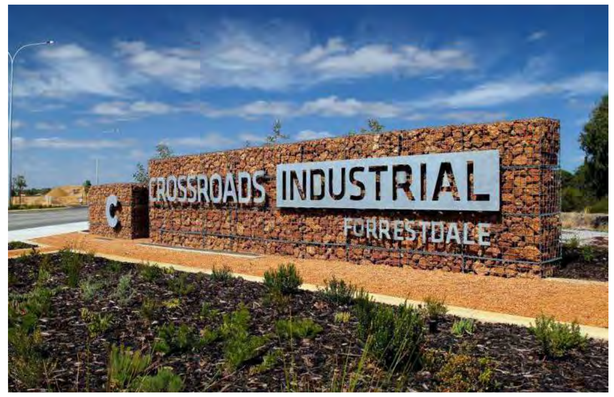
FRP LOW IMPACT AND DURABLE BOARDWALK

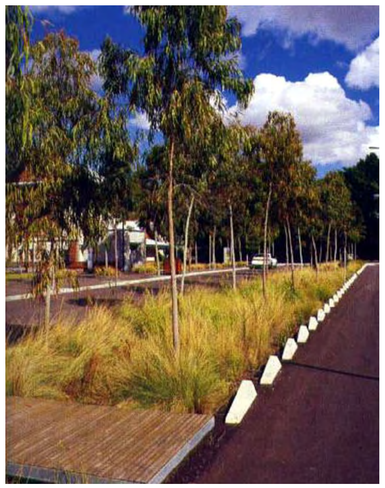
PERMASTRUCT COMPOSITE BOARDWALK



EXISTING REMNANT VEGETATION



TURF AND SHADE TREES IN AMENITY SPACE



RAIN GARDENS

VEGETATED SWALES AND FLUSH KERBING

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CONCEPT IMAGERY
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STREET TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


EUCALYPTUS UTILIS


MELALEUCA RHAPHIOPHYLLA


EUCALYPTUS TORQUATA


EUCALYPTUS VICTRIX


EUCALYPTUS LEUCOXYLON 'ROSEA'

POS/ REVEGETATION TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


MELALEUCA RHAPHIOPHYLLA


MELALEUCA LANCEOLATA


CALLITRIS PRESEII


BANKSIA LITTORALIS


BANKSIA ATTENUATA

FEATURE PLANTING


XANTHORRHOEA PREISEII


ANIGOZANTHOS MANGLESEII


LEUCOPHYTA BROWNII


SCAEVOLA 'MAUVE CARPET'


KENNEDIA PROSTRATA


CONOSTYLIS CANDICANS


PIMELEA FERRUGINEA

STREET VERGES


HEMIANDRA PUNGENS


EREMOPHILA GLABRA PROSTRATE


SCAEVOLA CRASSIFOLIA PROSTRATE


DIANELLA 'LITTLE JESS'


WESTRINGIA 'MUNDI'


GREVILLEA CRITHMIFOLIA PROSTRATE


MELALEUCA 'LITTLE PENTA'

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

JOB NO. 2011201 C3.102 REV C

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DRAINAGE SWALES/ RAINGARDENS


MACHAERINA JUNCEA


MACHAERINA ARTICULATA


FICINIA NODOSA


LEPIDOSPERMA LONGITUDINALE


CENTELLA ASIATICA


LOBELIA ANCEPS


ISOLEPIS CERNUA

POS/ REVEGETATION PLANTING


FICINIA NODOSA


OLEARIA AXILLARIS


GREVILLEA CRITHMIFOLIA


GUICHENOLTIA LEDIFOLIA


HARDENBERGIA COMPTONIANA


HAKEA PROSTRATA


MELALEUCA TERETIFOLIA


MELALEUCA SYSTENA


KENNEDIA PROSTRATA


MYOPORUM INSULARE


RHAGODIA BACCATA


ACACIA PULCHELLA


*ACACIA BENTHAMII


*JACKSONIA SERICEA

*RARE/PRIORITY FLORA

LARGE SHRUBS/ SCREEN PLANTING


CALOTHAMNUS QUADRIFIDUS


BANKSIA SESSILIS


ACACIA ROSTELLIFERA


DODONAEA HACKETTIANA


TEMPLETONIA RETUSA


MELALEUCA HUEGELLII


MELALEUCA SYSTENA

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

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E. Traffic Assessment

Porter
Consulting Engineers

TRAFFIC IMPACT ASSESSMENT

Port Kennedy Enterprise Park

Porter

REPORT PREPARED FOR

Development WA

Prepared by	**Porter Consulting Engineers**
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Job number	18-06-073
Date	21 February 2024
Our reference	R70.20G
Checked	EW

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Rev C	27/04/2021	J Hopfmueller	Development WA	Third Issue
Rev D	02/02/2023	J Hopfmueller	Development WA	Major Update
Rev E	09/02/2023	J Hopfmueller	Development WA	Fifth Issue
Rev F	22/11/2023	J Hopfmueller	Development WA	Sixth Issue
Rev G	21/02/2024	J Hopfmueller	Development WA	Seventh Issue

CONTENTS

1.0 INTRODUCTION

1.1 Background

Porter Consulting Engineers has been engaged to prepare a Transport Impact Assessment (TIA) for the local structure plan of Lot 4 Mandurah Road, Port Kennedy in the City of Rockingham. The Structure Plan comprises of approximately 35.8 hectares of developable land excluding land designated to public open space. **Figure 1.1** shows an aerial view of the Site and its immediate surrounds.

Figure 1.1: Aerial View of Site

1.2 Scope of Assessment

The intent of this assessment is to provide the approving authority with sufficient traffic information to confirm that the proponent has adequately considered the traffic aspects of the development.

2.0 STRUCTURE PLAN PROPOSAL

2.1 Structure Plan Context

The subject Site is currently zoned industrial under the Metropolitan Region Scheme. The Site is subject to the provisions under the City of Rockingham Town Planning Scheme No.2 where it is zoned as *Port Kennedy Business Enterprise* and so too is the land immediately abutting the west. To the north of the Site is an established residential area. To the south and east the land is zoned *Parks and Reserves*.

The Site is bounded on the west by Bakewell Drive, on the east by Ennis Avenue and on the south by Port Kennedy Drive, in Port Kennedy.

Figure 2.1 shows the subject Site in a local zoning context.

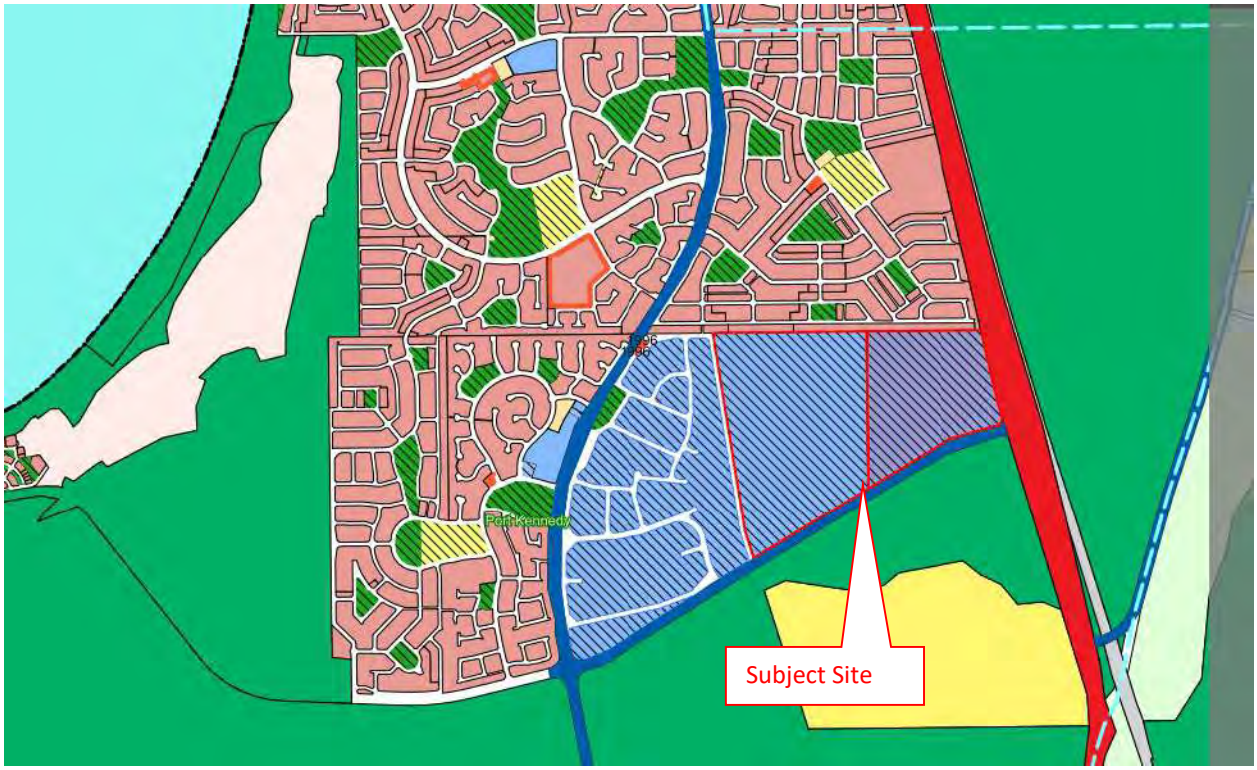


Figure 2.1: Structure Plan Lots (*City of Rockingham Intramaps*)

The Site is situated approximately 10 km to the south of the Rockingham Centre, 20 km north of Mandurah and 57 km southwest of the Perth CBD. Major regional roads within close proximity include Ennis Avenue, Port Kennedy Drive and Warnbro Sound Avenue. **Figure 2.2** shows the Site in a regional context.

A copy of the Structure Plan layout is included in **Appendix A.**

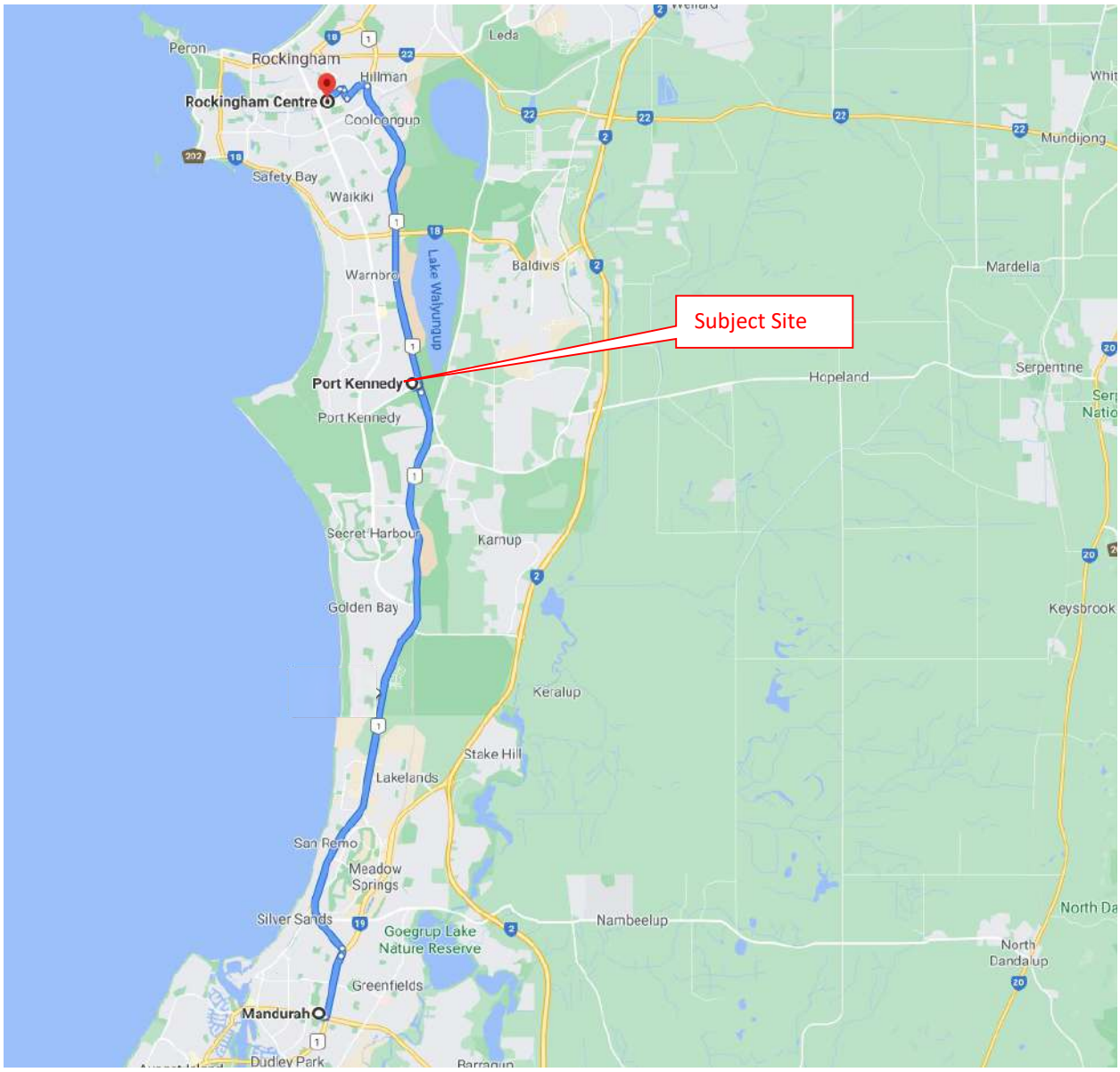


Figure 2.2: Location in a Regional Context

2.2 Proposed Land Uses

Travel demand is dependent upon the location and densities of land use development. Given that the Port Kennedy Structure Plan provides for a broad range of land uses with different trip generation it has been necessary to refine the anticipated spatial allocation of land uses to inform the traffic modelling.

For this purpose, we have drawn on a number of sources, including forecasting the land use mix based on other, similar developed business enterprise parks whilst also drawing on Development WA's understanding of the market and land use enquires. Other developments

that have been reviewed to inform the land use mix have included the Bibra Lake area east of Sudlow Road and west of North Lake Road and the land to the immediate west of the site between Bakewell Drive and Warnbro Sound Avenue.

This land use review has informed the proposed mix of land uses for the Port Kennedy Structure Plan area as being anticipated as comprising Bulky Goods / Showrooms (33%), Storage / Warehouse (28%), Light Industrial (26%), Office (10%), Recreational (such as community centre) (1%), Gymnasiums (such as an indoor gym or martial arts centre) (1%) and Consulting Rooms (such as medical or allied health consultancies) (1%).

Benchmarking the mix of land uses on these other comparable developments adds significant validity to this as a key assumption that has been used in the TIA.

In addition, a conservative Floor Space Ratio of 0.5:1 has been applied across all proposed land uses for the purposes of the traffic analysis. The 0.5 plot ratio has also been benchmarked against comparable developments in Port Kennedy and Bibra Lake and has been cross checked with the Department of Planning, Lands and Heritage (DPLH) as an appropriate density assumption.

Using a conservative (but not worst case) floor space ratio ensures that the traffic estimated in the TIA is appropriate and not over-estimated, as it is highly unlikely that all of the individual developments in an area would be developed with a higher floor space ratio given the setbacks, car parking and landscaping requirements that need to be accommodated on each site. In this regard the Western Australian Planning Commission's (WAPC) Technical Guidance on Traffic Impact Assessments states that it is important not to overestimate car generation and that no more road infrastructure is provided than will be required.

Notably, DPLH's review of the existing Port Kennedy Business Enterprise Park indicated that the plot ratio of these existing developed sites is in the order of 0.32:1. Thus the use of the 0.5:1 plot ratio for the current analysis is considered to be appropriately robust.

Based on an indicative lot layout the total developable area is approximately 35.8 hectares which corresponds to a GFA of 179,108m^2 as summarised in **Table 2.1** by land use.

Table 2.1: Land Use Profile

Land Use	% of Land Use Within Structure Plan	Site Area (ha)	Plot Ratio	GFA m2
Bulky Goods / Showroom	33%	11.82	0.5	59,106
Storage/Warehouse	28%	10.03	0.5	50,150
Light Industrial	26%	9.31	0.5	46,568
Office	10%	3.58	0.5	17,911
Recreational	1%	0.36	0.5	1,791
Gymnasium	1%	0.36	0.5	1,791
Consulting Rooms	1%	0.36	0.5	1,791
	100%	35.82		179,108

2.3 Major Attractors and Generators of Traffic

The proposed Structure Plan will attract traffic from the surrounding residential areas primarily from within the City of Rockingham. For this purpose the future population of these areas as shown in **Figure 2.3** were reviewed. **Appendix B** contains an extract of the population growth of the expanding City of Rockingham area sourced from *https://forecast.id.com.au/rockingham.*

Due to the nature of the proposed Structure Plan it is likely to also become a major employment attractor from surrounding areas. Review of current Australian Bureau of Statistics (ABS) data for the City of Rockingham indicates that 70% of the City of Rockingham workforce currently also reside in the City.
https://profile.id.com.au/rockingham/workers (Refer **Appendix B**.)

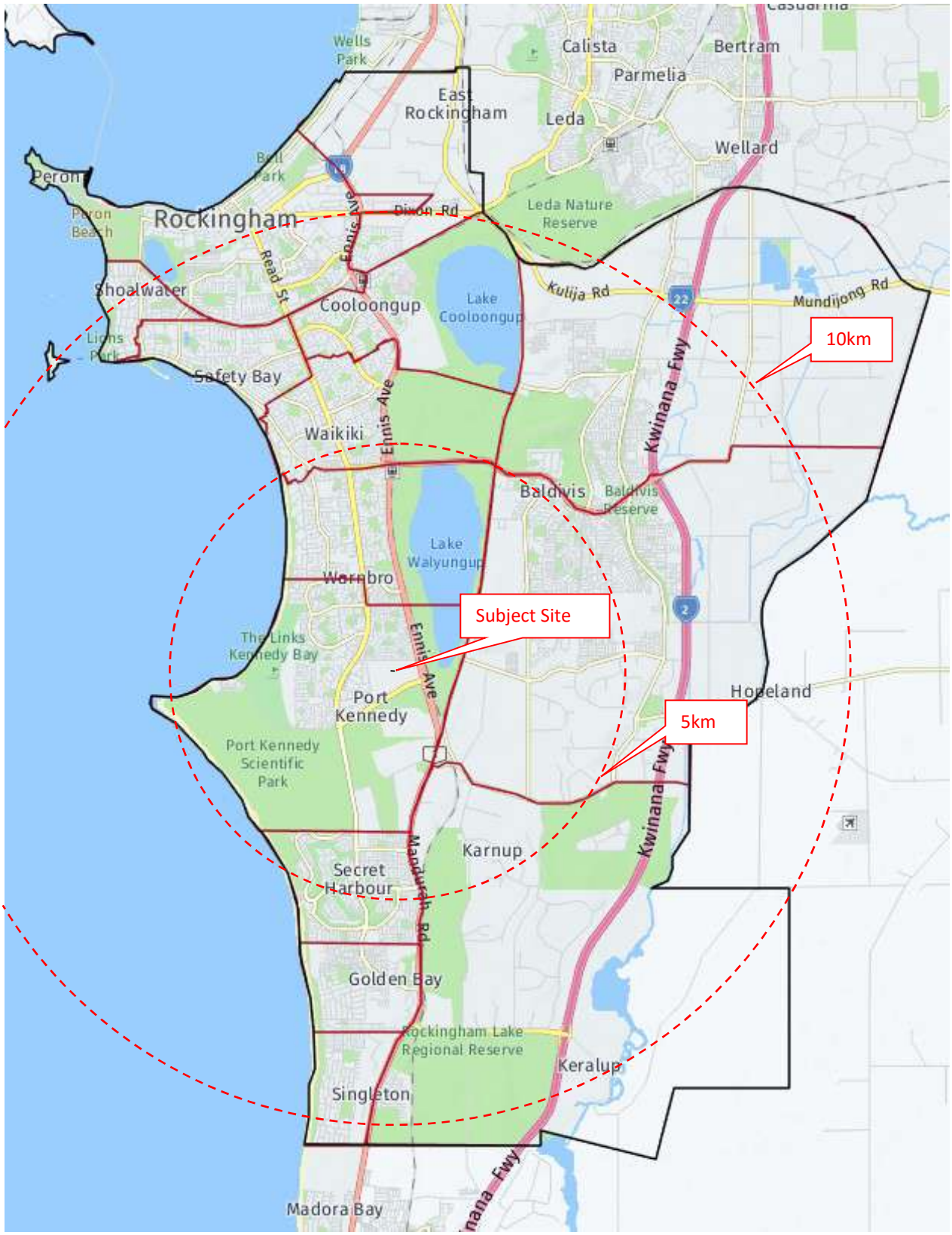


Figure 2.3: City of Rockingham Locality Map

3.0 ROAD NETWORK SITUATION

3.1 Existing Road Network

Figure 3.1 illustrates the road network within approximately 2 kilometres surrounding the Site. Key distributor roads surrounding the Site include: Port Kennedy Drive, Ennis Avenue, Warnbro Sound Avenue, Mandurah Road, Sixty Eight Road and Stakehill Road. Two of those roads also form a boundary with the Structure Plan.

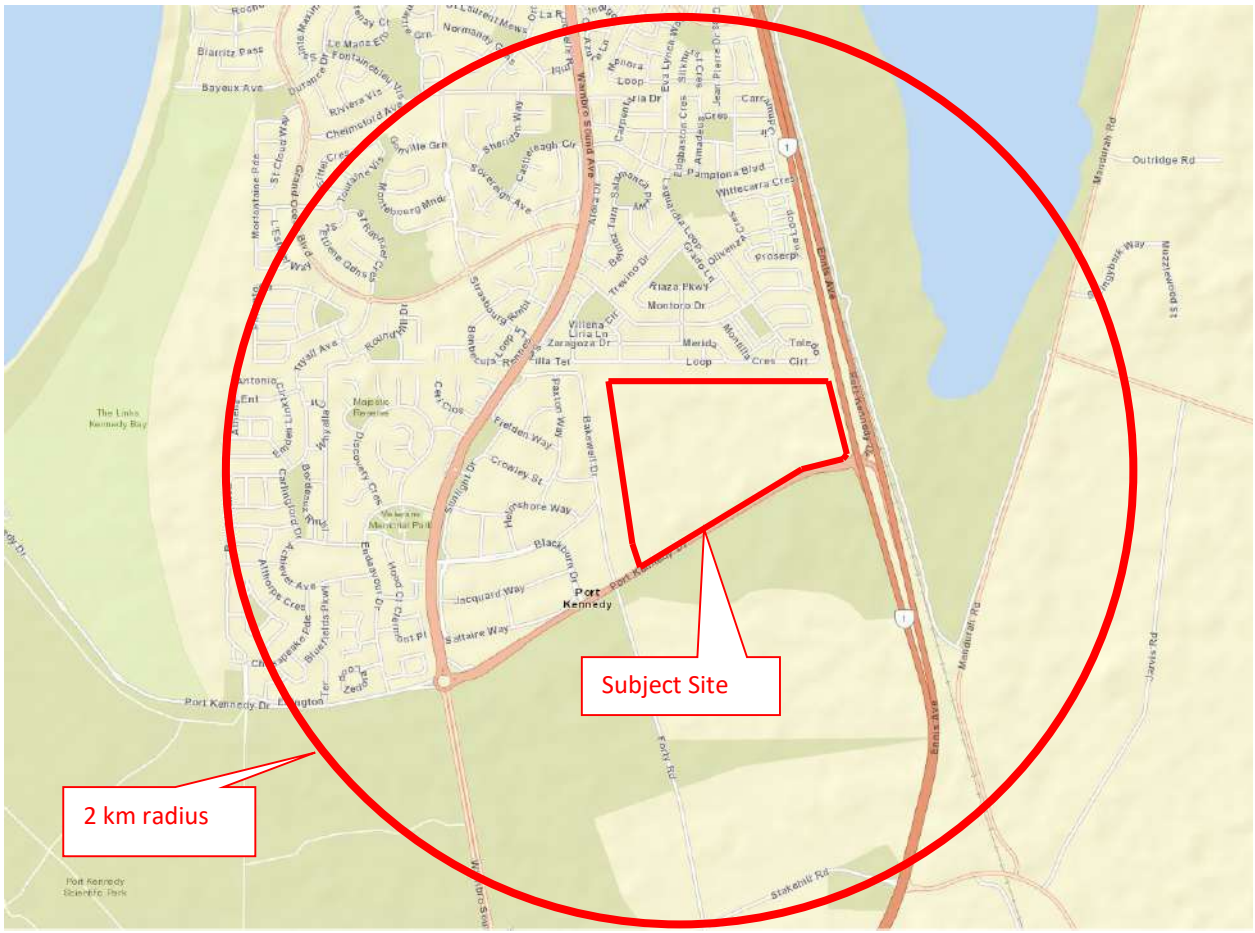


Figure 3.1: Existing Surrounding Road Network

3.2 Road Infrastructure and Road Hierarchy Classification

The road hierarchy classification of the surrounding road network as defined by Main Roads WA functional road hierarchy is shown in **Figure 3.2**.

Ennis Avenue

Ennis Avenue forms part of the Primary Distributor Road network and as such is controlled by Main Roads WA. By definition its function is to "*provide for major regional and inter-*

regional traffic movement and carry large volumes of generally fast moving traffic." This road runs in a generally north south direction and forms the eastern boundary of the Site.

Ennis Avenue is constructed to a four lane median-divided standard and includes sealed shoulders. Its intersection with Port Kennedy Drive is signalised on its northbound approach only. The existing sign posted speed limit is 100km/hr with the northbound approach to Port Kennedy Drive reduced to 80km/hr through the traffic signals.

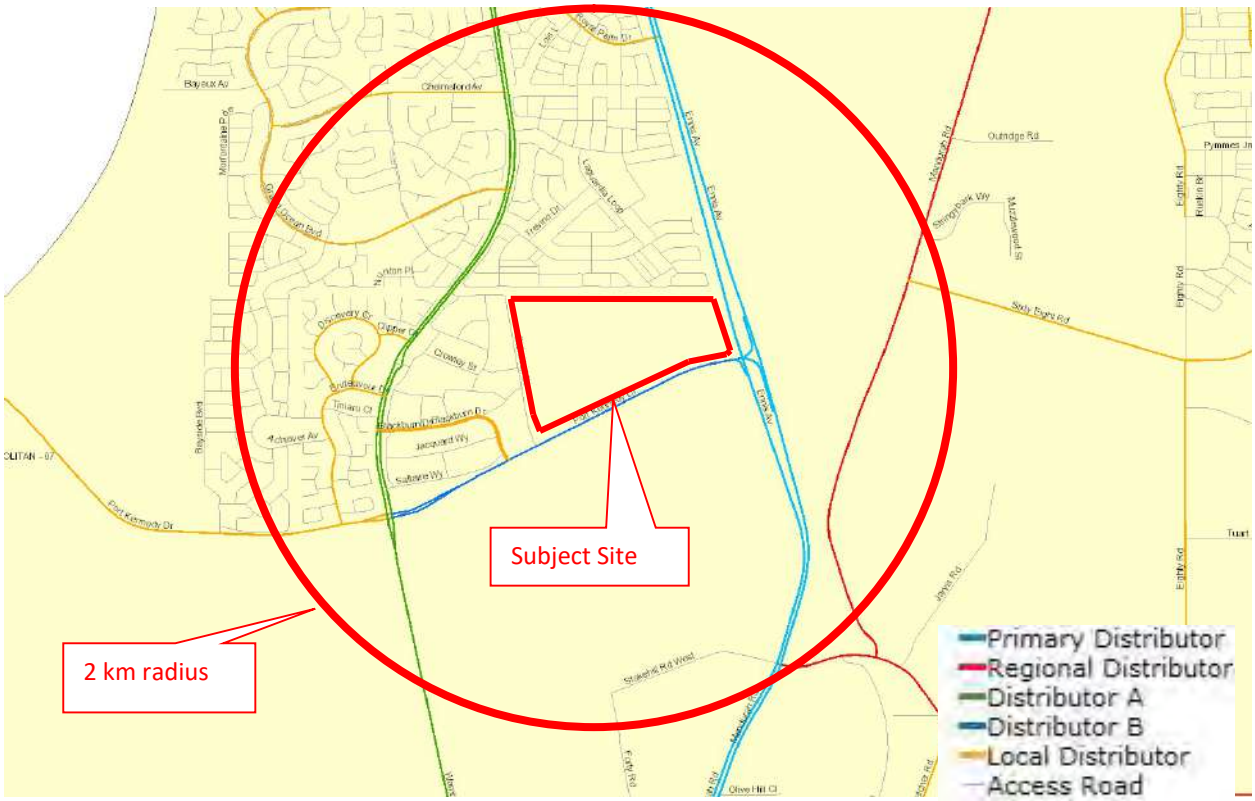


Figure 3.2 Functional Road Hierarchy (MRWA)

Port Kennedy Drive

Port Kennedy Drive is classified as a District Distributor B (DDB) road between Ennis Avenue and Warnbro Sound Avenue. To the west of Warnbro Sound Avenue its classification is reduced to a Local Distributor Road. As a DDB road its role is to "*carry traffic between industrial, commercial and residential areas and generally connect to Primary Distributors*" These roads have a slightly reduced capacity compared to District Distributor A roads typically due to commercial or residential access. This road is controlled by the City of Rockingham.

Port Kennedy Drive runs in an east west direction and forms the southern boundary of the Structure Plan. Its eastern end forms the minor road of the T-junction with Ennis Avenue. Its

intersection with Warnbro Sound Avenue is controlled by a dual lane roundabout. Port Kennedy Drive is constructed to a four lane dual carriageway standard between Ennis Avenue and Warnbro Sound Avenue. The road has a posted speed of 80km/h adjacent to the Site reducing to 60km/h west of Warnbro Sound Avenue.

Warnbro Sound Avenue
Warnbro Sound Avenue is classified as a District Distributor A road that *carries traffic between industrial, commercial and residential areas and generally connect to Primary Distributors*". This road is controlled by the City of Rockingham.

Warnbro Sound Avenue runs in a generally north south direction from Read Street, Rockingham/Warnbro for some 11 kilometres to Dampier Drive, Golden Bay. In the vicinity of the Structure Plan, it is constructed to a four lane median-divided carriageway standard. It has a posted speed limit of 70km/h with a short length of 80km/h south of Port Kennedy Drive.

3.3 Existing Traffic Volumes

Table 3.1 and **Figure 3.3** show the traffic flows recorded on the road network surrounding the Structure Plan obtained from Main Roads WA traffic map website and the City of Rockingham.

Table 3.1: Recorded Traffic Volumes on the Surrounding Road Network

Location	Date	AWT (veh/day)	Am Peak Hour	Pm Peak Hour	Heavy Vehicles (%)	85% Speed (km/h)
Port Kennedy Drive, west of Ennis Avenue SLK 1.08	2020/21	11,852 5,789(E) 6,063(W)	8-9am 932vph	4-5pm 1,130vph	7.9	66.7
Ennis Avenue, north of Mandurah Road SLK 39.09	2021/22	25,930 13,066(N) 12,864 (S)	8-9am 2,106vph	3-4pm 2,417vph	6.5	94.3
Warnbro Sound Avenue, north of Port Kennedy Drive SLK 5.44	2021/22	14,999 7,317 (N) 7,682 (S)	8-9am 1,121vph	4-5pm 1,459vph	7.9	69.5
Warnbro Sound Avenue, south of Port Kennedy Drive SLK 6.00	2017/18	13,570 6,461 (N) 7,109 (S)	8-9am 996vph	4-5pm 1,210vph	9.7	86.2

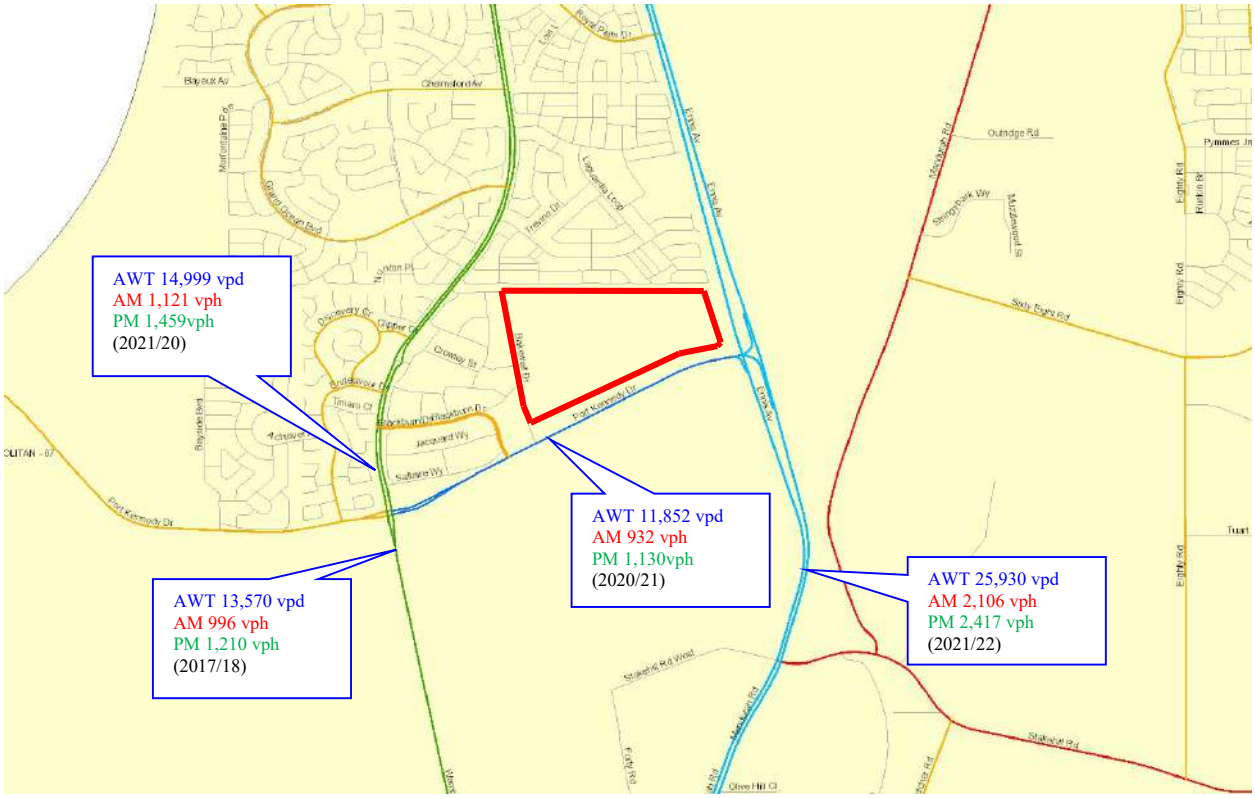


Figure 3.3. Existing Traffic Volumes on the Surrounding Road Network

Supplementary peak hour turn counts were undertaken on Wednesday, 26th October 2022 at key intersections on the adjacent road network as follows:

- Ennis Avenue and Port Kennedy Drive; and
- Port Kennedy Drive and Bakewell Drive.

Existing turn counts were available on the Main Roads WA traffic map website for the intersection of Port Kennedy Drive and Warnbro Sound Avenue. *(September 2019) https://trafficmap.mainroads.wa.gov.au/map*

3.4 Crash History

A study of the recent crash history for Port Kennedy Drive in the vicinity of the Structure Plan has been conducted for the five year period to the end of December 2021 from the Main Roads Western Australia Integrated Road Information System (IRIS) crash database. The database records the following crashes:

- 22 crashes at the intersection of Port Kennedy Drive and Ennis Avenue. 1 crash resulted in hospitalisation, 4 resulted in medical attention being required, 9 involved major property damage and 8 involved minor property damage. 19 were rear end crashes, 2 right angle crashes and 1 right turn thru crash.

- 1 mid-block crashes along Port Kennedy Drive adjacent to the Site which involved minor property damage from hitting an animal.
- 4 crashes at the intersection of Port Kennedy Drive and Bakewell Road. All crashes involved property damage. Crash types included: 1 right turn thru crash; 1 rear end and 2 side swipe crash.

These crashes are shown in **Figure 3.4** as well as the various crashes along Warnbro Sound Avenue and within the adjacent existing industrial estate.

Figure 3.4. Recent Crash History on Adjacent Road Network

3.5 RAV Network

The existing surrounding road network allows for the movements of Restricted Access Vehicles (RAV). Typically, the existing road network accommodates RAV 2, RAV 3 and RAV 4 combinations along Port Kennedy Drive to facilitate access into the existing *Port Kennedy Business Enterprise Park* as shown in **Figure 3.5.**

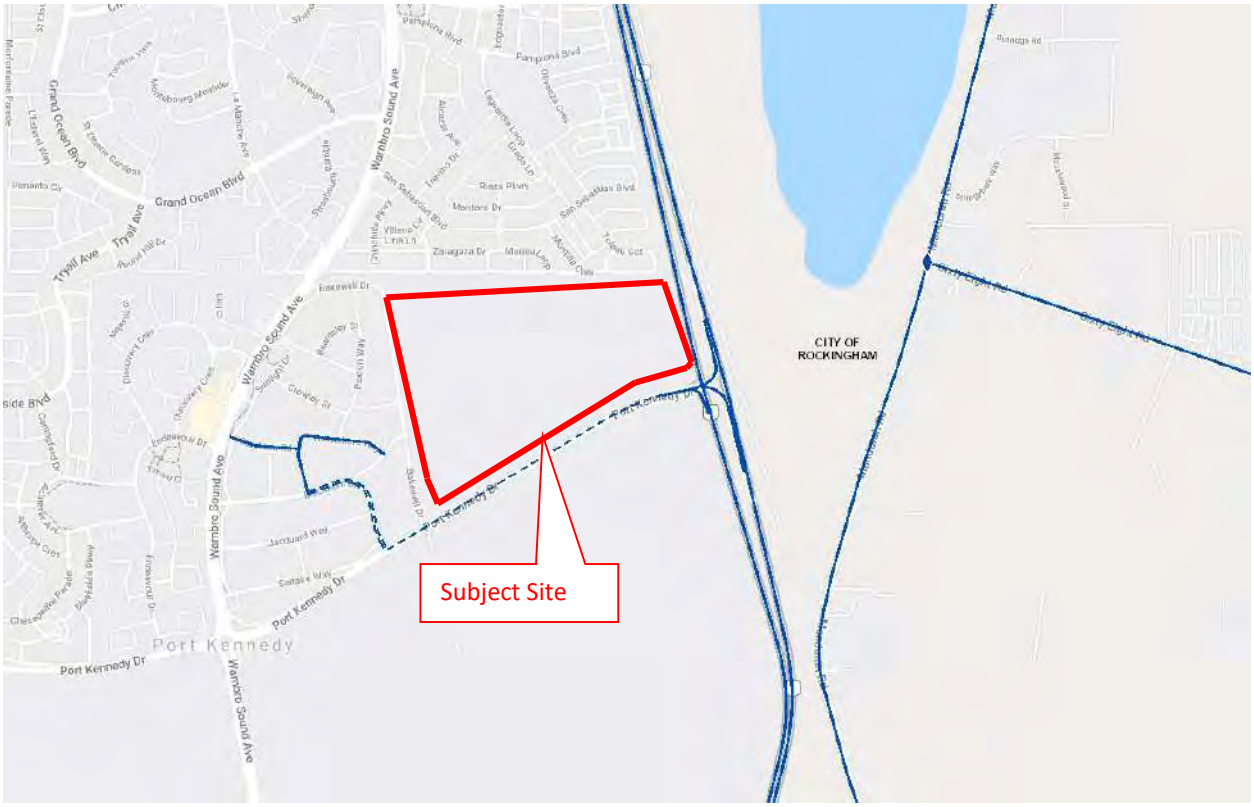


Figure 3.5. RAV Network (MRWA)

3.6 Public Transport

The Structure Plan has limited access to existing public transport services with only a portion of the Structure Plan located within 800m of the closest bus stops. The closest bus stops are located on Warnbro Sound Avenue, south of Bakewell Drive (Stop ID 17291 and 17273), located approximately 400m from the northwest corner of the Structure Plan. **Figure 3.6** shows an 800m radius (approximately 10 minute walk) around the existing bus stop**.** This would mean the majority of the Structure Plan would be in excess of 800m to a bus stop. Existing routes that use Warnbro Sound Avenue are 558, 559, 561 and 563.

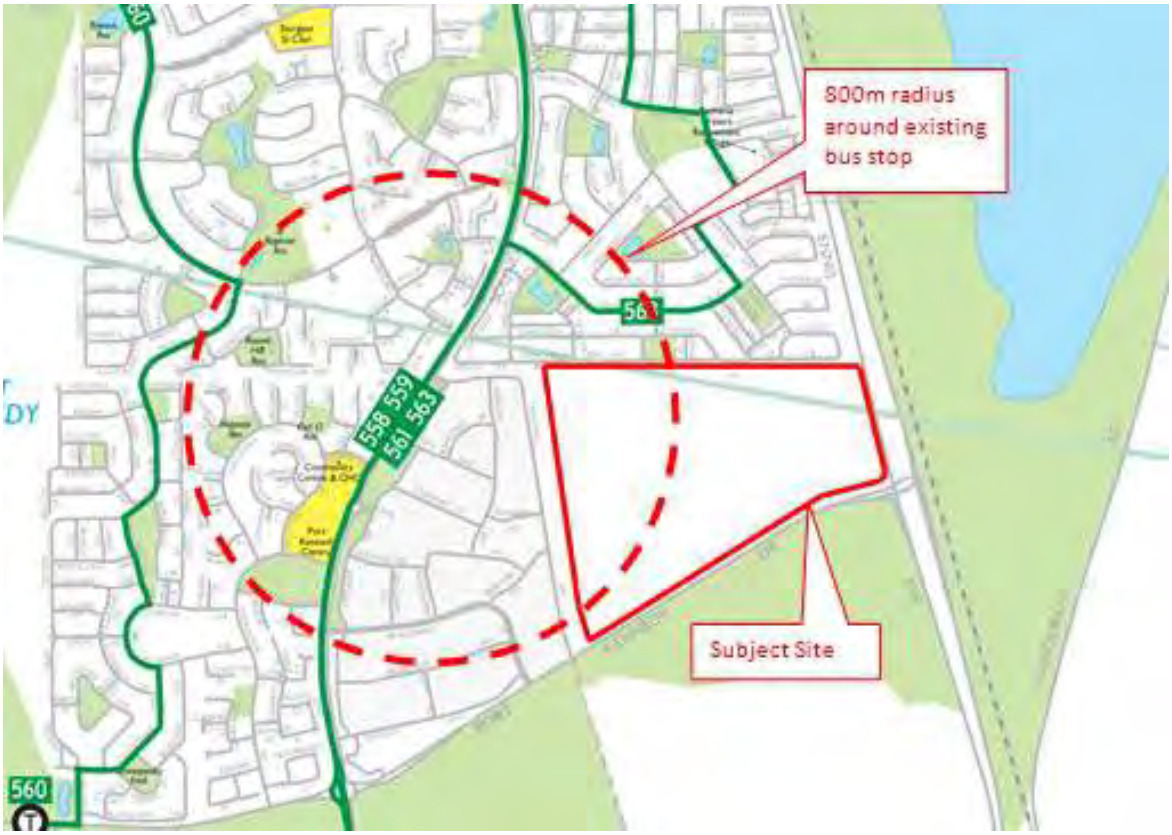


Figure 3.6: Existing Public Transport Routes Surrounding the Site (*PTA Network Maps)*

3.7 Pedestrian and Cyclist Network

Port Kennedy Drive includes a 3m asphalt path on the northern side of the road.

There are limited pedestrian and cyclist facilities in the adjoining existing *Port Kennedy Business Enterprise Park* to the west due to the nature of the development which does not always result in pedestrian desire lines between the various lots. There is however an existing path located along the western side of Bakewell Drive. **Figure 3.7** shows a 1200m radius around the subject site with respect to the existing path network.

The Long Term Cycle Network as defined by the Department of Transport details a primary cycle route along Ennis Avenue as shown in **Figure 3.8** whilst Port Kennedy Drive is nominated to be a local route and Warnbro Sound Avenue to be a secondary route.

Figure 3.7: Existing Path Network Surrounding the Site (*Perth Bike Map Series)*

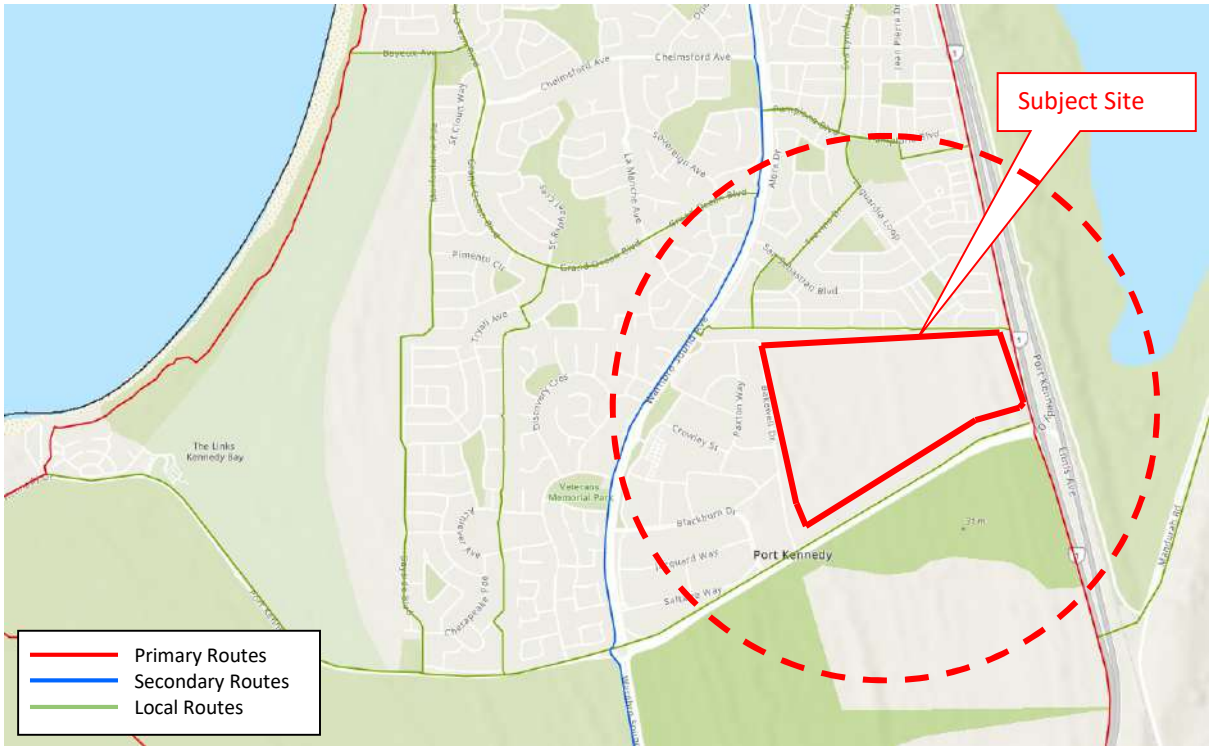


Figure 3.8: Long Term Cycle Network Surrounding the Site (*Department of Transport)*

4.0 PROPOSED INTERNAL ROAD TRANSPORT NETWORK

4.1 Connections to the Existing Road Network

The Site does not currently have any existing roads located within it. The Site primarily abuts Port Kennedy Drive to the south and Ennis Avenue to the east, existing industrial development to the west and residential properties to the north.

Port Kennedy Drive is classified as a District Distributor Road (DDB) and as such the number of connections to this road has been limited to two as requested by the DPLH. The two proposed connections have been located centrally to the Structure Plan development and are approximately evenly spaced along the developable Port Kennedy frontage.

To cater for the future Structure Plan traffic at these new intersections on Port Kennedy Drive in conjunction with through traffic growth two dual lane roundabouts are proposed. Roundabout control ensures right turn movements into and out of the development can be accommodated without excessive delays and long queue lengths within the development under the future scenario with traffic growth along Port Kennedy Drive.

The eastern connection is located approximately 270m to the west of the Ennis Avenue and Port Kennedy Drive signalised intersection. Main Roads preferred practice is that intersection proximity is typically determined on the basis of at least 5 seconds of travel time between an intersection and the start of the auxiliary lanes for the downstream intersection. In this instance there are no auxiliary lanes as it is a roundabout although depending on the detailed design there may be a requirement for pre-deflection (say 100m in length). Based on 80-90km/h, 5 seconds of travel time equates to a distance of 110-125m which can be provided prior to pre-deflection if needed i.e. 125m+100m = 225m <270m. Alternatively, from a design perspective, distance on the approach to the roundabout from the signalised intersection would need to take into account manoeuvring distances i.e. changing lanes. Based on 80-90km/h this equates to 130-146m which can be provided prior to pre-deflection if needed i.e. 146m+100m = 246m <270m which is still less than the 270m provided. Using both methods it is considered that the spacing of approximately 270m is adequate. It should be noted that the average speed of vehicles entering Port Kennedy Drive from the signals will in fact be less than the posted speed limit of 80km/hr hence these distances are considered to be robust. The same approach can be adopted for the spacing of the roundabouts which are also 270m apart. This distance is considered to be robust as again the average speed between the roundabouts would be less than 80km/h as vehicles would not exit or enter the roundabout at 80km/h. Notably, the 85th percentile speed recorded along Port Kennedy Drive, west of Ennis Avenue (SLK 1.08) is 66.7km/hr somewhat lower than 80km/h-90km/hr adopted.

Appendix C contains a concept sketch layout (subject to detailed design) for the sole purpose of demonstrating the indicative intersection spacings along Port Kennedy Drive only.

4.2 Road Hierarchy, Road Reserve Widths and Road Cross Section

The Structure Plan is to be an Industrial Development. Under Development Control Policy (DCP 4.1) a minimum road reserve of 20m is required and this will allow a typical two lane single carriageway with a 10m wide pavement.

A road reserve width of 25m is proposed on the southern section of the north-south road links to Port Kennedy Drive to allow for adequate approach lane widths and a central island boulevard treatment along these sections of road due to the anticipated road volumes. The central island boulevard treatment will provide separation of through traffic and restrict right turning movements as required to properties in close proximity to the proposed roundabouts on Port Kennedy Drive. Traffic volumes are anticipated to progressively decrease along the internal road network. **Figure 4.1** outlines the indicative road reserve widths and road hierarchy with reference to the anticipated daily traffic volumes. Typical cross sections subject to detailed design are shown in **Figures 4.2 and 4.3**. Local distributor roads have been defined where traffic volumes are typically expected to be more than 3,000 vehicles per day. The main east-west road that facilitates access to/from the two north-south connections to Port Kennedy Drive has also been defined as part of the local distributor road network due to its connectivity function albeit traffic volumes are anticipated to be lower than 3,000 vehicles per day.

It is proposed that the Structure Plan accommodate RAV 4 vehicles i.e. B-Double (27.5m) as outlined in **Figure 4.4**. RAV access will not be permitted along the west-east road on the northern boundary of the site abutting the residential properties. The proposed 10m pavement will accommodate the RAV 4 vehicles with the exception of intersections or right angle bends where the swept paths of these vehicles will require some road widenings and larger than normal truncations to suit. Detailed design as part of the subdivisional works should confirm these requirements.

There are a number of right angle bends incorporated within the Structure Plan. Bends can assist with reducing the speed limit however they can also result in drivers “cutting the corner” which can increase crash risk. Based on the low volume of traffic on the internal road network and the subsequent design speed, the bends are likely to be considered “low risk”. Good practice would be to include road widening to separate vehicle movements. To ensure that the road network is RAV 4 compliant these bends will need to be designed accordingly with the RAV 4 vehicle being the checking vehicle. Truncations (larger than typical) on the corner lots are likely to be required to provide adequate sight distance between opposing vehicles approaching the bend as well as for potential driveways located around bends.

The ultimate design as part of the sub division design will need to demonstrate that the road reserve is adequate to accommodate swept paths of the design vehicle (RAV 4) at intersections and bends.

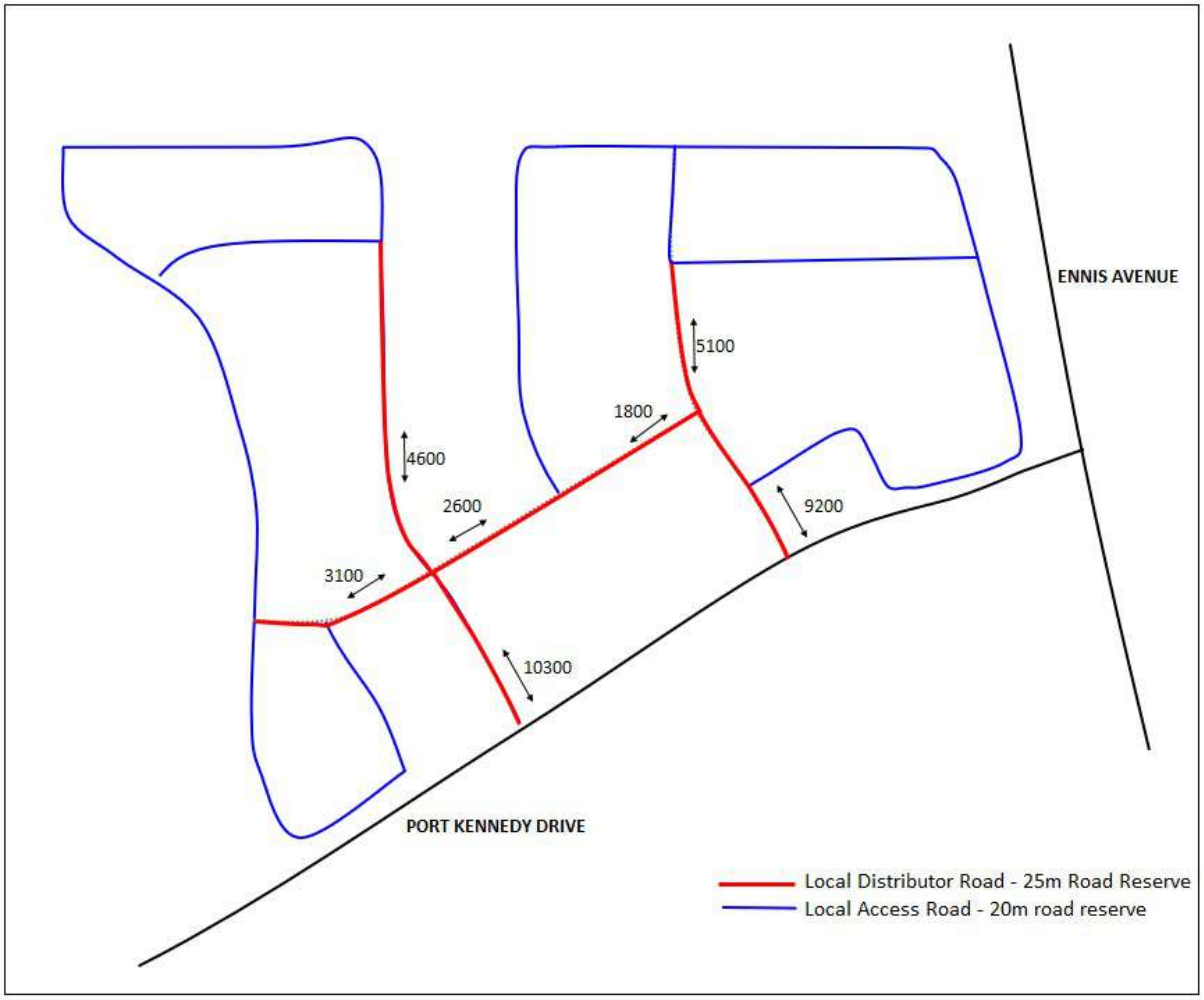


Figure 4.1: Proposed Road Hierarchy and Road Reserve Widths

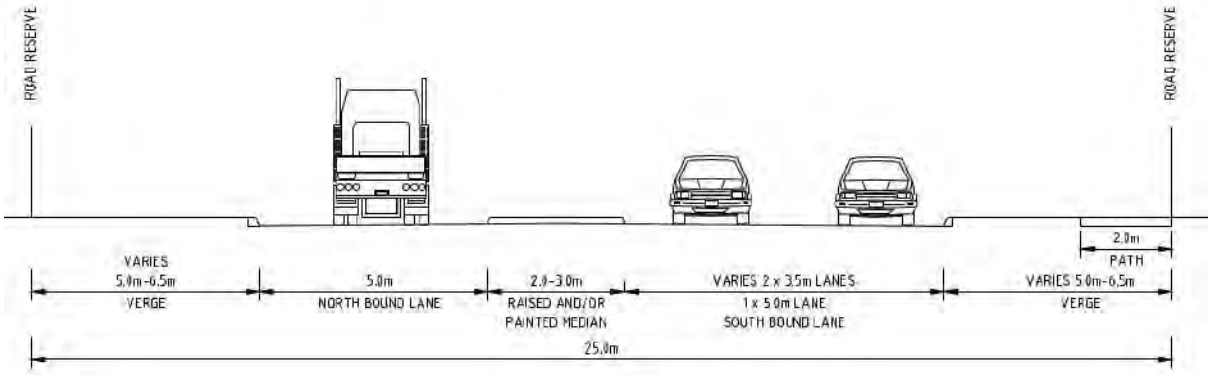


Figure 4.2: 25m Road Reserve Local Distributor Road (near Port Kennedy Drive)

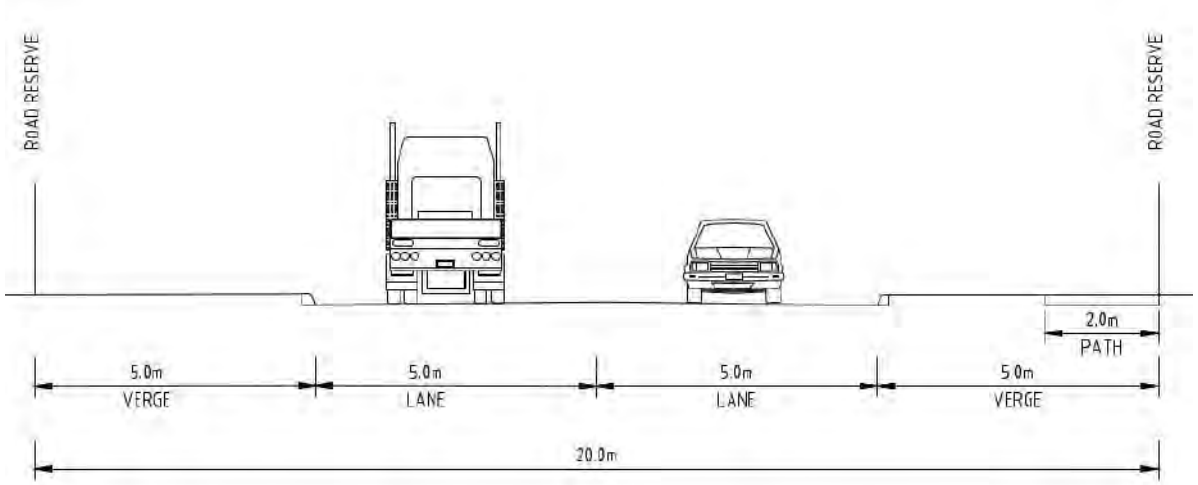


Figure 4.3: 20m Road Reserve Local Access Road

Figure 4.4: Indicative RAV Network for Structure Plan Area

4.3 Proposed Road Access Strategies

The lots proposed as part of this Structure Plan will not have any direct access onto Port Kennedy Drive. All access will be via the new internal roads. Individual access to lots developed will need to be considered at the subdivisional stage to ensure each lot can be serviced in accordance with Australian Standards and guidelines.

Traffic volumes are at their highest along the southern portion of two new connections to Port Kennedy Drive. Access to properties along these southern sections, particularly in close

proximity to the proposed Port Kennedy roundabouts should be limited to left in and left out. Alternatively, where possible access should be provided on the side roads that carry lower traffic volumes. Ideally larger lots that naturally limit the number of accesses required would be preferable along the southern sections of these two Port Kennedy Drive road connections.

Figure 4.5 shows an indicative sub-divisional layout and the potential access restrictions. The internal road network, internal 4 way roundabout and side road connections would together ensure that properties restricted to left in left out movements are still readily accessible.

Ultimately, approvals for driveway access would form part of individual development applications with consideration to standards including proximity to intersections and the specific trip generation to/from that property.

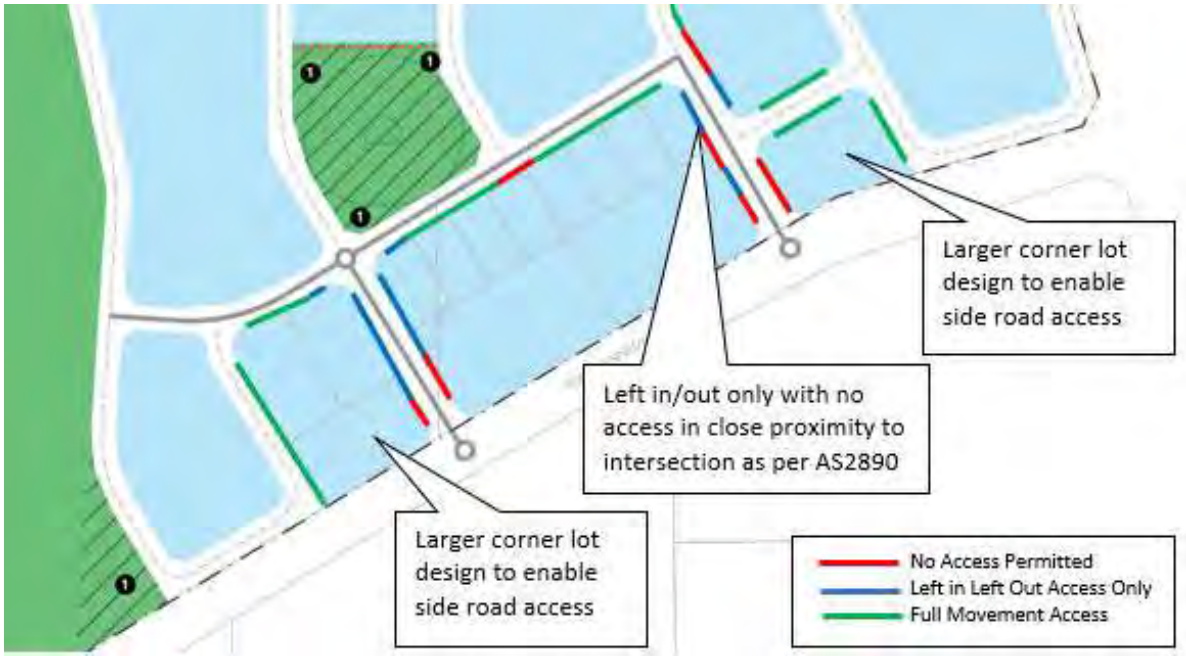


Figure 4.5: Indicative Access Restrictions for Structure Plan

4.4 Intersection Control

Intersection spacing has been guided by the indicative lot sizes to be incorporated within the road network grid. Typically –t junctions are proposed throughout the internal road network that will operate under standard give way control.

One four way intersection is included in the internal road network which is proposed to be controlled by a roundabout. This roundabout will need to be designed for RAV 4 vehicles. Detailed design of the subdivisional layout will need to confirm access requirements to the individual lots located in close proximity to the roundabout and the associated median islands as such lots may be restricted to left in and left out vehicle movements subject to detailed design.

4.5 Pedestrian and Cycle Networks

At this stage there are no clear pedestrian desire lines within the Structure Plan. Historically, industrial estates do not always include footpaths as evident by the adjoining estate immediately to the west. The 20m road reserve proposed is adequate to accommodate a path network should the proposed land uses create a demand for pedestrian and cyclist facilities.

4.6 Public Transport Routes

No public transport routes are proposed within the Structure Plan. Liaison with the PTA indicates that there are no plans to provide a new service within the Structure Plan. Since the road network will be designed to cater for trucks it could readily accommodate bus routes if they were to be introduced in the future should the demand warrant services feasible.

5.0 ANALYSIS OF INTERNAL TRANSPORT NETWORK

5.1 Assessment Year

The Structure Plan is assumed to be fully developed by 2036 with the initial stages opening in 2026. On this basis the assessment will be undertaken for the year 2026 (at opening) as well as the longer time horizon being plus 10 years, i.e in 2036. For the purpose of the assessment both the 2026 (at opening) and 2036 scenarios are with full development however Section 6.6 outlines some staging options for 2026 without full development.

5.2 Traffic Generation

For the purpose of trip generation the Structure Plan area has been broken to various land uses types that may occur based on the City of Rockingham scheme as summarised in Section 2.2**.**

A detailed review of various trip generation rate sources was undertaken for the potential land uses identified for the purpose of the traffic assessment. Trips rates were reviewed for the peak hour of the land use, the peak hour during the adjacent road network as well as the daily trip rate. The peak hour rates adopted are those rates that correspond with the peak hour of the adjacent road network as the peak hour of the land use does not always correspond with the road network peak. Details pertaining to the various trip rates including their source are summarised in **Appendix D.**

The proposed Structure Plan is estimated to generate in the order of 19,501 vehicle trips per weekday with approximately 1,229 and 2,106 vehicle trips during the am and pm peak hours respectively as summarised in **Table 5.1.** It is likely that there would be common trips between some land uses which would result in a reduction of overall trips into and out of the development. For the purpose of a robust assessment no reduction has been made.

Table 5.1 - Estimated Trip Generation for Full Development

Land Use	GFA	Trip Generation Rates			Trip Generation		
		Daily	Am Peak	Pm Peak	Daily	Am Peak	Pm Peak
		/100m2 GFA			veh/day	veh/hr	veh/hr
Bulky Goods/Showroom	59,106	18	n/a[2)]	1.51	10,639	52	893
Storage/Warehouse	50,150	4	0.50	0.50	2,006	251	251
Light Industrial	46,568	5	1.00	1.00	2,328	466	466
Office	17,911	11	1.60	1.20	1,970	287	215
Consulting Rooms	1,791	38.6[1)]	3.00[1)]	2.40[1)]	1,106	86	69
Gymnasium	1,791	45	2.68	8.98	806	48	161
Recreational Community	1,791	36	2.21	2.95	645	40	53
	179,108				19,501	1,229	2,106

1) Rate per doctor
2) Trip rate not available as stores not typically open within the am road network peak. An allowance for some staff arrivals made.

5.3 Traffic Distribution

The proposed Structure Plan will attract traffic from the surrounding residential areas typically from within the City of Rockingham. For this purpose the future population of these areas were reviewed. **Appendix B** contains an extract of the population growth of the expanding City of Rockingham area. Additionally, the peak hour arrival and departure trips are also likely to comprise of work trips which may be attracted from outside the City of Rockingham. Current ABS data for the City of Rockingham indicates that 70% of the City of Rockingham workforce also reside in the City. (Refer **Appendix B**) Therefore, traffic distribution patterns take into account the likely workforce catchment area, the surrounding residential areas with respect to both work trips and patronage trips including the potential areas for future residential growth as well as the road network. The resulting trip distribution patterns have subsequently been estimated to be as follows:

- Warnbro Sound Avenue (north) 30%
- Warnbro South Avenue (south) 10%
- Ennis Avenue (north) 35%
- Ennis Avenue (south) 25%

Inbound and outbound splits during the peak hours were adopted for the various land uses from trip generation documents as shown in **Table 5.3** with the resulting trip distribution patterns along the arrival and departure routes summarised in **Table 5.4.**

Table 5.3 - Estimated Trip Generation Peak Hour Arrivals /Departures by Land Use

Land Use	In/out Split				Am Peak			Pm Peak		
	Am Peak		Pm Peak							
	In	Out	In	Out	In	Out	Total	In	Out	Total
Bulky Goods/Showroom	0.8	0.2	0.5	0.5	42	10	52	446	446	893
Storage/Warehouse	0.8	0.2	0.2	0.8	201	50	251	50	201	251
Light Industrial	0.8	0.2	0.2	0.8	373	93	466	93	373	466
Office	0.8	0.2	0.2	0.8	229	57	287	43	172	215
Consulting Rooms	0.8	0.2	0.2	0.8	69	17	86	14	55	69
Gymnasium	0.5	0.5	0.57	0.43	24	24	48	92	69	161
Recreational Community	0.66	0.34	0.49	0.51	26	13	40	26	27	53
					963	266	1,229	764	1,342	2,106

Table 5.4 - Estimated Peak Hour Trip Distribution Patterns

Approach /Departure Route		Daily	Am Peak			Pm Peak		
			In	Out	Total	In	Out	Total
Warnbro Sound Avenue (north)	30%	5,850	289	80	369	229	403	632
Warnbro Sound Avenue (south)	10%	1,950	96	27	123	76	134	211
Ennis Avenue (north)	35%	6,825	337	93	430	267	470	737
Ennis Avenue (south)	25%	4,875	241	66	307	191	336	527
Total	100%	19,501	963	266	1,229	764	1,342	2,106

5.4 Non- Structure Plan Traffic

Due to the proposed road layout no through traffic is expected through the Structure Plan.

5.5 Design Traffic Flows

The number of connections to Port Kennedy Drive has been limited to two as requested by DPLH given the road hierarchy classification of Port Kennedy Drive, i.e. a District Distributor Road (DDB). The internal road network and the proposed size and location of lots suggest that slightly more traffic will use the western connection (approximately 10,300 vehicles per day) compared to the eastern connection (approximately 9,200 vehicles per day). **Figure 5.1 and 5.2** show the indicative peak hour and daily traffic flows at the external connections to the Site. Internal traffic flows are expected to decrease from these maximum flows near the external connections as the local road network distributes traffic within the Structure Plan.

Two lots are located on Bakewell Drive comprising of 6,497m2. This represents approximately 1.8% of the total lot yield for the Structure Plan. On this basis these lots are estimated to generate in the order of 354 daily trips, 22 am peak hour trips and 38 pm peak hour trips. These additional trips are estimated to be distributed onto the Warnbro Sound Avenue/Bakewell Drive intersection (40% i.e. 9/15 am/pm peak hour trips) and Port Kennedy Drive/Bakewell Drive intersection (60% i.e. 13/23 am/pm peak hour trips). It is noted that these additional volumes are less than those that would require further detailed traffic assessment and it is therefore anticipated that these volumes will have minimal impact on the existing operating conditions of these intersections.

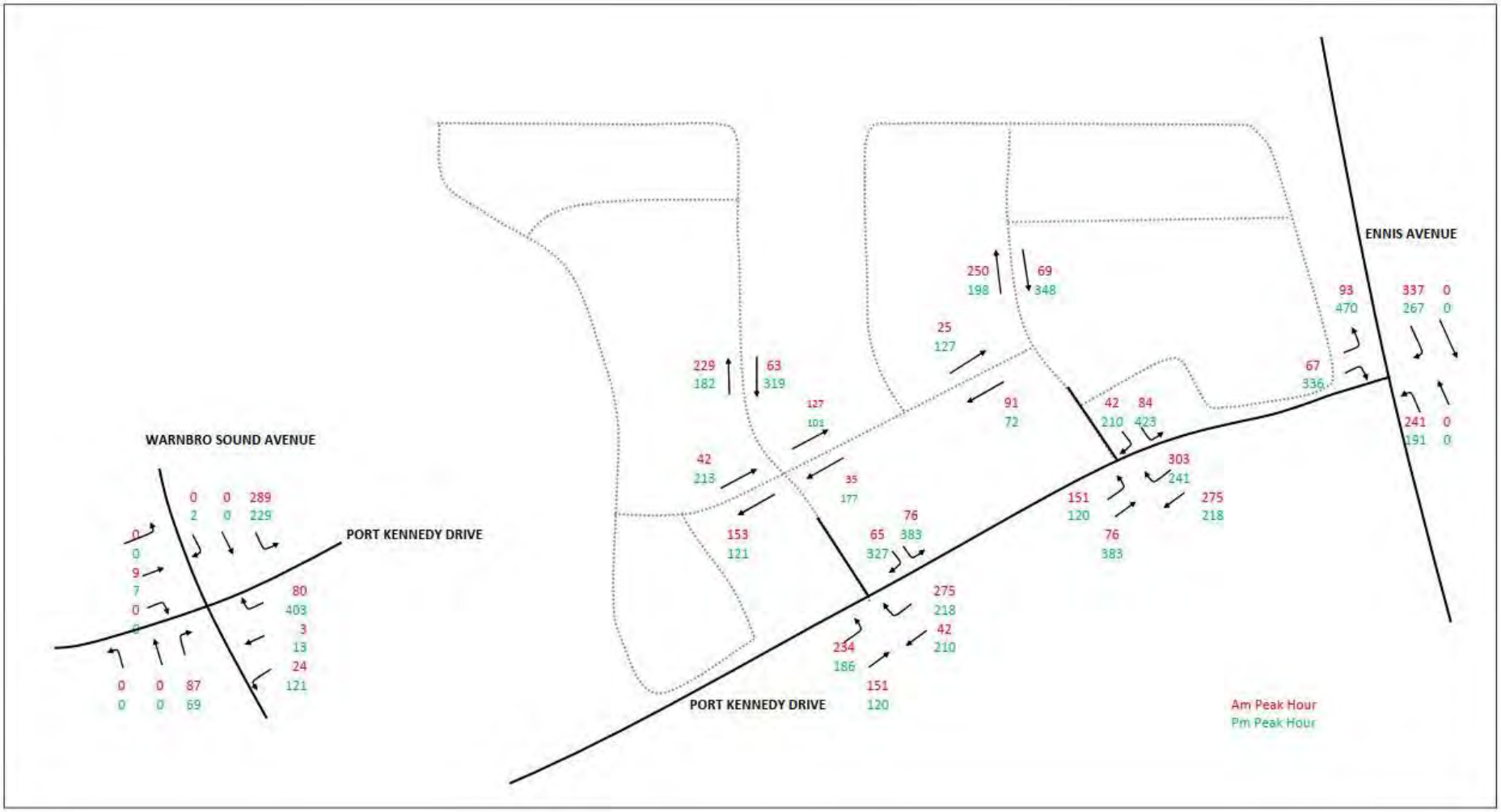


Figure 5.1: Indicative Peak Hour Development Traffic Distribution

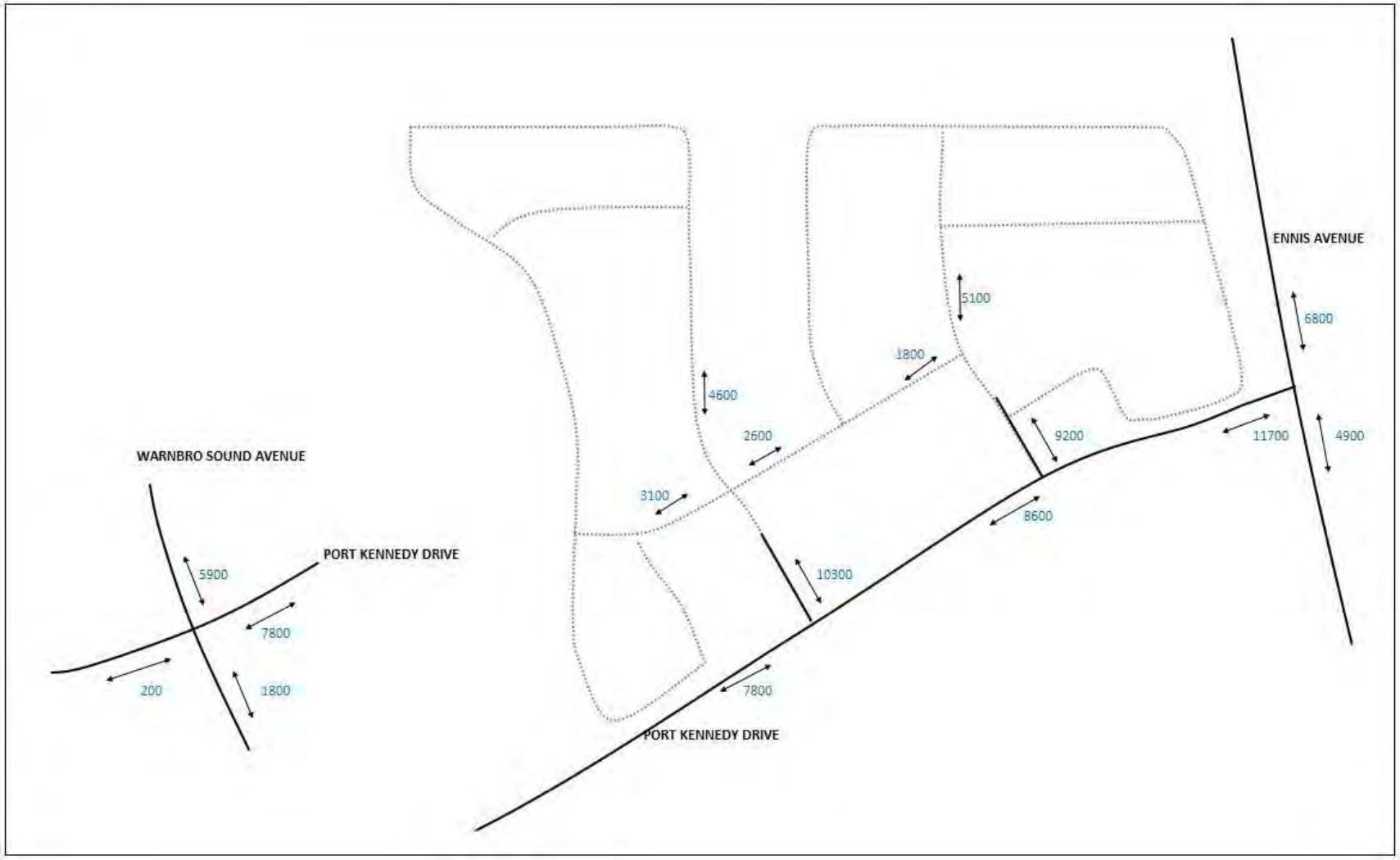


Figure 5.2: Daily Development Traffic Distribution

6.0 ANALYSIS OF THE EXTERNAL TRANSPORT NETWORK

6.1 Road Network Base Traffic Flows

Existing peak hour traffic flows on the external road network were determined from a video survey as outlined in Section 3.3.

Table 6.1.1 and 6.1.2 summarises the actual traffic growth based on historic traffic volumes and predicted traffic growth based on Main Roads ROM24 network model. Whilst **Table 6.1.3** outline the adopted growth rates as agreed with the various authorities to establish the base traffic flows. It should be noted that the ROM24 network models will include in part the development of the subject site hence adopting growth factors slightly less or equal to those reported in the model is considered to be robust as the traffic estimated to be generated by the development is added separate to these base traffic flows for the assessment. **Appendix E** contains the ROM24 outputs.

Table 6.1.1 – Growth per Annum Based on Historic Traffic Volumes

Location	2017/18	2020/21	2021/22	% Growth per Annum
Port Kennedy Dr, west of Ennis Ave, SLK 1.08	10,540	11,852		3.99%
Warnbro Sound Ave, north of Port Kennedy Dr, SLK 5.44	14,624	15,597	14,999	0.63%
Ennis Ave, north of Mandurah Rd, SLK 39.09	25,634	-	25,930	0.29%
Warnbro Sound Ave, south of Port Kennedy Dr, SLK 6.00	13,570	-	-	-

Table 6.1.2 – Growth per Annum Based on ROM24 Traffic Volumes

Location	2016	2021	2036	% Growth per Annum 2016-2021	% Growth per Annum 2021-2036
Port Kennedy Dr, west of Ennis Ave	4,400	5,300	9,100	3.8%	3.7%
Warnbro Sound Ave, north of Port Kennedy Dr	14,800	16,500	22,600	2.2%	2.1%
Warnbro Sound Ave, south of Port Kennedy Dr	14,800	16,400	22,100	2.1%	2.0%
Ennis Ave, north of Port Kennedy Dr	20,100	22,300	32,200	2.1%	2.5%
Ennis Ave, south of Port Kennedy Dr	18,900	21,400	30,400	2.5%	2.4%

Table 6.1.3 – Adopted Growth per Annum

Location	% Growth per Annum 2021-2036
Port Kennedy Dr, west of Ennis Ave	3.0%
Warnbro Sound Ave	2.0%
Ennis Ave	2.5%

Figure 6.1.1 shows the am and pm peak hour base traffic flows for 2022 with **Figure 6.1.2 and 6.1.3** showing the projected increases to these base traffic volumes for 2026 (opening year) and 2036 (10 years after opening).

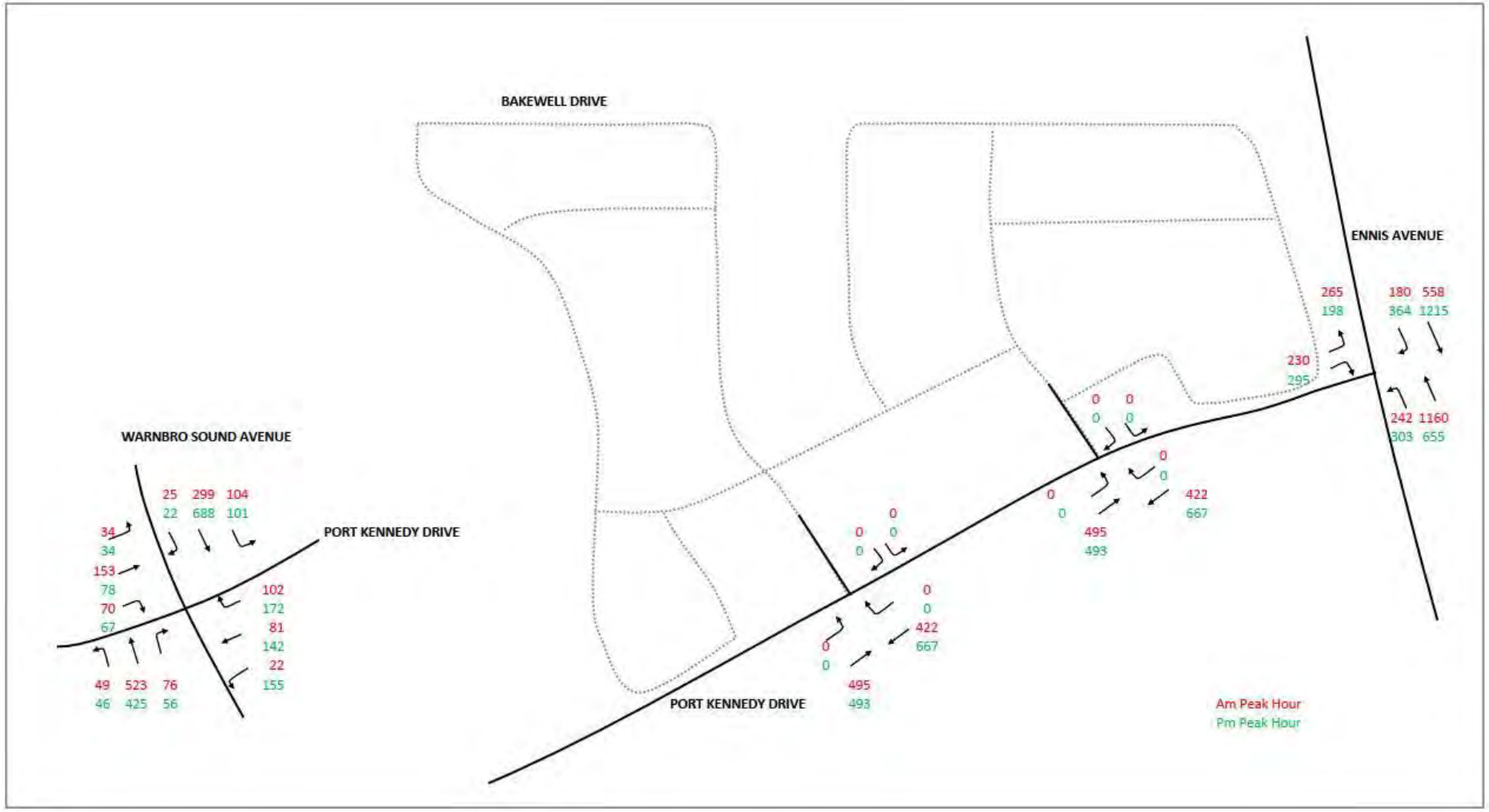


Figure 6.1.1: Existing Peak Hour Base Traffic Flows (2022)

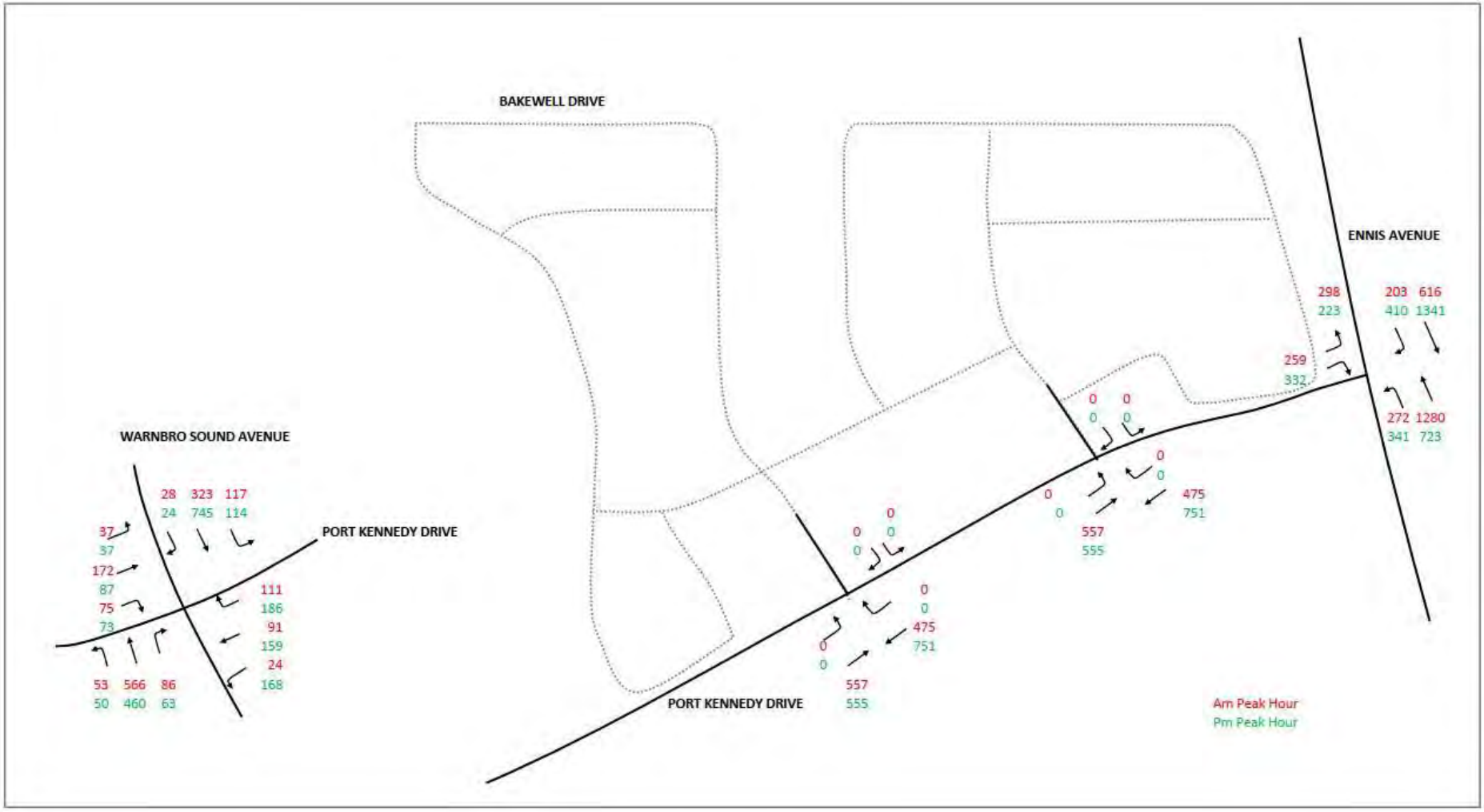


Figure 6.1.2: 2026 Peak Hour Base Traffic Flows

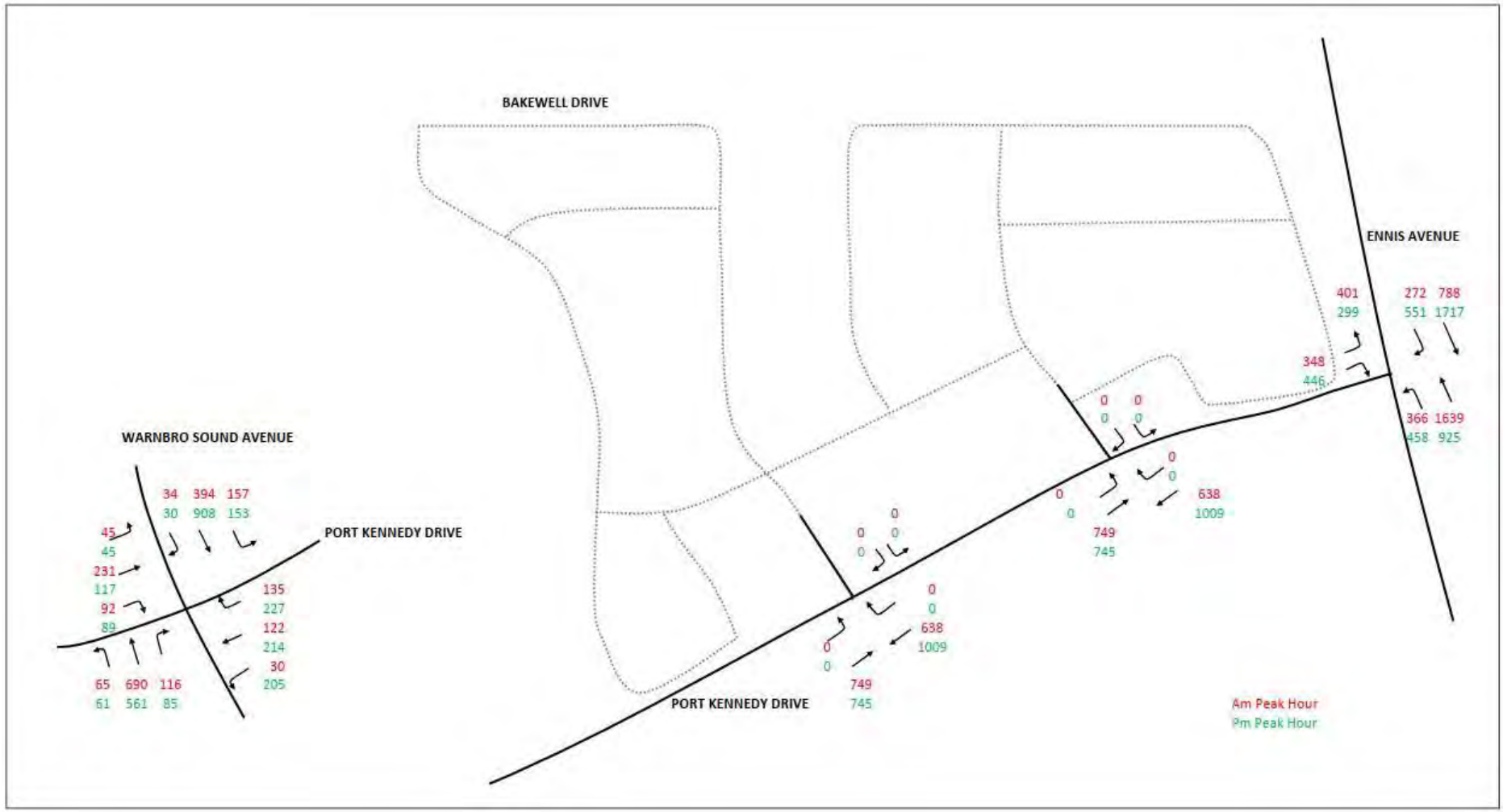


Figure 6.1.3: 2036 Peak Hour Base Traffic Flows

6.2 Analysis of Existing External Intersections for Base Traffic Scenarios

Key existing intersections were analysed using the SIDRA computer package (*version 9.1*) for the existing traffic volumes (2022) as well as base traffic volumes for 2026 and 2036 without the development traffic. These included:

- Port Kennedy Drive and Ennis Avenue; and
- Port Kennedy Drive and Warnbro Sound Avenue.

Appendix F contains detailed SIDRA outputs.

Ennis Avenue and Port Kennedy Drive

SIDRA outputs are summarised in **Table 6.2.1** for the existing operation of the signalised intersection of Port Kennedy Drive and Ennis Avenue for the existing layout for the base traffic flows of 2022, 2026 and 2036 for both the am and pm peak hours. In summary:

- At present (2022) the signalised intersection operates with a degree of saturation (DOS) ranging from 0.827 and 0.899. The overall level of service (LOS) is C which corresponds to an average delay of 30-32 seconds. The pm peak currently is almost at the practical DOS for signalised intersections of 0.9. The lowest level of service is associated with the right turn from Ennis Avenue into Port Kennedy Drive being E with a corresponding average delay of 56 seconds during the pm peak. The existing phase times from SCATS data were adopted for this 2022 assessment.
- With the existing layout, with the predicted 2026 base traffic flows (without development traffic), the DOS for the signalised intersection is 0.863 and 0.900 for the am and pm peak hour respectively. The phase times and cycle times were selected by SIDRA which does seems to cater for the additional traffic growth with minimal changed operating conditions. It is suggested that there is likely to be limited capacity for additional traffic growth given that the degree of saturation has remained at 0.9 during the pm peak since 2022 assessment. It is suggested that an upgrade to the layout is likely to be imminent to ensure that operating conditions remain satisfactory with continued traffic growth on the road network.
- Allowing for traffic growth for 2036 (without development traffic), with the existing layout, the DOS for the signalised intersection exceeds the practical DOS of 0.9 i.e ranging from 0.988 and 0.953 for the am and pm peak hours respectively. The phase times and cycle times were selected by SIDRA. The overall level of service is E which corresponds to an average delay of 62-72 seconds. The right turn movements experience a LOS F under the 2036 analysis with the existing layout. Various movements exceed the practical degree of saturation and subsequently experience long queues and delays confirming that intersection upgrades will be required prior to 2036 to cater for general traffic growth in the area.

Table 6.2.1: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Existing Layout – Base Traffic 2022, 2026 and 2036 – No development

	Approach	2022				Base Traffic 2026				Base Traffic 2036			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 87 seconds				Cycle Time 90 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.143	7.5	A	0	0.161	7.5	A	0	0.216	7.6	A	0
	Through	0.827	31.6	C	201	0.863	34.6	C	241	0.983	79.3	E	647
	Ennis Avenue (north)												
	Right	0.697	47.4	D	64	0.813	52.7	D	79	0.988	112.1	F	210
	Port Kennedy Drive (west												
	Left	0.352	15.2	B	44	0.419	17.0	B	57	0.672	42.8	D	190
	Right	0.734	45.3	D	91	0.855	53.2	D	117	0.988	109.4	F	305
	Intersection	0.827	29.6	C	201	0.863	32.8	C	241	0.988	72.2	E	647
Pm Peak		Cycle Time 90 seconds				Cycle Time 80 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.174	7.6	A	0	0.196	7.6	A	0	0.263	7.6	A	0
	Through	0.641	31.9	C	105	0.888	43.6	D	134	0.953	83.3	F	327
	Ennis Avenue (north)												
	Right	0.899	55.5	E	148	0.900	50.1	D	151	0.936	78.6	E	367
	Port Kennedy Drive (west)												
	Left	0.203	10.3	B	18	0.236	11.0	B	22	0.334	16.0	B	69
	Right	0.730	43.4	D	101	0.859	47.0	D	116	0.943	86.4	F	306
	Intersection	0.899	32.1	C	148	0.900	35.9	D	151	0.953	62.4	E	367

1) Program Calculated Practical Cycle Time Used – intersection saturated with existing phase times

Three options to improve the existing layout were investigated with each incorporating an additional upgrade treatment as follows:

Option 1:

- Double right turn from Ennis Avenue into Port Kennedy Drive in conjunction with give way control for the Ennis Avenue left turn into Port Kennedy Drive;

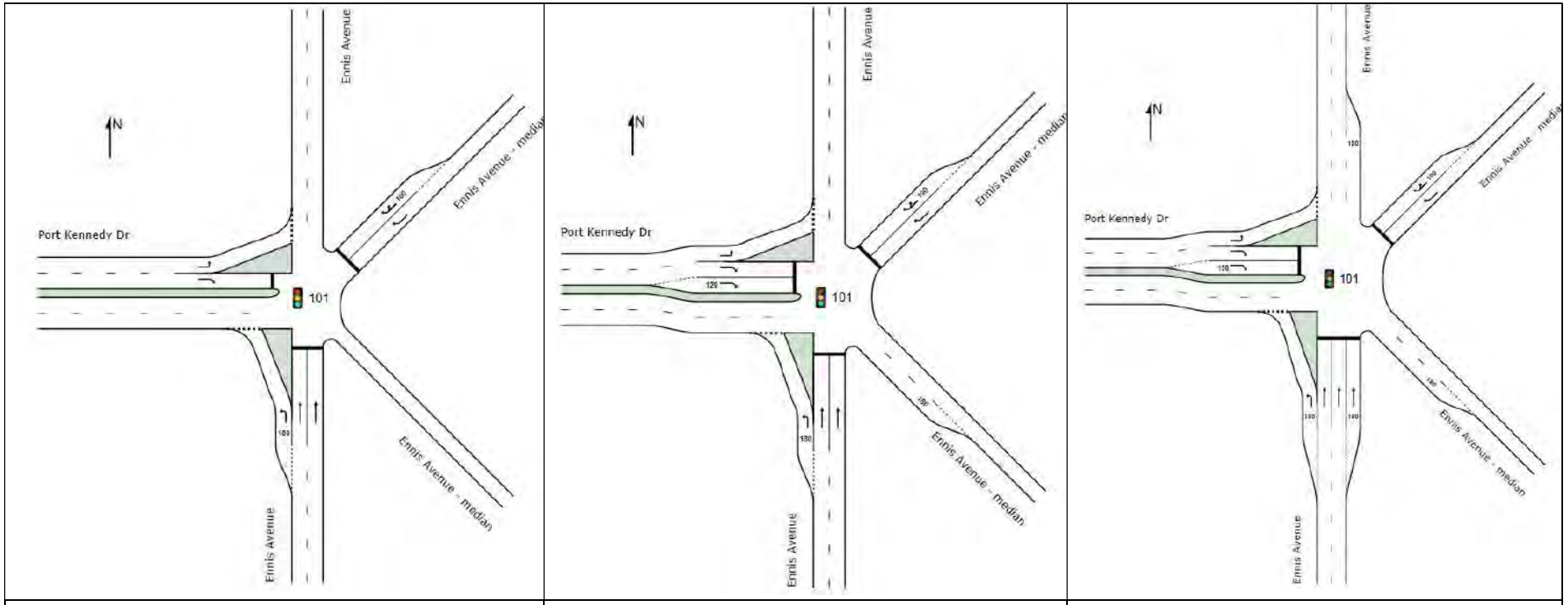
Option 2:

- Double right turn from Ennis Avenue into Port Kennedy Drive in conjunction with give way control for the Ennis Avenue left turn into Port Kennedy Drive; and
- Double right turn from Port Kennedy Drive into Ennis Avenue in conjunction with an appropriate merge treatment along Ennis Avenue southbound.

Option 3:

- Double right turn from Ennis Avenue into Port Kennedy Drive in conjunction with give way control for the Ennis Avenue left turn into Port Kennedy Drive;
- Double right turn from Port Kennedy Drive into Ennis Avenue in conjunction with an appropriate merge treatment along Ennis Avenue southbound; and
- Auxiliary through lane to be provided on Ennis Avenue northbound – south approach.

The indicative SIDRA geometry for the purpose of modelling is shown in **Figure 6.2.1.**



Option 1	Option 2	Option 3

Figure 6.2.1: Progressive Intersection Upgrade Options for Ennis Avenue and Port Kennedy Drive

With respect to upgrade requirements Main Road WA document "*MRWA Supplement to Austroads Guide to Road Design Part 4"* has been sourced. This outlines that signalised intersections be designed with an overall LOS C with no individual movement less than a LOS D for the design year (i.e.10 years time horizon). A lower LOS may be accepted in some situations provided the degree of saturation for the critical movement does not exceed 0.9 for a signalised intersection.

SIDRA outputs are summarised in **Table 6.2.2 to Table 6.2.4** for the operation of Port Kennedy Drive and Ennis Avenue for each of the progressive upgrade option treatment for the base traffic flows of 2026 and 2036 for both the am and pm peak hours. In summary Option 3 meets the typical criteria as outlined by Main Roads WA with respect to the design of infrastructure for a 10 year time horizon i.e. 2036. With the Option 3 modifications with the 2036 base case traffic scenario (i.e. without development traffic), the signalised intersection would operate at a DOS 0.870 and 0.813 during the am and pm peaks. The average intersection delay was approximately 27 seconds with the highest average delay incurred being 39 seconds.

Table 6.2.2: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Base Traffic 2026 and 2036
Option 1: Double Right Turn Lanes on Ennis Ave Only

	Approach	Base Traffic 2026				Base Traffic 2036			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 80 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.198	8.6	A	15	0.253	16.7	B	34
	Through	0.861	31.2	C	212	0.923[4)]	50.9	D	530
	Ennis Avenue (north)								
	Right	0.760	50.5	D	36	0.880	90.4	F[2)]	90
	Port Kennedy Drive (west)								
	Left	0.409	16.6	B	52	0.650	41.8	D	185
	Right	0.806	45.1	D	100	0.896	79.4	E[2)]	256
	Intersection	0.861	29.9	C	212	0.923[4)]	52.4	D[3)]	530
Pm Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 100 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.273	9.5	A	20	0.353	11.3	B	47
	Through	0.894	35.5	D	103	0.876	46.3	D	198
	Ennis Avenue (north)								
	Right	0.843	40.3	D	55	0.888	61.0	E[2)]	122
	Port Kennedy Drive (west)								
	Left	0.239	11.0	B	19	0.325	13.8	B	47
	Right	0.908	44.1	D	99	0.871	52.1	D	190
	Intersection	0.908	30.8	C	103	0.888	40.7	D[3)]	198

1) Program Calculated Practical Cycle Time Used
2) Individual Movement to be LOS D or better outlined by MRWA guidelines
3) Overall LOS C or better outlined by MRWA guidelines
4) Exceeds practical DOS of 0.9

Table 6.2.3: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Base Traffic 2026 and 2036
Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Drive

	Approach	Base Traffic 2026				Base Traffic 2036			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 70 seconds-PCT[1)]				Cycle Time 90 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.203	8.6	A	13	0.267	8.8	A	24
	Through	0.803	22.4	C	168	0.893	32.7	C	314
	Ennis Avenue (north)								
	Right	0.665	43.2	D	30	0.858	58.3	E[2)]	56
	Port Kennedy Drive (west)								
	Left	0.459	15.6	B	46	0.708	25.4	C	116
	Right	0.756	44.0	D	45	0.831	55.0	E[2)]	78
	Intersection	0.803	24.1	C	168	0.893	33.7	D[3)]	314
Pm Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 70 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.276	9.5	A	21	0.377	10.6	B	39
	Through	0.726	23.8	C	82	0.858	33.2	C	142
	Ennis Avenue (north)								
	Right	0.749	36.1	D	51	0.813	41.0	D	81
	Port Kennedy Drive (west)								
	Left	0.254	10.7	B	18	0.367	12.8	B	35
	Right	0.681	35.8	D	41	0.854	45.6	D	70
	Intersection	0.749	24.4	C	82	0.858	30.7	C	142

1) Program Calculated Practical Cycle Time Used
2) Individual Movement to be LOS D or better outlined by MRWA guidelines
3) Overall LOS C or better outlined by MRWA guidelines
4) Exceeds practical DOS of 0.9

Table 6.2.4: SIDRA Analysis, Ennis Avenue/Port Kennedy Base Traffic 2026 and 2036
Option 3: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr, Auxiliary Thru Lane

	Approach	Base Traffic 2026				Base Traffic 2036			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 60 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.211	8.8	A	13	0.288	9.0	A	20
	Through	0.689	20.2	C	90	0.868	29.6	C	149
	Ennis Avenue (north)								
	Right	0.570	36.4	D	25	0.762	39.0	D	36
	Port Kennedy Drive (west)								
	Left	0.382	11.5	B	28	0.550	14.4	B	54
	Right	0.648	36.4	D	37	0.870	43.0	D	56
	Intersection	0.689	21.0	C	90	0.870	27.5	C	149
Pm Peak		Cycle Time 50 seconds-PCT[1)]				Cycle Time 60 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.291	9.7	A	19	0.394	10.4	B	36
	Through	0.717	23.8	C	49	0.813	30.1	C	79
	Ennis Avenue (north)								
	Right	0.702	30.3	C	42	0.755	33.8	C	67
	Port Kennedy Drive (west)								
	Left	0.235	9.9	A	13	0.321	10.5	B	24
	Right	0.757	33.2	C	36	0.813	38.4	D	58
	Intersection	0.757	22.7	C	49	0.813	26.7	C	79

1) Program Calculated Practical Cycle Time Used

Port Kennedy Drive and Warnbro Sound Avenue

SIDRA outputs are summarised in **Table 6.2.5** for the existing operation of Port Kennedy Drive and Warnbro Sound Avenue for the existing roundabout layout for the base traffic flows of 2022, 2026 and 2036 for both the am and pm peak hours. In summary:

- At present (2022) the intersection operates with a degree of saturation ranging from 0.246 and 0.309 indicating a high capacity for additional traffic. The overall level of service is A with an average delay of 7 seconds.
- Under the 2036 base case traffic scenario the intersection still has capacity for additional traffic as the degree of saturation is 0.362 and 0.451 during the am and pm peak hour respectively. The overall level of service would remain at A with an average delay of 7 seconds.

6.3 Road Network with Development Traffic Flows

The peak hour traffic volumes were added to the existing basecase traffic flows in 2026 (at opening) and 2036 (10 years after opening or full development). These traffic volumes are summarised in **Figures 6.3.1 and Figure 6.3.2.**

Table 6.2.5: SIDRA Analysis, Port Kennedy Drive/Warnbro Sound Avenue, Existing Layout – Base Traffic 2022, 2026 and 2036 – No development

	Approach	2022				Base Traffic 2026				Base Traffic 2036			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak	Warnbro Sound Avenue (south)												
	Left	0.250	4.2	A	10	0.281	4.4	A	12	0.362	4.7	A	16
	Through	0.250	4.8	A	10	0.281	4.9	A	12	0.362	5.2	A	16
	Right	0.250	12.5	B	10	0.281	12.7	B	11	0.362	13.1	B	16
	Port Kennedy Drive (east)												
	Left	0.080	5.7	A	3	0.092	5.8	A	3	0.128	6.0	A	5
	Through	0.080	6.4	A	3	0.092	6.6	A	3	0.128	6.8	A	5
	Right	0.096	14.5	B	3	0.111	14.8	B	4	0.145	15.2	B	5
	Warnbro Sound Avenue (north)												
	Left	0.183	4.5	A	7	0.203	4.6	A	8	0.269	4.9	A	11
	Through	0.183	5.0	A	7	0.203	5.2	A	8	0.269	5.6	A	11
	Right	0.183	12.9	B	7	0.203	12.9	B	8	0.269	13.4	B	10
	Port Kennedy Drive (west)												
	Left	0.124	3.9	A	4	0.145	4.1	A	5	0.206	4.6	A	8
	Through	0.124	4.1	A	4	0.145	4.3	A	5	0.206	4.7	A	8
	Right	0.124	11.8	B	4	0.145	12.1	B	5	0.206	12.8	B	7
	Intersection	0.250	6.4	A	10	0.281	6.5	A	12	0.362	6.9	A	16
PM Peak	Warnbro Sound Avenue (south)												
	Left	0.224	4.5	A	9	0.252	4.7	A	11	0.355	5.1	A	15
	Through	0.224	5.1	A	9	0.252	5.3	A	11	0.355	5.7	A	15
	Right	0.224	12.8	B	9	0.252	13.2	B	10	0.355	13.6	B	14
	Port Kennedy Drive (east)												
	Left	0.235	6.4	A	9	0.278	6.8	A	11	0.393	7.5	A	18
	Through	0.235	7.4	A	9	0.278	7.7	A	11	0.393	8.6	A	18
	Right	0.235	15.8	B	8	0.278	16.3	B	10	0.393	17.6	B	16
	Warnbro Sound Avenue (north)												
	Left	0.309	4.3	A	13	0.348	4.4	A	16	0.451	4.8	A	22
	Through	0.309	4.8	A	13	0.348	5.0	A	16	0.451	5.4	A	22
	Right	0.309	12.5	B	13	0.348	12.7	B	15	0.451	13.2	B	21
	Port Kennedy Drive (west)												
	Left	0.087	3.9	A	3	0.100	4.1	A	4	0.141	4.5	A	5
	Through	0.087	3.8	A	3	0.100	4.0	A	4	0.141	4.4	A	5
	Right	0.087	11.8	B	3	0.100	12.0	B	3	0.141	12.6	B	5
	Intersection	0.309	6.6	A	13	0.348	6.8	A	16	0.451	7.4	A	22

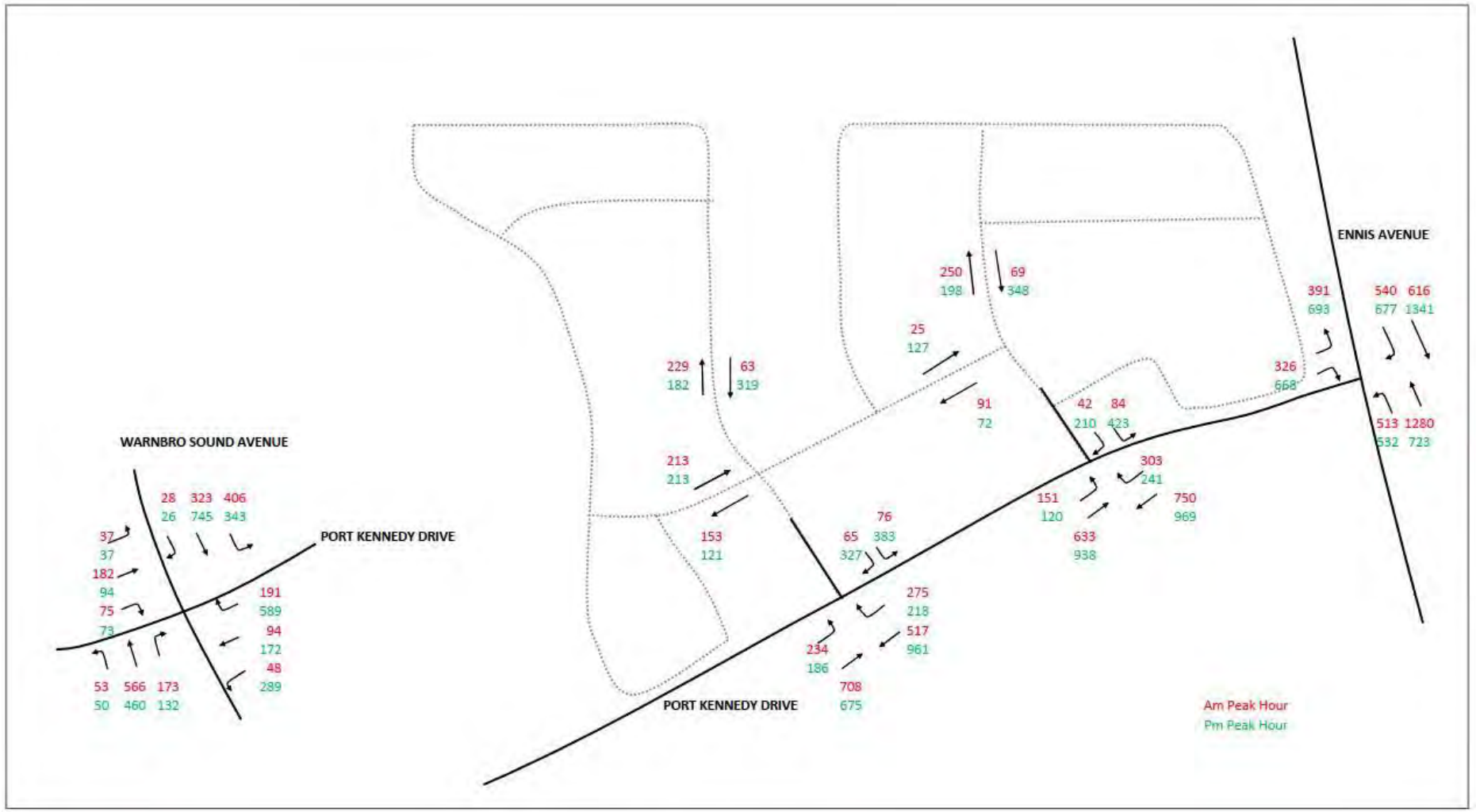


Figure 6.3.1: 2026 Road Network Traffic Volumes with Development Flows

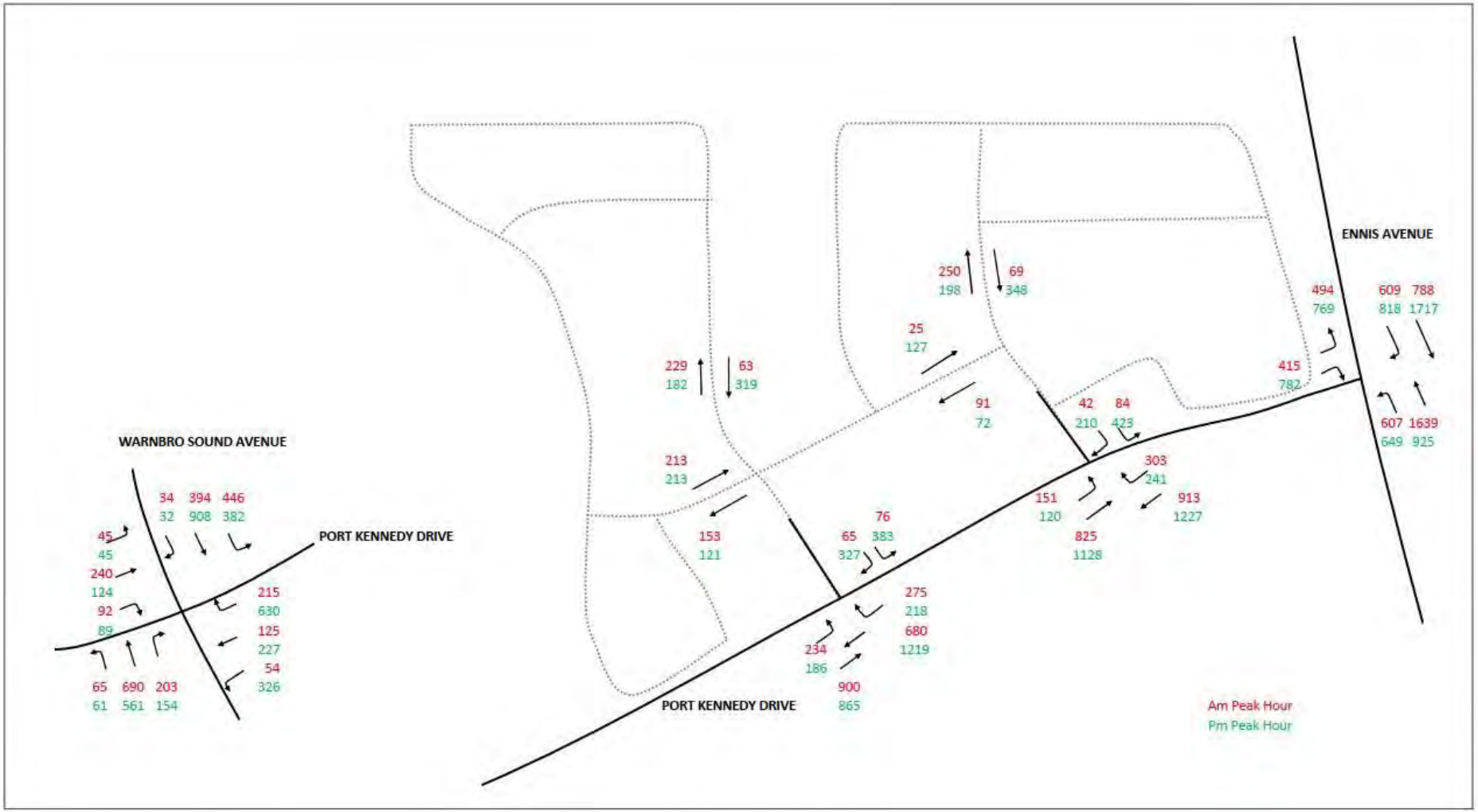


Figure 6.3.2: 2036 Road Network Traffic Volumes with Development Flows

6.4 Analysis of Existing External Intersections for Development Scenarios

Key existing external intersections were analysed using the SIDRA computer package (*version 9.1*) for the predicted 2026 (i.e at opening) and 2036 (i.e 10 years after opening) traffic flows including the development traffic. These included:

- Port Kennedy Drive and Ennis Avenue; and
- Port Kennedy Drive and Warnbro Sound Avenue.

Appendix F contains detailed SIDRA outputs.

Ennis Avenue and Port Kennedy Drive

The proposed modifications adopted in the SIDRA analysis are those outlined in section 6.2 for Option 3 which includes the provision of two right turning lanes from both Ennis Avenue and Port Kennedy Drive in addition to an auxiliary southbound through lane on Ennis Avenue. An appropriate merge treatment would be required along the southbound Ennis Avenue approach associated with the double right turn.

SIDRA outputs are summarised in **Table 6.4.1** for the operation of Port Kennedy Drive and Ennis Avenue for the proposed layout with the development traffic flows for 2026 and 2036 for both the am and pm peak hours. In summary:

- With full development at opening in 2026 with the proposed modifications the intersection will operate with a DOS 0.904 and 0.811 during the am and pm peak hours. The phase times and cycle times were selected by SIDRA. The overall level of service is C with an average intersection delay of 28-29 seconds. Worst level of service is D associated with a number of individual movements with delays of 36-40 seconds. Queue lengths along Port Kennedy Drive are in the order of 50m and 96m during the am and pm peaks which is clear of the proposed connection into the Structure Plan.
- With full development in 2036 or 10 years after opening with the proposed modifications the intersection will operate with a DOS of 0.891 and 0.875 during the am and pm peak hours. The overall level of service is D with an average intersection delay of 35-36 seconds. Worst level of service is D associated with a number of individual movements with delays of 40-53 seconds. Queue lengths along Port Kennedy Drive are in the order of 100m and 157m during the am and pm peaks which is clear of the proposed connection into the Structure Plan.

Table 6.4.1: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Proposed Layout Option 3, 2026 and 2036 – With Development

	Approach	2026 At Opening				2036 – 10 years after opening			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 80seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.449	10.8	B	43	0.514	12.8	B	65
	Through	0.904	36.4	D	127	0.891	39.6	D	198
	Ennis Avenue (north)								
	Right	0.824	37.4	D	73	0.851	47.1	D	108
	Port Kennedy Drive (west)								
	Left	0.482	12.6	B	44	0.676	16.8	B	100
	Right	0.817	40.2	D	50	0.883	53.4	D	88
	Intersection	0.904	29.6	C	127	0.891	35.0	D[3)]	198
Pm Peak		Cycle Time 70 seconds-PCT[1)]				Cycle Time 90 seconds-PCT[1)]			
	Ennis Avenue (south)								
	Left	0.463	12.4	B	52	0.573	16.2	B	91
	Through	0.809	36.2	D	72	0.861	46.6	D	120
	Ennis Avenue (north)								
	Right	0.811	38.8	D	98	0.840	46.1	D	151
	Port Kennedy Drive (west)								
	Left	0.661	11.1	B	80	0.762	13.9	B	157
	Right	0.799	38.6	D	96	0.875	51.5	D	154
	Intersection	0.811	28.1	C	98	0.875	36.1	D[3]	157

1) Program Calculated Practical Cycle Time Used
2) Individual Movement to be LOS D or better outlined by MRWA guidelines
3) Overall LOS C or better outlined by MRWA guidelines
4) Exceeds practical DOS of 0.9

Port Kennedy Drive and Warnbro Sound Avenue

SIDRA outputs are summarised in **Table 6.4.2** for the existing operation of Port Kennedy Drive and Warnbro Sound Avenue for the existing roundabout layout for with the development flows for 2026 and 2036 for both the am and pm peak hours. In summary:

- In 2026 with full development the roundabout will continue to operate at a high level of service being A and B during the am an pm peak hours respectively. The degree of saturation is anticipated to range from 0.344 to 0.599 for the peak hours.
- In 2036 with full development the roundabout operates satisfactorily with a degree of saturation is 0.424 and 0.777 during the am an pm peak hour respectively. The overall level of service would remain at A with an average delay of 8 seconds during the am peak and will operate with a LOS B during the pm peak with corresponds to an average delay of 12 seconds

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Table 6.4.2: SIDRA Analysis, Port Kennedy Drive/Warnbro Sound Avenue, Existing Layout –2026 and 2036 – With development

	Approach	2026 With Development				2036 With Development			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak	Warnbro Sound Avenue (south)								
	Left	0.335	4.7	A	15	0.423	5.0	A	20
	Through	0.335	5.3	A	15	0.423	5.6	A	20
	Right	0.335	13.1	B	14	0.423	13.5	B	19
	Port Kennedy Drive (east)								
	Left	0.148	6.5	A	6	0.194	6.9	A	8
	Through	0.148	7.3	A	6	0.194	7.7	A	8
	Right	0.159	14.7	B	7	0.194	15.0	B	8
	Warnbro Sound Avenue (north)								
	Left	0.343	5.0	A	15	0.422	5.4	A	19
	Through	0.343	5.9	A	15	0.422	6.4	A	19
	Right	0.343	13.5	B	14	0.422	14.2	B	19
	Port Kennedy Drive (west)								
	Left	0.165	4.6	A	6	0.236	5.1	A	10
	Through	0.165	4.7	A	6	0.236	5.3	A	10
	Right	0.165	12.7	B	6	0.236	13.5	B	9
	Intersection	0.344	7.2	A	15	0.424	7.6	A	20
Pm Peak	Warnbro Sound Avenue (south)								
	Left	0.388	6.3	A	20	0.533	8.2	A	35
	Through	0.388	7.1	A	20	0.533	9.1	A	35
	Right	0.388	15.5	B	18	0.533	17.9	B	31
	Port Kennedy Drive (east)								
	Left	0.599	10.7	B	34	0.777	16.1	B	58
	Through	0.599	11.3	B	38	0.777	16.1	B	67
	Right	0.599	17.6	B	38	0.777	21.8	C	67
	Warnbro Sound Avenue (north)								
	Left	0.462	4.8	A	23	0.575	5.5	A	34
	Through	0.462	5.5	A	23	0.575	6.4	A	34
	Right	0.462	13.2	B	22	0.575	14.3	B	34
	Port Kennedy Drive (west)								
	Left	0.141	5.9	A	6	0.203	6.8	A	10
	Through	0.141	5.9	A	6	0.203	6.8	A	10
	Right	0.141	14.5	B	6	0.203	15.7	B	8
	Intersection	0.599	9.6	A	38	0.777	11.8	B	67

6.5 Analysis of New Intersections for Development Scenarios

Key new intersections created as part of the new development were analysed using the SIDRA computer package (*version 9.1*) for 2026 and 2036 which include the following as shown in Figure 6.4.1:

- New western connection to Port Kennedy Drive – roundabout control;
- New eastern connection to Port Kennedy Drive – roundabout control;
- Internal 4 way junction along the western connection to Port Kennedy Drive; and
- Internal t-junction along the eastern connection to Port Kennedy Drive.

Appendix F contains detailed SIDRA outputs.

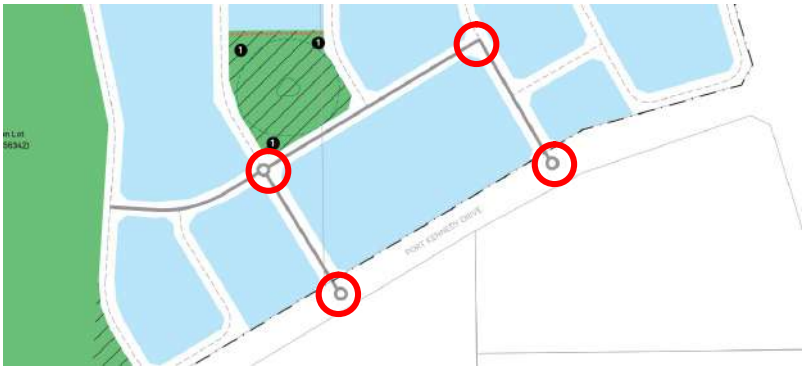

Figure 6.4.1: 2036 Internal Connections/Intersections Analysed

Western Connection to Port Kennedy Drive

A dual lane roundabout is proposed for the western connection to Port Kennedy Drive. SIDRA outputs are summarised in **Table 6.5.1** for the operation of the proposed roundabout with the development traffic flows for 2026 and 2036 for both the am and pm peak hours. In summary:

- With full development at opening in 2026 the roundabout will operate with a DOS 0.408 and 0.561 during the am and pm peak hours. The overall level of service is A with an average intersection delay of 8-9 seconds. Worst level of service is B associated with the right turn movement to/from Port Kennedy Drive with delays of 10-15 seconds. Queue lengths along the new connection reach up to 23m in the pm peak. The longest queues along Port Kennedy Drive are on the west approach in the pm peak of up to 26m and on the east approach up to 42m in the am peak. The LOS for the Port Kennedy Drive through traffic is still A.
- With full development at opening in 2036 the roundabout will operate with a DOS 0.492 and 0.693 during the am and pm peak hours. The overall level of service remains at A with an average intersection delay of 8-10 seconds. Worst level of service is B associated with the right turn movement to/from Port Kennedy Drive with delays of 10-15 seconds. Queue lengths along the new connection reach up to 28m in the pm peak. The longest queues along Port Kennedy Drive are on the west approach in the am peak of up to 34m and on the east approach up to 70m in the am peak. The LOS for the Port Kennedy Drive through traffic for the westbound traffic changes to B with 2036 through traffic volumes during the am peak compared to A with 2026 through traffic volumes.

Eastern Connection to Port Kennedy Drive

A dual lane roundabout is proposed for the eastern connection to Port Kennedy Drive. SIDRA outputs are summarised in **Table 6.5.2** for the operation of the proposed roundabout

with the development traffic flows for 2026 and 2036 for both the am and pm peak hours. In summary:

- With full development at opening in 2026 the roundabout will operate with a DOS 0.363 and 0.593 during the am and pm peak hours. The overall level of service is A with an average intersection delay of 8-9 seconds. Worst level of service is B associated with the right turn movement to/from Port Kennedy Drive with delays of 10-14 seconds. Queue lengths along the new connection reach up to 33m in the pm peak. The longest queues along Port Kennedy Drive are on the west approach in the pm peak of up to 33m and on the east approach up to 35m in the 9m peak. The LOS for the Port Kennedy Drive through traffic is A.
- With full development at opening in 2036 the roundabout will operate with a DOS 0.428 and 0.679 during the am and pm peak hours. The overall level of service remains at A with an average intersection delay of 8-9 seconds. Worst level of service is B associated with the right turn movement to/from Port Kennedy Drive with delays of 11-15 seconds. Queue lengths along the new connection reach up to 41m in the pm peak. The longest queues along Port Kennedy Drive are on the west approach in the pm peak of up to 42m and on the east approach up to 51m in the am peak. The LOS for the Port Kennedy Drive through traffic for the westbound traffic changes to B with 2036 through traffic volumes during the am peak compared to A with 2026 through traffic volumes.

Internal 4 way roundabout along Western North-South Connection

A single lane roundabout is proposed to control vehicular movements at the internal 4-way intersection located along the north-south "Western Connection". SIDRA outputs are summarised in **Table 6.5.3** for full development traffic for both the am and pm peak hours. The internal roundabout will operate at an overall LOS A during both the am and pm peak periods. During the pm peak some individual movements would operated at a LOS B. Queuing along the roundabout approaches range from 2-23m.

Internal t junction along Eastern North–South Connection

The southern t junction along the internal north -south "Eastern Connection" has been modelled under give way control. SIDRA outputs are summarised in **Table 6.5.4** for full development traffic for both the am and pm peak hours. The internal intersection will operate at an overall LOS A during both the am and pm peak periods including all individual movements. Queuing at the intersection is minimal i.e. 1 vehicle.

Table 6.5.1: SIDRA Analysis, Western Connection, Port Kennedy Drive Proposed Roundabout –2026 and 2036 – With development

	Approach	2026 With Development				2036 With Development			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak	Port Kennedy Drive (east)								
	Through	0.283	6.3	A	17	0.341	6.4	A	22
	Right	0.283	12.3	B	16	0.341	12.3	B	21
	Western Internal Road Connection (north)								
	Left	0.093	4.8	A	4	0.106	5.3	A	4
	Right	0.096	10.4	B	3	0.113	11.1	B	4
	Port Kennedy Drive (west)								
	Left	0.408	7.2	A	26	0.492	7.4	A	34
	Through	0.408	8.0	A	26	0.492	8.2	A	34
	Intersection	0.408	8.0	A	26	0.492	8.0	A	34
Pm Peak	Port Kennedy Drive (east)								
	Through	0.564	8.7	A	42	0.693	10.5	B	70
	Right	0.564	15.4	B	42	0.693	17.4	B	68
	Western Internal Road Connection (north)								
	Left	0.458	5.9	A	23	0.518	7.1	A	27
	Right	0.467	11.8	B	22	0.548	13.7	B	28
	Port Kennedy Drive (west)								
	Left	0.35	6.8	A	24	0.449	6.9	A	32
	Through	0.365	7.4	A	24	0.449	7.6	A	32
	Intersection	0.561	8.8	A	42	0.693	9.9	A	70

Table 6.5.2: SIDRA Analysis, Eastern Connection, Port Kennedy Drive Proposed Roundabout –2026 and 2036 – With development

	Approach	2026 With Development				2036 With Development			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak	Port Kennedy Drive (east)								
	Through	0.363	6.2	A	22	0.419	6.3	A	28
	Right	0.363	12.1	B	21	0.419	12.2	B	27
	Eastern Internal Road Connection (north)								
	Left	0.098	4.5	A	3	0.111	5.0	A	4
	Right	0.065	10.4	B	2	0.075	11.1	B	3
	Port Kennedy Drive (west)								
	Left	0.343	7.4	A	23	0.428	7.6	A	30
	Through	0.343	8.1	A	23	0.428	8.3	A	30
	Intersection	0.363	7.9	A	23	0.428	7.9	A	30
Pm Peak	Port Kennedy Drive (east)								
	Through	0.513	7.6	A	35	0.624	7.9	A	51
	Right	0.513	13.7	B	33	0.624	14.1	B	47
	Eastern Internal Road Connection (north)								
	Left	0.593	8.0	A	33	0.679	10.1	B	41
	Right	0.403	13.0	B	16	0.471	14.6	B	20
	Port Kennedy Drive (west)								
	Left	0.452	7.1	A	33	0.537	7.3	A	42
	Through	0.452	7.8	A	33	0.573	8.0	A	42
	Intersection	0.593	8.6	A	35	0.679	9.0	A	51

Table 6.5.3: SIDRA Analysis, Internal 4 way Roundabout on Western Connection, Full development

	Approach	2026 and 2036 Full Development			
		DOS	Ave Delay	LOS	Queue (m)
Am Peak	Internal North-South Western Connection (south)				
	Left	0.368	2.8	A	23
	Through	0.368	2.4	A	23
	Right	0.368	7.6	A	23
	Internal West-East Link (east)				
	Left	0.050	3.3	A	2
	Through	0.050	2.9	A	2
	Right	0.050	8.1	A	2
	Internal North-South Western Connection (north)				
	Left	0.081	3.7	A	4
	Through	0.081	3.3	A	4
	Right	0.081	8.5	A	4
	Internal West-East Link (west)				
	Left	0.071	4.8	A	3
	Through	0.071	4.4.	A	3
	Right	0.071	9.6	A	3
	Intersection	0.368	4.2	A	22
Pm Peak	Internal North-South Western Connection (south)				
	Left	0.297	2.8	A	18
	Through	0.297	2.4	A	18
	Right	0.297	7.6	A	18
	Internal West-East Link (east)				
	Left	0.286	7.2	A	15
	Through	0.286	6.8	A	15
	Right	0.286	12.0	B	15
	Internal North-South Western Connection (north)				
	Left	0.390	5.4	A	22
	Through	0.390	5.1	A	22
	Right	0.390	10.2	B	22
	Internal West-East Link (west)				
	Left	0.251	4.7	A	12
	Through	.0251	4.3	A	12
	Right	0.251	9.5	A	12
	Intersection	0.390	5.9	A	22

Table 6.5.4: SIDRA Analysis, Internal T-junction on Eastern Connection, Full development

	Approach	2026 and 2036 Full Development			
		DOS	Ave Delay	LOS	Queue (m)
Am Peak	Internal North-South Eastern Connection (south)				
	Left	0.187	4.6	A	0
	Through	0.187	0	A	0
	Internal North-South Eastern Connection (north)				
	Through	0.046	0	A	1
	Right	0.046	7.5	A	1
	Internal West-East Link (west)				
	Left	0.038	5.4	A	1
	Right	0.038	6.1	A	1
	Intersection	0.187	1.5	-	1
Pm Peak	Internal North-South Eastern Connection (south)				
	Left	0.148	4.6	A	0
	Through	0.148	0	A	0
	Internal North-South Eastern Connection (north)				
	Through	0.196	0	A	1
	Right	0.196	6.7	A	1
	Internal West-East Link (west)				
	Left	0.199	5.3	A	5
	Right	0.199	7.9	A	5
	Intersection	0.199	1.9	A	5

6.6 Indicative Staging

Whilst the 2026 analysis assumes that the Structure Plan will be fully developed the reality is that it will be progressive over a longer time period. For this reason some analysis scenarios with progressive intersection improvements and staging have been undertaken for opening (2026) and 10 year time horizon (2036). These include:

- Scenario 1: Option 1 – double right turn on Ennis Avenue, Stage 1 traffic, 2026 and 2036
- Scenario 2: Option 1 – double right turn on Ennis Avenue, Stage 1, and 2 traffic, 2026 and 2036
- Scenario 3: Option 2 – double right turn on Ennis Avenue and Port Kennedy Drive, Stage 1 traffic, 2026 and 2036
- Scenario 4: Option 2 – double right turn on Ennis Avenue and Port Kennedy Drive, Stage 1 and 2 traffic, 2026 and 2036

For the purpose of the traffic assessment the indicative trip generation for various stages of development is as shown in **Table 6.6.1. Figure 6.6.1** outlines the indicative stages**.** Trip generation will vary based on the uptake of various land uses within each area however for the purpose of the traffic assessment the trip generation has been distributed based on land area or expected GFA within the stages.

Table 6.6.1 - Estimated Trip Generation for Indicative Stages

Stages	Land Area	GFA	Daily	Am Peak	Pm Peak
1	150,034	75,017	8,168	515	882
2	67,626	33,812	3,681	232	398
3	37,937	18,970	2,065	130	223
4	55,412	27,707	3,017	190	326
5	47,208	23,603	2,570	162	278
Total	358,217	179,108	19,501	1,229	2,106

Figure 6.6.1: Indicative Stages for Structure Plan for Traffic Assessment

The results as shown in **Table 6.6.2 and 6.6.5** indicate that adequate capacity can be provided for the earlier stages of development at opening (2026) with a lower level of treatment initially however ultimately with increases in general traffic growth and further development the signalised intersection would require further modification. **Appendix F** contains detailed SIDRA outputs. In summary:

- Scenario 1: Upgrade improvements include the provision of double right turn from Ennis Avenue into Port Kennedy Drive only. With 2026 plus Stage 1 development traffic the intersection operates satisfactorily with a DOS <0.9. The overall LOS is C/D i.e. an average delay of 35-36 seconds. The right turn from Ennis Avenue does however operate at a LOS E, average delay of 58 seconds. With 2036 plus Stage 1 development traffic the intersection exceeds its practical capacity of 0.9 but does not exceed 1.0. The overall LOS is E i.e. an average delay of 59-74 seconds. Numerous individual movements would operate at a LOS E or worse.
- Scenario 2: Upgrade improvements include the provision of double right turn from Ennis Avenue into Port Kennedy Drive only. With 2026 plus Stage 1 and 2 development traffic the intersection operates satisfactorily with a DOS <0.9. The

overall LOS is D with a range of average delay of 36-39 seconds. The right turn from Ennis Avenue does however operate at a LOS E, average delay of 62 seconds. The queue length along the Port Kennedy Drive is estimated to reach 230m. With 2036 traffic volumes the intersection becomes over saturated i.e. DOS >1.0 with long queues and delays.

- Scenario 3: Upgrade improvements include the provision of double right turn from Ennis Avenue and from Port Kennedy Drive. With 2026 plus Stage 1 development traffic the intersection operates satisfactorily with a DOS <0.9. The overall LOS is C with an average delay of 28 seconds. The right turn movements operate at a LOS D, with an average delay of 40-46 seconds. With 2036 plus Stage 1 development traffic the intersection is just approaching its practical capacity in the pm peak i.e. 0.908. The overall LOS is D with an average delay of 36-39 seconds. The worst individual movement are the right turns during the am peak with a LOS E with an average delay of 64-69 seconds.
- Scenario 4: Upgrade improvements include the provision of double right turn from Ennis Avenue and from Port Kennedy Drive. With 2026 plus Stage 1 and 2 development traffic the intersection operates satisfactorily with a DOS <0.9. The overall LOS is C with an average delay of 29-31 seconds. The worse individual movements operates at a LOS D. With 2036 plus Stage 1 and 2 development traffic the intersection operates satisfactorily with a DOS <0.9. The overall LOS is D with an average delay of 38-47 seconds. The worst individual movement operate at a LOS E.

Main Roads WA are the controlling authority for Ennis Avenue and its intersection with Port Kennedy Drive. Main Roads WA approval of both the staged and final intersection layout to be adopted will be required. Main Roads will need to confirm the acceptance of the various operating conditions presented with respect to the stages and upgrade treatments for this signalised intersection.

Table 6.6.2: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2026
Option 1: Double Right Turn Lanes on Ennis Ave Only – Stage 1 and 2 traffic

	Approach	Base Traffic 2026				2026+ Stage 1				2026+Stage 1,2			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 80 seconds-PCT[1)]				Cycle Time 90 seconds-PCT[1)]				Cycle Time 100 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.198	8.6	A	15	0.279	9.2	A	29	0.316	9.9	A	39
	Through	0.861	31.2	C	212	0.885	37.8	D	247	0.861	36.4	D	255
	Ennis Avenue (north)												
	Right	0.760	50.5	D	36	0.867	57.7	E	70	0.878	62.5	E	93
	Port Kennedy Drive (west)												
	Left	0.409	16.6	B	52	0.460	17.8	B	69	0.490	19.1	B	83
	Right	0.806	45.1	D	100	0.837	50.5	D	126	0.873	57.9	E	150
	Intersection	0.861	29.9	C	212	0.885	35.2	D	247	0.878	36.4	D	255
Pm Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 90 seconds-PCT[1)]				Cycle Time 100 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.273	9.5	A	20	0.326	10.5	B	40	0.356	11.5	B	49
	Through	0.894	35.5	D	103	0.830	41.3	D	133	0.880	50.8	D	156
	Ennis Avenue (north)												
	Right	0.843	40.3	D	55	0.858	53.7	D	101	0.870	58.4	E	123
	Port Kennedy Drive (west)												
	Left	0.239	11.0	B	19	0.416	12.1	B	56	0.492	12.9	B	83
	Right	0.908	44.1	D	99	0.863	46.3	D	180	0.889	51.2	D	232
	Intersection	0.908	30.8	C	103	0.863	34.9	C	180	0.889	39.1	D	232

1) Program Calculated Practical Cycl3e Time Used

Table 6.6.3: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2036
Option 1: Double Right Turn Lanes on Ennis Ave Only – Stage 1 and 2

	Approach	Base Traffic 2036				2036+ Stage 1				2036+Stage 1,2			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 150 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.253	16.7	B	34	0.334	20.9	C	54	0.373	20.4	C	65
	Through	0.923	50.9	D	529	0.987	79.8	E	656	1.015	97.8	F	705
	Ennis Avenue (north)												
	Right	0.880	90.4	F	90	0.963	104.4	F	151	1.001	119.7	F	189
	Port Kennedy Drive (west)												
	Left	0.650	41.8	D	185	0.724	45.9	D	205	0.748	46.5	D	213
	Right	0.896	79.4	E	256	0.997	113.1	F	336	1.029	131.1	F	366
	Intersection	0.923	52.4	D	529	0.997	73.9	E	656	1.029	85.3	F	705
Pm Peak		Cycle Time 100 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.353	11.3	B	47	0.419	15.3	B	90	0.454	16.4	B	104
	Through	0.876	46.3	D	198	0.920	72.8	E	302	0.994	101.4	F	355
	Ennis Avenue (north)												
	Right	0.888	61.0	E	122	0.939	94.2	F	226	1.011	128.1	F	282
	Port Kennedy Drive (west)												
	Left	0.325	13.8	B	47	0.512	18.7	B	151	0.598	20.7	C	205
	Right	0.871	52.1	D	190	0.926	72.8	E	380	1.006	105.4	F	509
	Intersection	0.888	40.7	D	198	0.939	59.2	E	380	1.011	79.8	E	509

1) Program Calculated Practical Cycl3e Time Used

Table 6.6.4: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2026
Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr – Stage 1 and 2

	Approach	Base Traffic 2026				2026+Stage 1				2026+Stage 1,2			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 70 seconds-PCT[1)]				Cycle Time 70 seconds-PCT[1)]				Cycle Time 80 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.203	8.6	A	13	0.291	9.2	A	25	0.333	9.5	A	31
	Through	0.803	22.4	C	168	0.861	28.5	C	190	0.893	33.2	C	206
	Ennis Avenue (north)												
	Right	0.665	43.2	D	30	0.843	46.1	D	55	0.888	48.8	D	68
	Port Kennedy Drive (west)												
	Left	0.459	15.6	B	46	0.516	16.5	B	55	0.540	16.7	B	59
	Right	0.756	44.0	D	45	0.837	46.8	D	52	0.873	48.9	D	55
	Intersection	0.803	24.1	C	168	0.861	28.5	C	190	0.893	31.4	C	206
Pm Peak		Cycle Time 60 seconds-PCT[1)]				Cycle Time 70 seconds-PCT[1)]				Cycle Time 70 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.276	9.5	A	21	0.352	10.2	B	30	0.378	10.8	B	39
	Through	0.726	23.8	C	82	0.830	29.5	C	93	0.797	31.2	C	102
	Ennis Avenue (north)												
	Right	0.749	36.1	D	51	0.858	40.0	D	71	0.844	42.8	D	87
	Port Kennedy Drive (west)												
	Left	0.254	10.7	B	18	0.469	11.7	B	42	0.552	12.1	B	62
	Right	0.681	35.8	D	41	0.863	41.1	D	65	0.789	40.2	D	78
	Intersection	0.749	24.4	C	82	0.863	27.7	C	93	0.844	28.5	C	102

1) Program Calculated Practical Cycl3e Time Used

Table 6.6.5: SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2036
Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr – Stage 1 and 2

	Approach	Base Traffic 2036				2036+Stage 1				2036+Stage 1,2			
		DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)	DOS	Ave Delay	LOS	Queue (m)
Am Peak		Cycle Time 90 seconds-PCT[1)]				Cycle Time 110 seconds-PCT[1)]				Cycle Time 150 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.267	8.8	A	24	0.350	*10.2*	*B*	*48*	0.386	12.7	B	65
	Through	0.893	32.7	C	313	0.889	*35.7*	*D*	361	0.896	39.4	D	432
	Ennis Avenue (north)												
	Right	0.858	58.3	E	56	0.848	*64.0*	*E*	*99*	0.867	*73.4*	*E*	*135*
	Port Kennedy Drive (west)												
	Left	0.708	25.4	C	116	0.808	37.5	D	182	0.892	60.6	E	250
	Right	0.831	55.0	E	78	0.862	66.4	E	103	0.866	75.8	E	124
	Intersection	0.893	33.7	C	313	0.889	39.3	D	361	0.892	47.0	D	432
Pm Peak		Cycle Time 70 seconds-PCT[1)]				Cycle Time 80 seconds-PCT[1)]				Cycle Time 70 seconds-PCT[1)]			
	Ennis Avenue (south)												
	Left	0.377	10.6	B	39	0.446	12.5	B	53	0.479	13.7	B	67
	Through	0.858	33.2	C	142	0.892	41.3	D	169	0.883	43.7	D	184
	Ennis Avenue (north)												
	Right	0.813	41.0	D	81	0.908	53.3	D	125	0.878	52.6	D	141
	Port Kennedy Drive (west)												
	Left	0.367	12.8	B	35	0.584	14.5	B	82	0.684	16.5	B	127
	Right	0.854	45.6	D	70	0.856	48.3	D	103	0.889	55.5	E	132
	Intersection	0.858	30.7	C	142	0.908	36.1	D	169	0.889	38.2	D	184

1) Program Calculated Practical Cycl3e Time Used

6.7 Development Contributions for Port Kennedy Drive and Ennis Avenue Intersection

The SIDRA analysis both without and with the development indicates that the signalised intersection of Port Kennedy Drive and Ennis Avenue will need to be upgraded to accommodate general growth in traffic on the adjacent road network from the broader development of the local area even without the development traffic but similarly would also require upgrading due to the development traffic. It is acknowledged that the timing for these improvements will likely be required to be earlier with the addition of the development traffic. Accordingly, it is suggested that the signalised intersection upgrade should be jointly funded. For the purpose of cost distribution it is considered appropriate to proportion the costs in accordance with the traffic using the signalised intersection in the future i.e. development traffic compared to traffic growth. **Table 6.7.1** outlines a summary of the traffic increases predicted at the intersection associated with the development and those associated with general growth in traffic. On this basis the development contribution would be in the order of 52% of costs i.e. it represents a 52% increase in traffic in the overall traffic increase.

Table 6.7.1: Additional Peak Hour Turning Volumes Using the Signalised Intersection

	Traffic Growth 2022 to 2036		Development Traffic	
	Am peak	Pm Peak	Am peak	Pm Peak
Port Kennedy Drive (west)				
Left Turn	136	101	93	470
Right Turn	118	151	67	336
Ennis Avenue (south)				
Left Turn	124	155	241	191
Through	479	270	0	0
Ennis Avenue (north)				
Right Turn	92	187	337	267
Through [1)]	-	-	-	-
Total (with Ennis northbound growth)	1,813		2,002	
% Contribution (with Enn 2036is northbound growth)	48%		52%	

1)Exclude southbound traffic as it is not controlled by the signalised intersection.

6.8 Impact on the Local Road Network

Port Kennedy Drive, west of Ennis Avenue, carries in the order of 11,850 vehicles per day. (*AWT, 2020/21).* Port Kennedy Drive has recently (2020) been upgraded to a four lane dual carriageway standard. Based on 3% growth per annum it is anticipated that traffic volumes along Port Kennedy Drive would increase to 13,700 vehicles per day by 2026 and to 18,500 vehicles per day by 2036.

The proposed development is anticipated to result in traffic volumes on Port Kennedy Drive increasing by approximately 11,600 vehicles per day near Ennis Avenue and 7,700 vehicles per day near Bakewell Drive at full development. In 2036, this would correspond to 30,200 vehicles per day on Port Kennedy Drive near Ennis Avenue and 26,300 vehicles per day near Bakewell Drive.

According to the *Main Roads Functional Hierarchy* Port Kennedy Drive is classified as a *District Distributor B*. This classification of road is typically expected to carry in excess of 6,000vpd based on its function. According to *Liveable Neighbourhoods* Port Kennedy Drive would be classified as an Integrator Arterial and would be anticipated to carry traffic volumes between 15,000vpd and 35,000vpd.

On this basis, there is sufficient spare capacity for the additional traffic generated by the proposed Structure Plan onto Port Kennedy Drive as well as proposed background traffic growth from the area in line with traffic volumes expected based on the road classification and function.

Warnbro Sound Avenue, north of Port Kennedy Drive, carries in the order of 15,000 vehicles per day. (*AWT, 2021/22).* Warnbro Sound Avenue is constructed to a four lane dual carriageway standard. Based on 2% growth per annum it is anticipated that traffic volumes along Port Kennedy Drive would increase to 16,300 vehicles per day by 2026 and to 20,000 vehicles per day by 2036.

The proposed development is anticipated to result in traffic volumes on Warnbro Sound Avenue increasing by approximately 5,800 vehicles per day north of Port Kennedy Drive and 1,700 vehicles per day south of Port Kennedy Drive at full development. In 2036, this would correspond to 25,800 vehicles per day on Port Kennedy Drive north of Port Kennedy Drive.

As a 4 lane dual carriageway road, Warnbro Sound Avenue is expected to carry similar volumes of traffic as Port Kennedy Drive. On this basis, there is sufficient spare capacity for the additional traffic generated by both local traffic growth and the proposed Structure Plan onto Warnbro Sound Avenue

Figures 6.8.1, 6.8.2 and 6.8.3 show diagrammatically the 2022 traffic volumes, 2036 base traffic volumes and 2036 traffic volumes with full development of the Structure Plan.

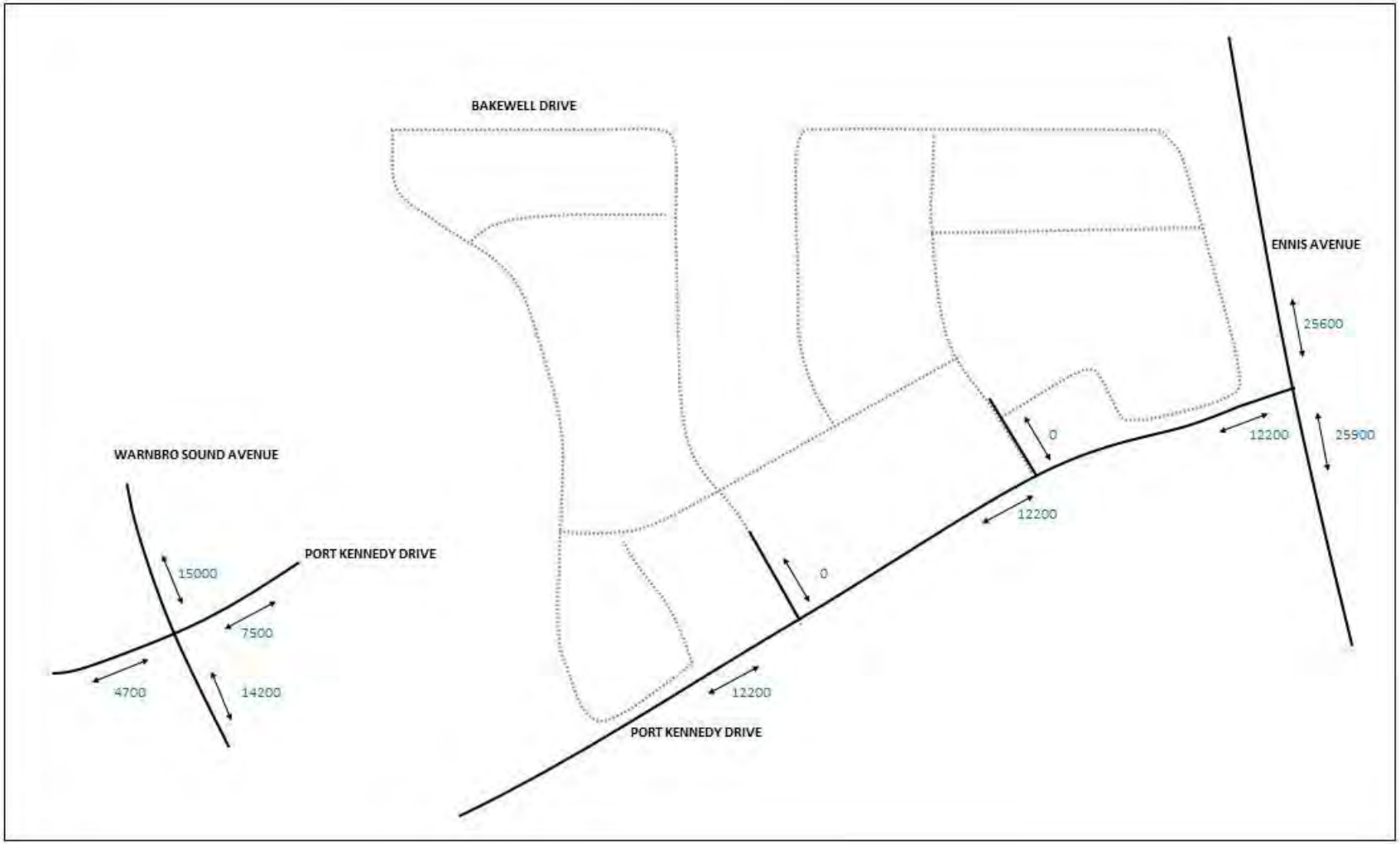

Figure 6.8.1: 2022 Daily Traffic Volumes

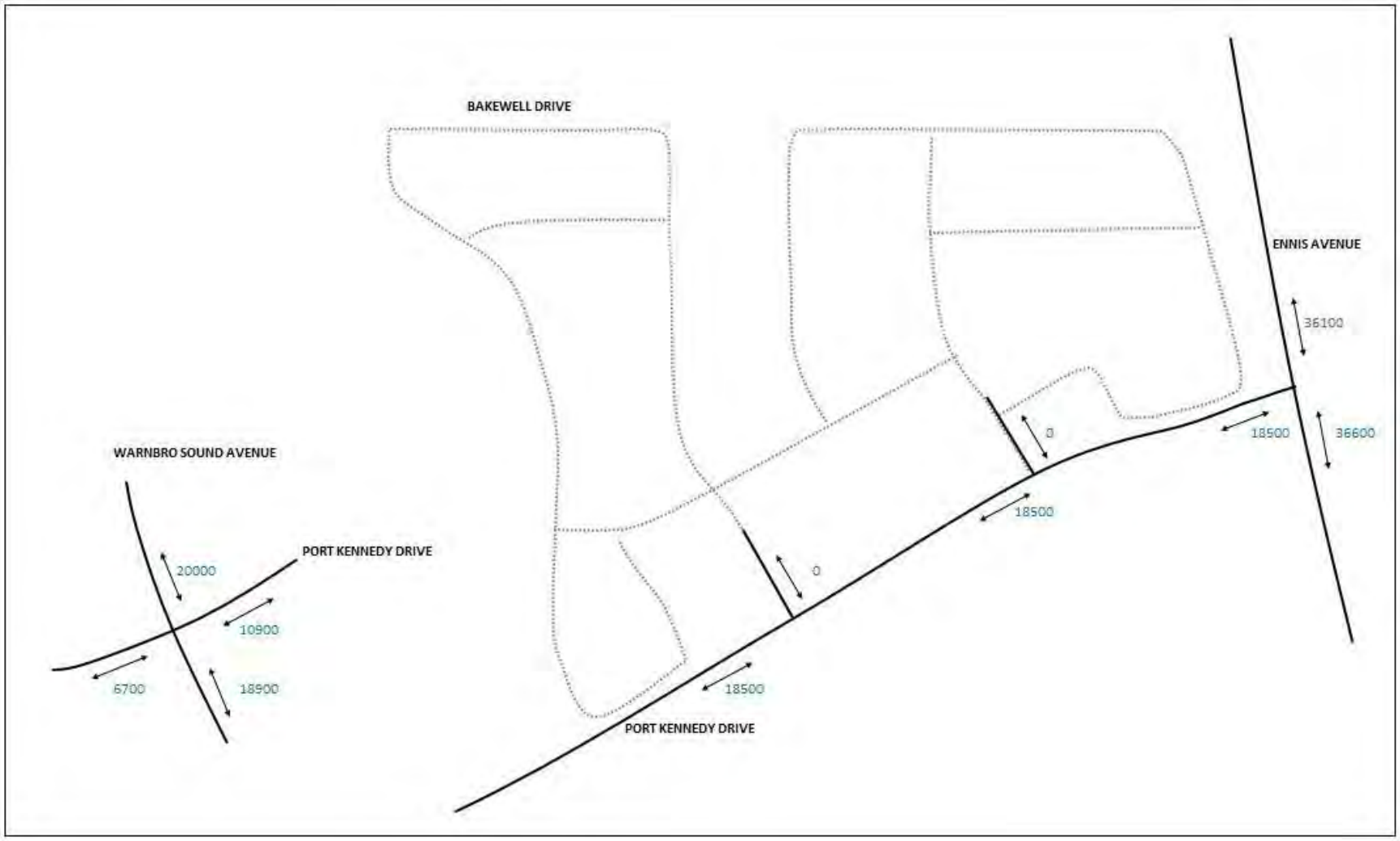

Figure 6.8.2: 2036 Base Flow Daily Traffic Volumes

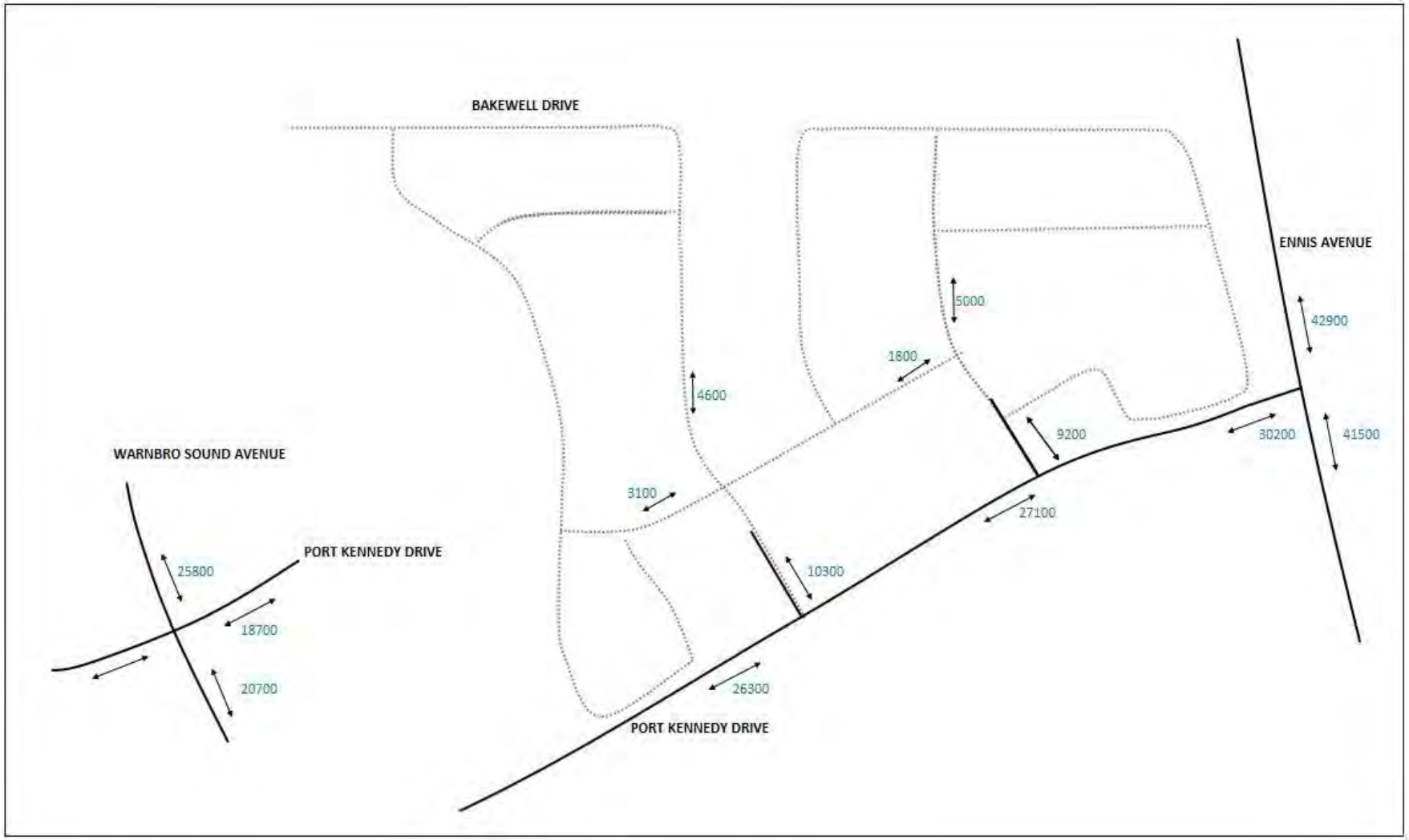

Figure 6.8.3: 2036 Daily Traffic Volumes with Full Development of the Structure Plan

7.0 SUMMARY AND CONCLUSION

The Local Structure Plan for Lot 4 Mandurah Road, Port Kennedy in the City of Rockingham allows for an Industrial Estate / Business Park. The Structure Plan comprises of approximately 35.8 hectares of developable land excluding land designated to public open space.

Port Kennedy Drive, forms the southern boundary to the south and is to provide access to the Structure Plan. This road is classified as a District Distributor Road (DDB) and such the number of connections to this road has been limited to two as requested by the DPLH. The two proposed connections have been located centrally to the Structure Plan development and are approximately evenly spaced along the developable Port Kennedy frontage.

The Structure Plan typically adopts the 20m minimum road reserve as per the Development Control Policy (DCP 4.1) and this will allow a typical two lane single carriageway with a 10m wide pavement. A road reserve width of 25m is proposed for the local distributor roads that includes a length of the proposed north-south road links to Port Kennedy Drive and the new west-east roads connecting these. This widened road reserve will allow for a central island boulevard as well as additional lanes on the intersection approaches to Port Kennedy Drive. The central island boulevard treatment will provide separation of through traffic and restrict right turning movements as required to properties in close proximity to the proposed roundabouts on Port Kennedy Drive to ensure minimum disruption to traffic entering/ exiting the Structure Plan at these locations.

The Structure Plan is estimated to generate in the order of 19,501 vehicle trips per weekday with approximately 1,230 and 2,100 vehicle trips during the am and pm peak hours respectively.

To cater for the future Structure Plan traffic at the two new connections to Port Kennedy Drive in conjunction with through traffic growth over a 10 year time horizon (2036) two dual lane roundabouts are proposed. SIDRA analysis indicates that these roundabouts will operate satisfactory in 2036 with spare capacity i.e. DOS <0.8. The overall level of service will be A that corresponds to an average delay of typically 8-10 seconds. No individual movement has a level of service worse than B or in the order of 15 seconds.

SIDRA analysis has indicated that the intersection of Port Kennedy Drive and Ennis Avenue will require modification in the future in order to accommodate the additional traffic volumes associated with local traffic growth, (excludes the development traffic). The identified modifications works to the signalised intersection comprised of the following:

- Double right turn from Ennis Avenue into Port Kennedy Drive in conjunction with give way control for the Ennis Avenue left turn into Port Kennedy Drive;

- Double right turn from Port Kennedy Drive into Ennis Avenue in conjunction with an appropriate merge treatment along Ennis Avenue southbound; and
- Auxiliary through lane to be provided on Ennis Avenue northbound – south approach.

With these proposed modifications with the 2036 base case traffic scenario (i.e. without development traffic), the SIDRA modelling indicated that the signalised intersection of Port Kennedy Drive and Ennis Avenue would operate at a DOS 0.870 and 0.813 during the am and pm peaks. The average intersection delay was approximately 27 seconds with the highest average delay incurred being 39 seconds.

With the addition of full development traffic in 2036, the SIDRA modelling indicated that the signalised intersection of Port Kennedy Drive and Ennis Avenue would operate at a DOS 0.891 and 0.875 during the am and pm peaks. The average intersection delay was approximately 35 seconds with the highest average delay incurred being 47 seconds. By comparison the 2026 analysis (at opening) with full development indicated that with these improvements the signalised intersection would operate with an average intersection delay of 29 seconds with the highest average delay incurred being 37 seconds.

Whilst the 2026 analysis (at opening) assumes that the Structure Plan will be fully developed the reality is that it will be progressive over a longer time period. Some indicative staging analysis suggests that adequate capacity can be provided for the earlier stages of development with fewer upgrades to the signalised intersection. For example, incorporating double right turns on both Port Kennedy Drive and Ennis Avenue (without the auxiliary Ennis Avenue northbound through lane) would likely be sufficient for Stages 1, 2 or approximately 60% of the Structure Plan at opening (2026) and for an additional 10 years (2036).

Given the signalised intersection needs to be upgraded to cater for the additional traffic growth without the development it is suggested that the upgrade be jointed funded. For the purpose of cost distribution it is considered appropriate to proportion the costs in accordance with the additional traffic using the signalised intersection in the future i.e. development traffic compared to traffic growth. On this basis the development contribution would be in the order of 52% of costs.

SIDRA modelling of the Port Kennedy Drive and Warnbro Sound Avenue indicates that with the additional development traffic in 2036 the intersection would continue to operate satisfactorily with a degree of saturation of 0.424 and 0.777 during the am an pm peak hours. The overall level of service would remain at A with an average delay of 8 seconds during the am peak and will operate with a LOS B during the pm peak which corresponds to an average delay of 12 seconds

Both Port Kennedy Drive and Warnbro Sound Avenue are constructed to a 4 lane dual carriageway standard. Accordingly, there is sufficient spare capacity for the additional traffic generated by the Structure Plan on these roads with resulting traffic volumes in line with their classification and function as District Distributor roads.

In summary, the traffic assessment as documented within this report with various recommendations throughout confirms that the proposed Structure Plan can be accommodated by the proposed internal road network as well as the external road network configurations.

APPENDIX A

Structure Plan Layout

Legend

- Structure Plan Boundary

MRS Reserves

- Parks and Recreation

Local Reserves

- Public Open Space and Drainage

Local Zones

- Port Kennedy Enterprise Zone

Other

- Local Distributor Road 25m Road Reserve
- Local Access Road
- Pedestrian Path
- Dual Use Path
- Principal Shared Path
- Wetland
- Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1
- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Lot 4 and 17 Port Kennedy Drive, Port Kennedy

Date: 8 Feb 2024 Scale: 1:4000 @ A3 1:2000 @ A1 File: **717-278 ST-1** Staff: MR GW Checked: MR

0 40 80m

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APPENDIX B

Forecast.id.com.au Data

https://forecast.id.com.au/rockingham

Population summary

export reset

City of Rockingham	Forecast year							Change between 2016 and 2046	
Area	2016	2021	2026	2031	2036	2041	2046	Total change	Avg. annual % change
City of Rockingham	**128,991**	**139,613**	**158,084**	**178,984**	**201,020**	**221,579**	**239,146**	**+110,155**	**+2.08**
Baldivis (North)	8,349	11,454	17,582	24,795	29,463	31,045	31,352	+23,003	+4.50
Baldivis (South)	24,355	27,345	32,317	36,137	39,080	42,151	44,921	+20,566	+2.06
Cooloongup	6,864	6,849	6,845	6,827	6,853	6,822	6,794	-70	-0.03
Golden Bay	3,898	5,177	6,345	7,654	8,408	8,927	9,086	+5,188	+2.86
Hillman - East Rockingham	2,190	2,226	2,273	2,298	2,350	2,343	2,344	+154	+0.23
Karnup - Keralup	1,425	2,468	4,324	10,582	20,938	32,654	43,879	+42,454	+12.09
Port Kennedy	14,228	13,770	13,919	14,518	15,279	15,805	15,911	+1,683	+0.37
Rockingham (Balance) - Peron - Garden Island	9,892	10,146	11,039	11,433	11,801	11,983	12,178	+2,286	+0.69
Rockingham City Centre	5,811	6,844	7,637	8,810	11,032	14,477	17,599	+11,788	+3.76
Safety Bay	7,754	7,910	8,279	8,414	8,496	8,597	8,701	+947	+0.38
Secret Harbour	12,447	12,603	13,156	12,973	12,727	12,519	12,369	-78	-0.02
Shoalwater	4,180	4,361	4,477	4,542	4,558	4,528	4,506	+326	+0.25
Singleton	3,854	4,350	5,014	5,320	5,421	5,332	5,253	+1,399	+1.04
Waikiki	12,752	13,146	13,936	13,782	13,755	13,634	13,555	+803	+0.20
Warnbro	10,992	10,966	10,941	10,897	10,859	10,762	10,698	-294	-0.09

Population and household forecasts, 2016 to 2046, prepared by id, the population experts, June 2020

https://profile.id.com.au/rockingham/workers

Overview

Residential location of local workers

export

City of Rockingham	2016	
Location	**Number**	**%**
Live and work in the area	21,168	70.6
Work in the area, but live outside	8,812	29.4
Total workers in the area	29,980	100.0

Residential location of local workers by LGA

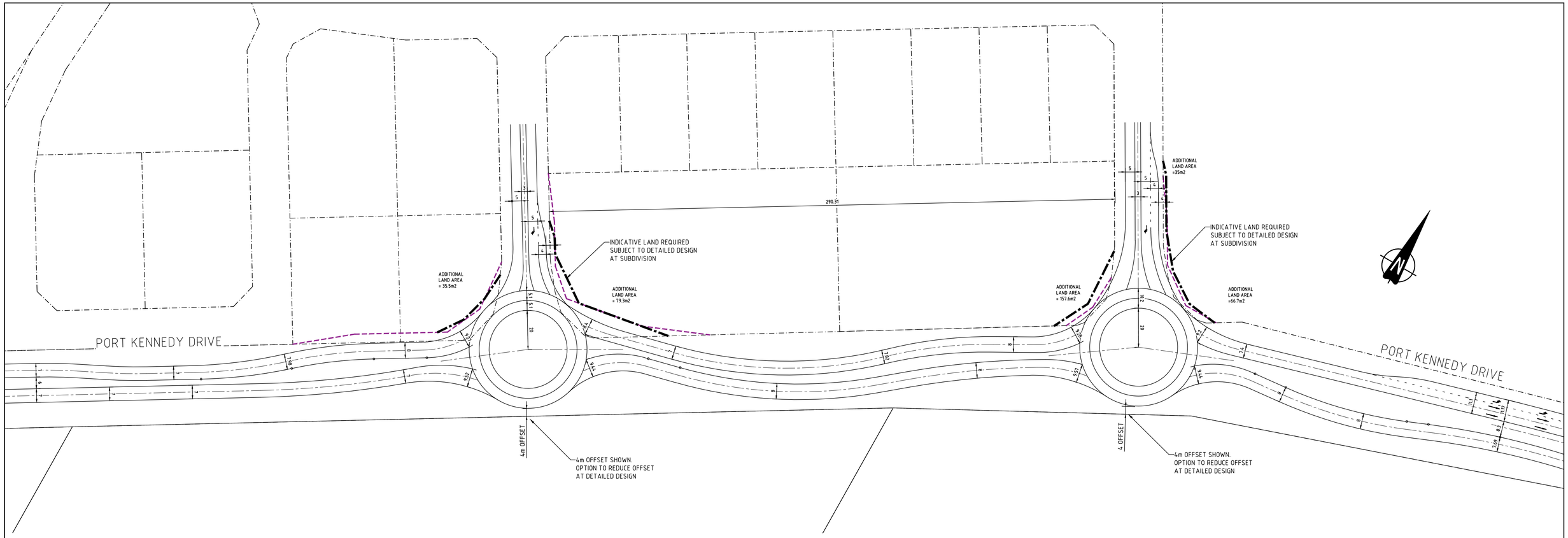
export reset

City of Rockingham	2016	
LGA	**Number**	**Percentage**
Rockingham (C)	21,168	70.6
Mandurah (C)	2,067	6.9
Kwinana (C)	1,749	5.8
Cockburn (C)	1,138	3.8
Melville (C)	496	1.7
Serpentine-Jarrahdale (S)	412	1.4
Armadale (C)	376	1.3
Murray (S)	349	1.2
Gosnells (C)	337	1.1
Canning (C)	277	0.9
Fremantle (C)	208	0.7
Stirling (C)	207	0.7
South Perth (C)	146	0.5
Wanneroo (C)	93	0.3
Joondalup (C)	81	0.3
Kalamunda (S)	81	0.3
Swan (C)	76	0.3
Bayswater (C)	67	0.2
Victoria Park (T)	64	0.2
Perth (C)	46	0.2

Show me more!

APPENDIX C

Port Kennedy Drive Intersections and Concept Layouts



ROUNDABOUT LAYOUT

SCALE 1:250

MIN CENTRAL ISLAND RADIUS 20m BASED ON AUSTROADS MINIMUM
PRE-DEFLECTIONS BASED ON MRWA DRAWING 200331-0203
10.2m LANE WIDTH BASED ON AUSTROADS CIRCULATING WIDTH (TOTAL)
ADDITIONAL AREA SHOWN IN GREEN HATCH (BASED ON 4m OFFSET FROM FACE OF KERB)

1:1000 0 10 20 40 60
Half Size 1:2000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
C	22-11-2023	UPDATED LEFT SLIP LANE TO 30m STORAGE	MJV
B	15-8-2023	ROUNDABOUTS UPDATED TO MEET MRWA REQUIREMENTS.	MJV
A	17-5-2023	ISSUED FOR 25% DESIGN REVIEW	MJV

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@porterenq.com.au
www.porterenq.com.au

TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

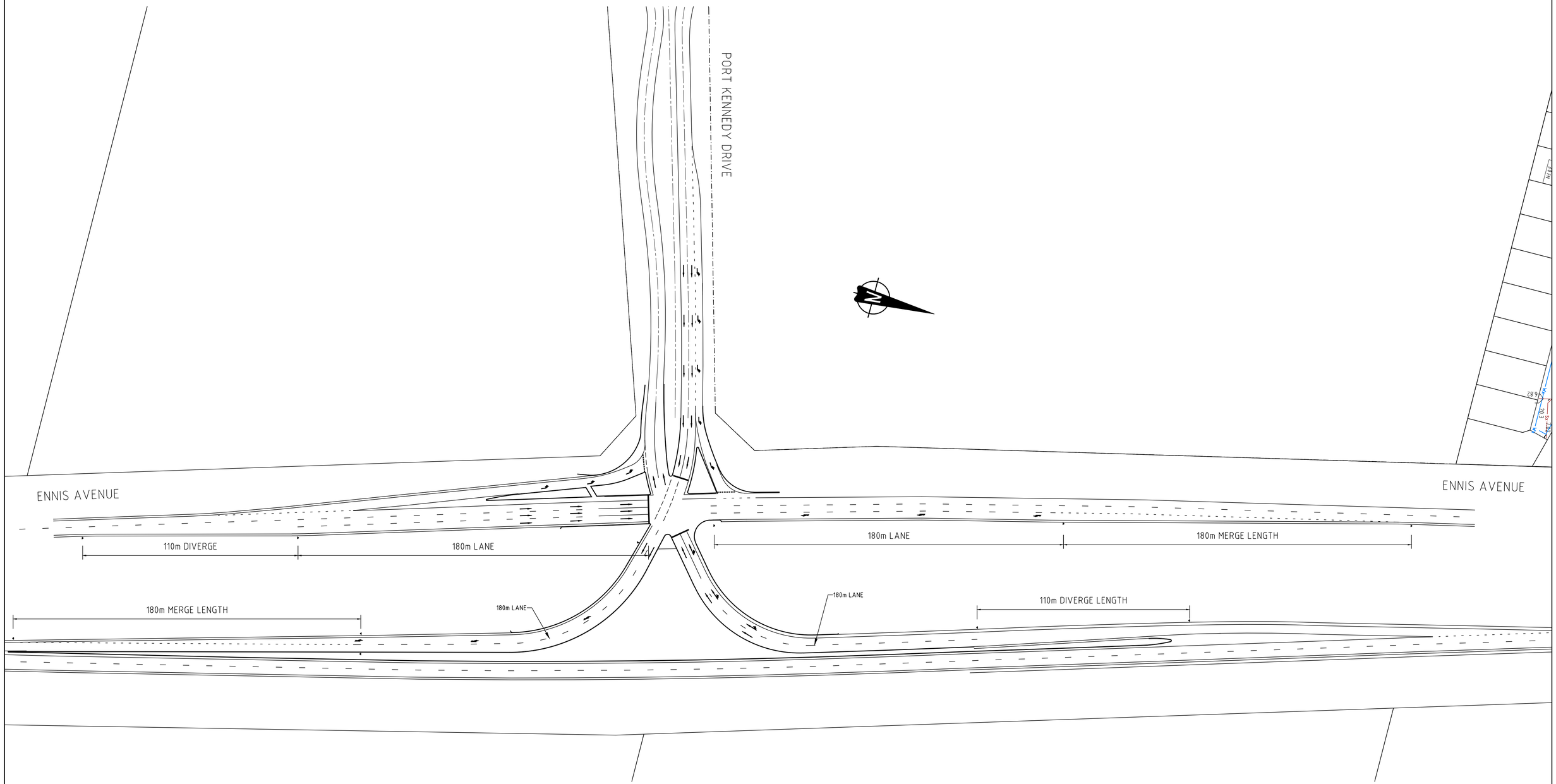
CLIENT:
DEVELOPMENT WA

DRAWING:
ROUNDABOUT CONCEPT LAYOUT
MINIMUM 20m RADIUS

STATUS: **FOR COMMENT**

SCALE	1:1000
DATE	AUG 2023
DESIGN	JH
DRAWN	MV
CHECK	
APP'D	

DRAWING No. **18-6-73/936**
REV No. **C**
ORIGINAL DRAWING SIZE **A1**
FILE NAME ..3\ACAD_PLANNING\18673-935-936.dwg



1:1000 0 10 20 40 60
Half Size 1:2000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
B	22-11-2023	VIEWPORT ALTERED. ISSUE DIN REPORT.	MJV
A	17-5-2023	ISSUED FOR 25% DESIGN REVIEW	MJV

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

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www.porterenq.com.au

TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:
DEVELOPMENT WA

DRAWING:
ENNIS AVE - PORT KENNEDY DRIVE INTERSECTION LAYOUT - CONCEPT

STATUS: **FOR COMMENT**

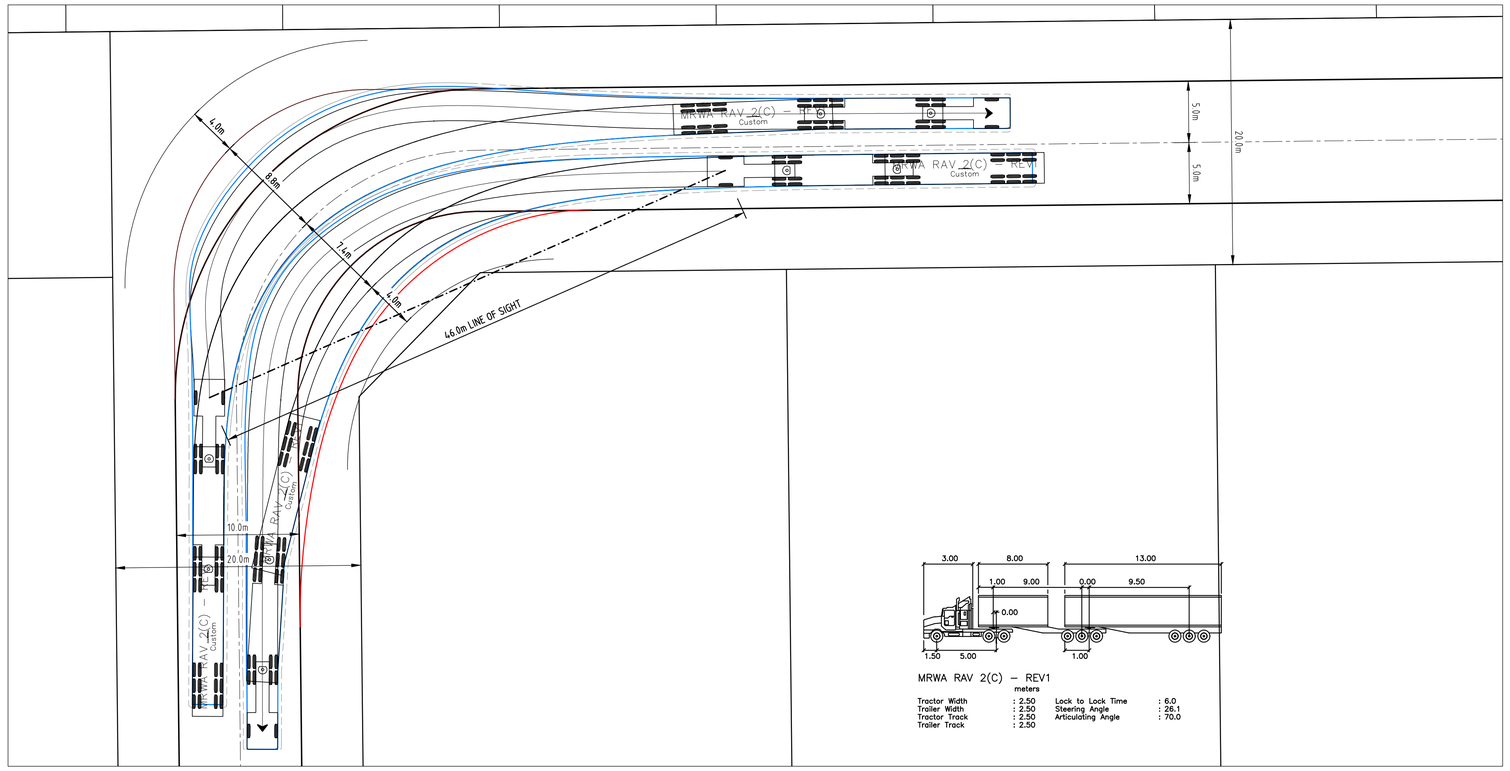
SCALE	1:1000
DATE	MAY 2023
DESIGN	JH
DRAWN	MV
CHECK	
APP'D	

DRAWING No. **18-6-73/931**

REV No. **B**

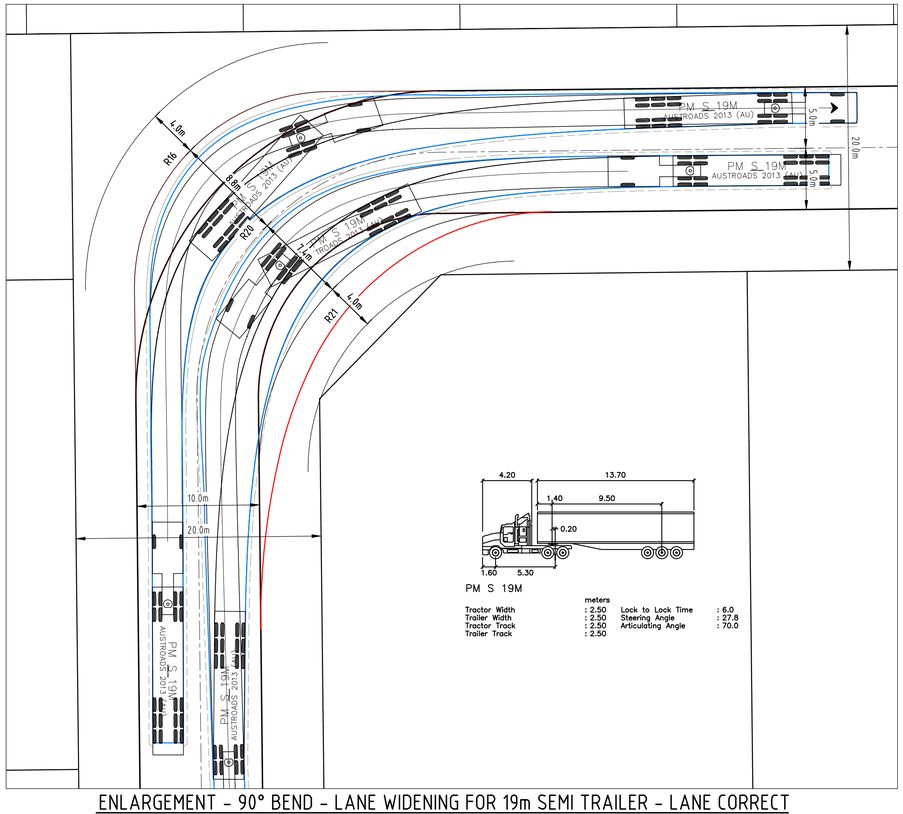
ORIGINAL DRAWING SIZE **A1**

FILE NAME J:\ACAD_PLANNING\18673-930-934.dwg



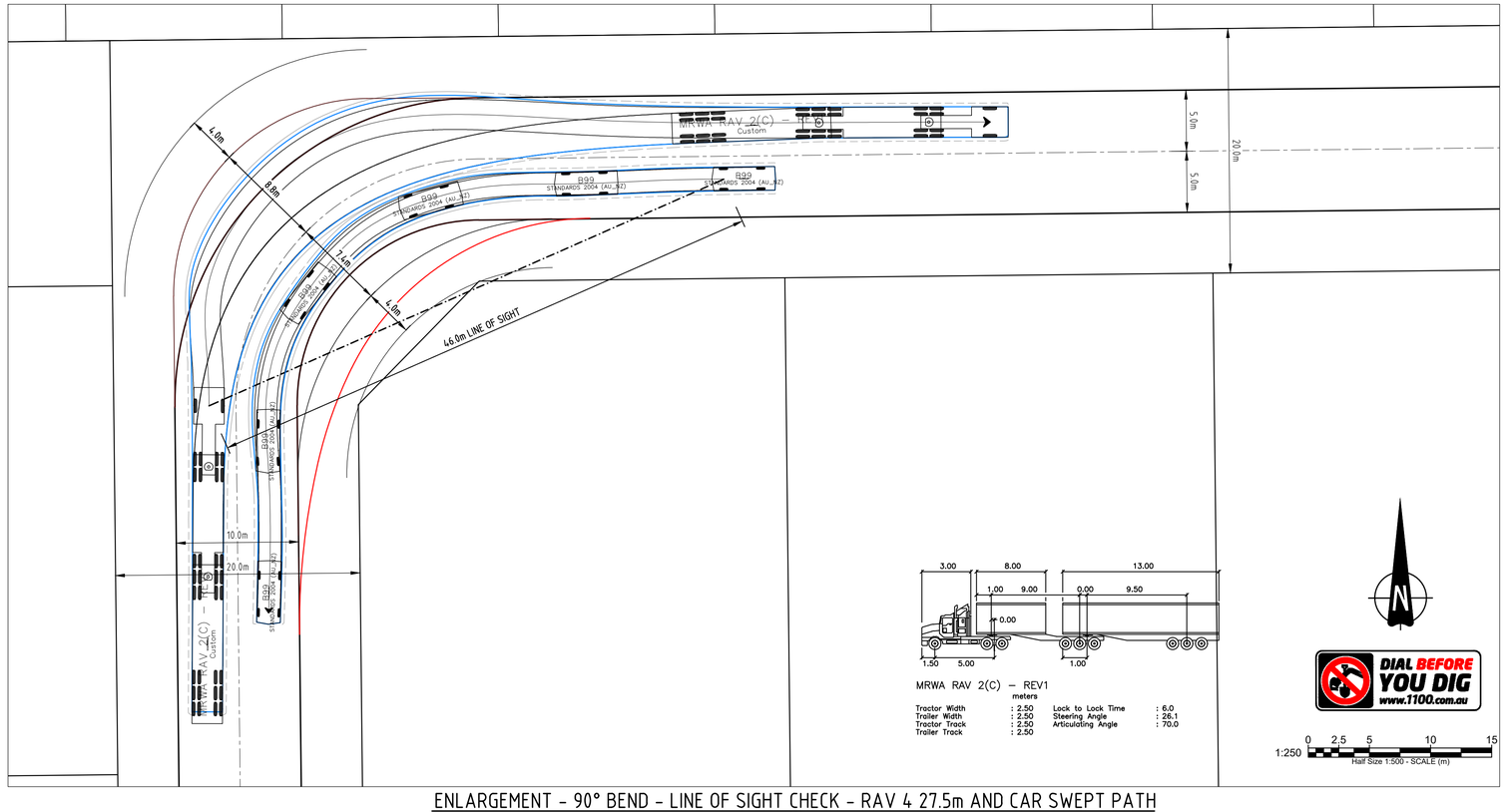
ENLARGEMENT - 90° BEND - LINE OF SIGHT CHECK - RAV 4 27.5m SWEPT PATHS

1:250



ENLARGEMENT - 90° BEND - LANE WIDENING FOR 19m SEMI TRAILER - LANE CORRECT

1:250



ENLARGEMENT - 90° BEND - LINE OF SIGHT CHECK - RAV 4 27.5m AND CAR SWEPT PATH

1:250

PROJECT:

LOT 4 & LOT 17 PORT KENNEDY DRIVE, PORT KENNEDY

No.	DATE	REVISION	BY
B	19-4-2023	UPDATED TO LOT LAYOUT OPTION 4A	MEG
A	17-12-2020	ISSUED FOR COMMENT	MJV

Porter Consulting Engineers

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Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@porterceng.com.au
www.porterceng.com.au

TUSMO Pty Ltd ACN 070 997 968 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

DEVELOPMENT WA

DRAWING:

RIGHT ANGLE BEND
19m SEMI TRAILER AND
MRWA RAV 4 27.5m SWEPT PATHS

STATUS: **FOR COMMENT**

SCALE	1:250
DATE	DEC 2020
DESIGN	JH
DRAWN	MJV
CHECK	
APP'D	

DRAWING No. **18-6-73/804** REV No. **B** ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD\18673-804.dwg

APPENDIX D

Land Use Trip Generation Review Data

Bulky Goods/Showroom

- Source: RTA Trip Generation and Parking Generation Surveys, Bulky Goods /Hardware Stores, Analysis Report, May 2009
- Non-metropolitan sites generally had higher trip rates than the metropolitan sites hence in this instance trip rates were adopted based on the reported non-metropolitan sites.
- Average Site Peak Hour Rate = 2.92 trips per 100m2 GFA
- Road Network Am Peak – stores are not typically open during the am peak hour 7-9am hence no rates reported. For the purpose of the assessment a nominal allowance for staff arrivals has been made during this time.
- Road Network Pm Peak – 1.51 trips per 100m2 GFA
- Daily Vehicle Trip – 18.08 trips per 100m2 GFA

Storage Warehouse

- Source: RTA Guide to Trip Generating Developments, May 2009
- Am Peak = 0.5 trips per 100m2 GFA – this is assumed to correspond to the road network am peak
- Pm Peak = no rate specified – assumed to be the same as the am peak i.e. 0.5 trips per 100m2 GFA
- Daily Vehicle Trip – 4 trips per 100m2 GFA

Light Industrial

- Source: RTA Guide to Trip Generating Developments, May 2009 -Factories
- Am Peak = no rate specified – assumed to be the same as the pm peak i.e. 1 trips per 100m2 GFA
- Pm Peak = 1 trips per 100m2 GFA – this is assumed to correspond to the road network pm peak
- Daily Vehicle Trips = 5 trips per 100m2 GFA

Office

- Source: RTA Trip Generation and Parking Generation Surveys, Office Blocks, Analysis Report, Sept 2010
- Am peak = 1.6 trips per 100m2 GFA
- Pm Peak = 1.2 trips per 100m2 GFA
- Road Network Am Peak = 1.19 trips per 100m2 GFA
- Road Network Pm Peak = 0.82 trips per 100m2 GFA
- Daily Vehicle Trips = 10.98 trips per 100m2 GFA
- Higher am/pm rates adopted for robust assessment

Medical Consulting Rooms

- Source: Transport Roads and Maritime Services, Trip Generation Surveys, Medical Centres, Analysis Report, August 2015
- No data available for consulting rooms therefore adopted medical centre rates. Rates per doctor are likely to be robust as GP appointment times are typically less than say a physiotherapy treatment appointment i.e. 15 minutes verses 30 minutes.
- Road Network Am Peak = 3 trips per doctor
- Road Network Am Peak = 2.4 trips per doctor

- Daily Vehicle Trips = 22.7 trips per doctor
- 1.6 doctors per 100m2 GFA

Gymnasium

- Source: RTA Guide to Trip Generating Developments, May 2009, ITE Trip Generation Manual.
- Non-metropolitan sites generally had higher trip rates than the metropolitan sites hence in this instance trip rates were adopted based on the reported non-metropolitan sites.
- Pm Peak Hour Rate = 9 trips per 100m2 GFA
- Daily Vehicle Trip = 45 trips per 100m2 GFA
- Road Network Am Peak = 2.68 trips per 100m2 GFA
  – estimated from ITE data split i.e. am road peak/pm peak x RTA pm peak
- Road Network Pm Peak = 8.98 trips per 100m2 GFA
  – estimated from ITE data split i.e. pm road peak/pm peak x RTA pm peak

Recreational Community Centre

- Source: ITE Trip Generation Manual.
- Road Network Am Peak = 2.21 trips per 100m2 GFA
- Road Network Pm Peak = 2.95 trips per 100m2 GFA
- Daily Vehicle Trip = 36 trips per 100m2 GFA

APPENDIX E

ROM24 Output

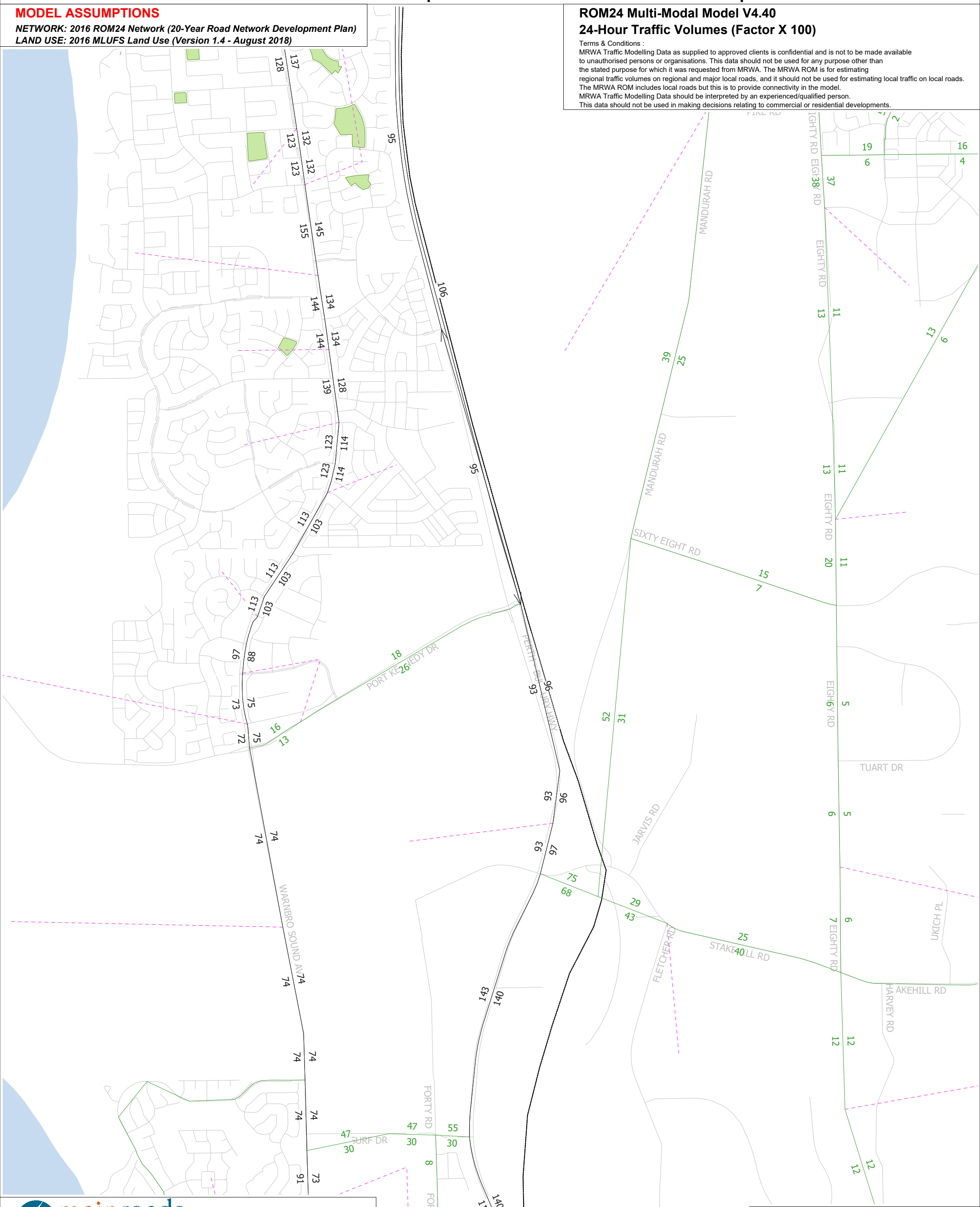
2016 ROM24 Scenario - Link Volume Plot for Port Kennedy Dr, Port Kennedy Traffic Assessment
All Day
MLUFS Version 1.4 land use assumption with 20-Year Road Network Development Plan

MODEL ASSUMPTIONS

NETWORK: 2016 ROM24 Network (20-Year Road Network Development Plan)
LAND USE: 2016 MLUFS Land Use (Version 1.4 - August 2018)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model.
MRWA Traffic Modelling Data should be interpreted by an experienced/qualified person.
This data should not be used in making decisions relating to commercial or residential developments.



mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Thomas Ng 9323 6366
MRWA Reference Job #42414
Mon 07 Nov 2022
T:\VOYAGER\JOBS_V2022\42414\Reports\LVP\42414_LVP_All Day_Y16_Port Kennedy Dr_Port Kennedy.VPR

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- >=4 Lanes Each Direction
- Zone Connector

2021 ROM24 Scenario - Link Volume Plot for Port Kennedy Dr, Port Kennedy Traffic Assessment
All Day
MLUFS Version 1.4 land use assumption with 20-Year Road Network Development Plan

MODEL ASSUMPTIONS

NETWORK: 2021 ROM24 Network (20-Year Road Network Development Plan) with modification to Port Kennedy Dr - 4 lane divided arterial
LAND USE: 2021 MLUFS Land Use (Version 1.4 - August 2018)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model.
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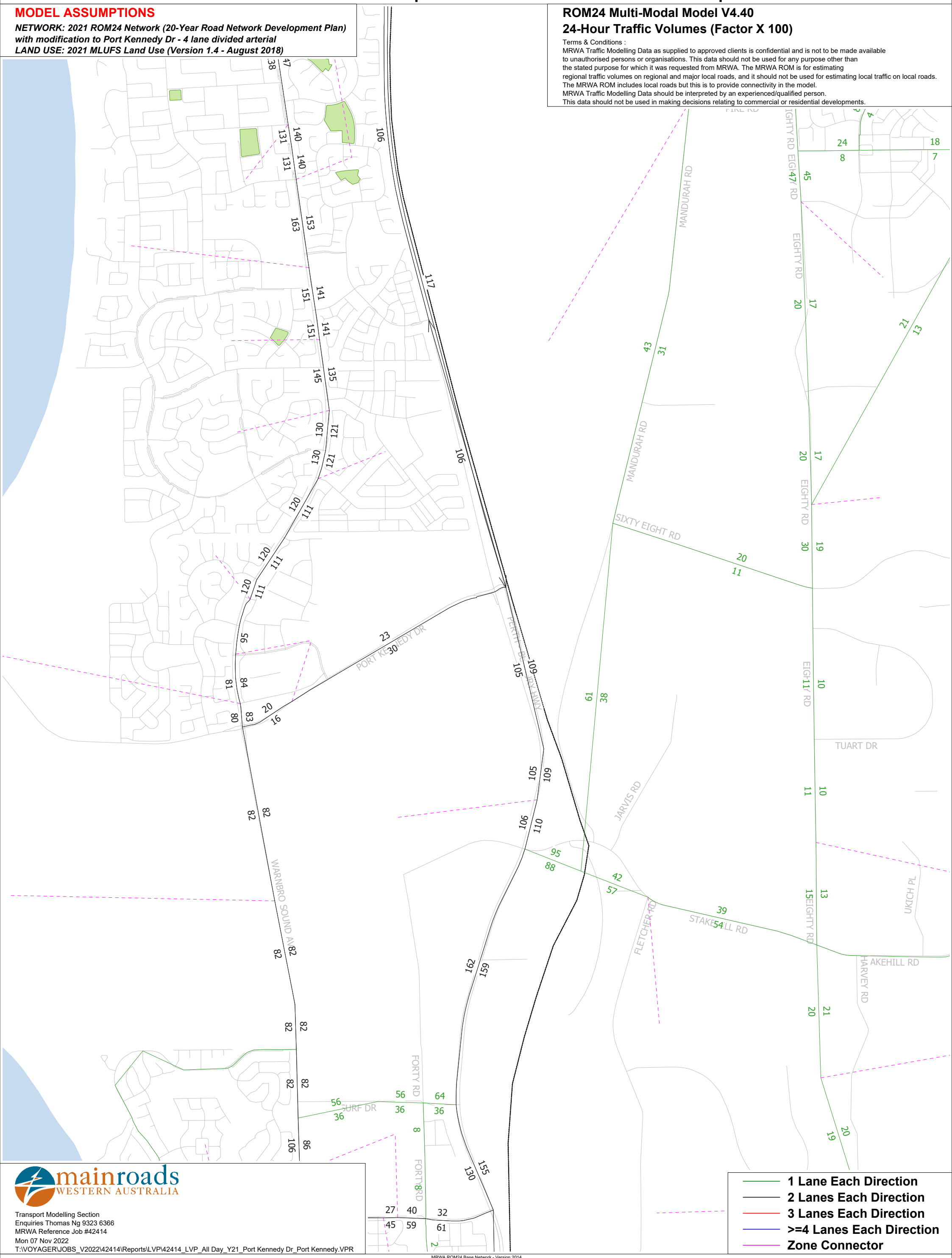

mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Thomas Ng 9323 6366
MRWA Reference Job #42414
Mon 07 Nov 2022
T:\VOYAGER\JOBS_V2022\42414\Reports\LVP\42414_LVP_All Day_Y21_Port Kennedy Dr_Port Kennedy.VPR

2026 ROM24 Scenario - Link Volume Plot for Port Kennedy Dr, Port Kennedy Traffic Assessment
All Day
MLUFS Version 1.4 land use assumption with 20-Year Road Network Development Plan

MODEL ASSUMPTIONS

NETWORK: 2026 ROM24 Network (20-Year Road Network Development Plan) with modification to Port Kennedy Dr - 4 lane divided arterial
LAND USE: 2026 MLUFS Land Use (Version 1.4 - August 2018)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
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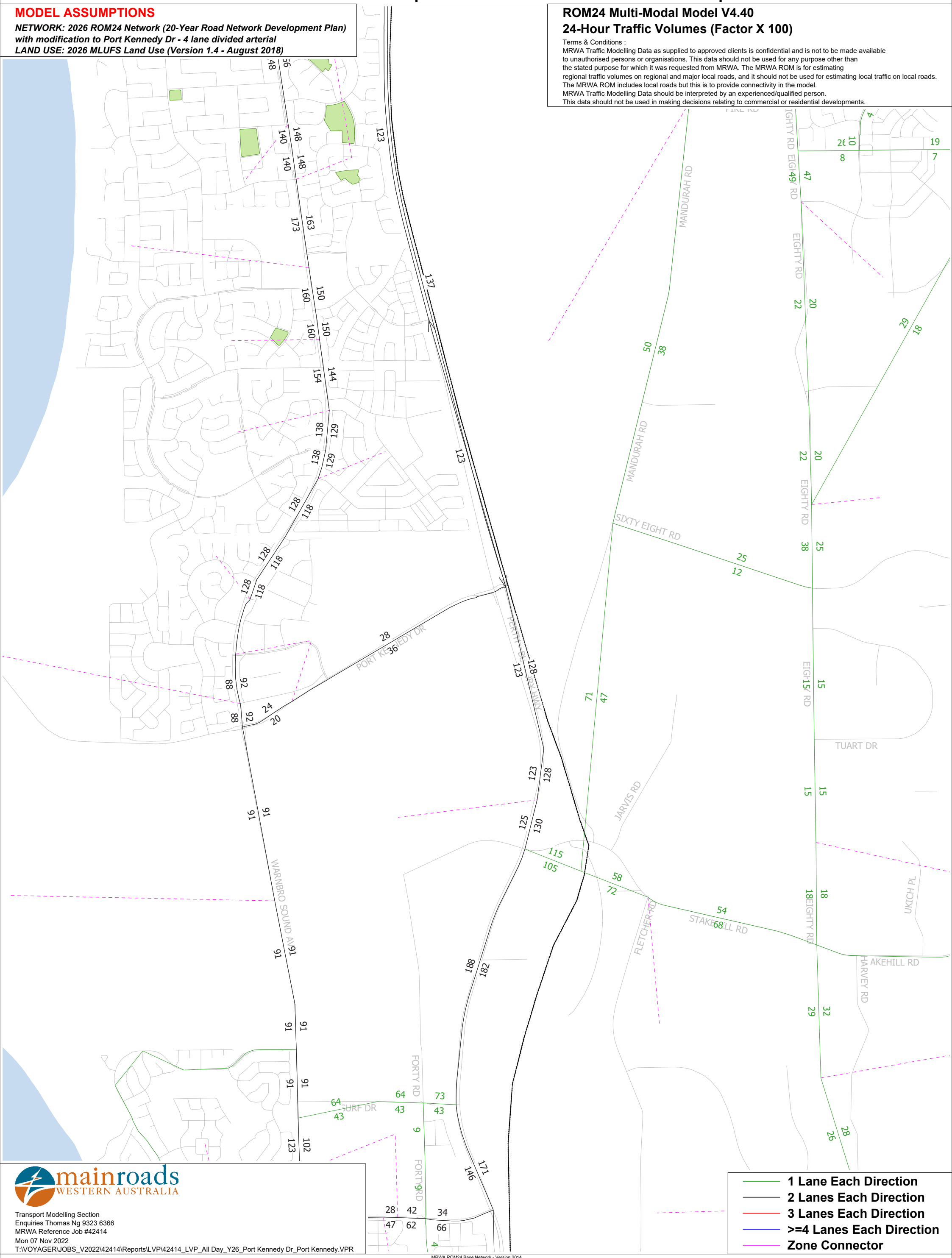

mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Thomas Ng 9323 6366
MRWA Reference Job #42414
Mon 07 Nov 2022
T:\VOYAGER\JOBS_V2022\42414\Reports\LVP\42414_LVP_All Day_Y26_Port Kennedy Dr_Port Kennedy.VPR

2031 ROM24 Scenario - Link Volume Plot for Port Kennedy Dr, Port Kennedy Traffic Assessment
All Day
MLUFS Version 1.4 land use assumption with 20-Year Road Network Development Plan

MODEL ASSUMPTIONS

NETWORK: 2031 ROM24 Network (20-Year Road Network Development Plan) with modification to Port Kennedy Dr - 4 lane divided arterial
LAND USE: 2031 MLUFS Land Use (Version 1.4 - August 2018)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
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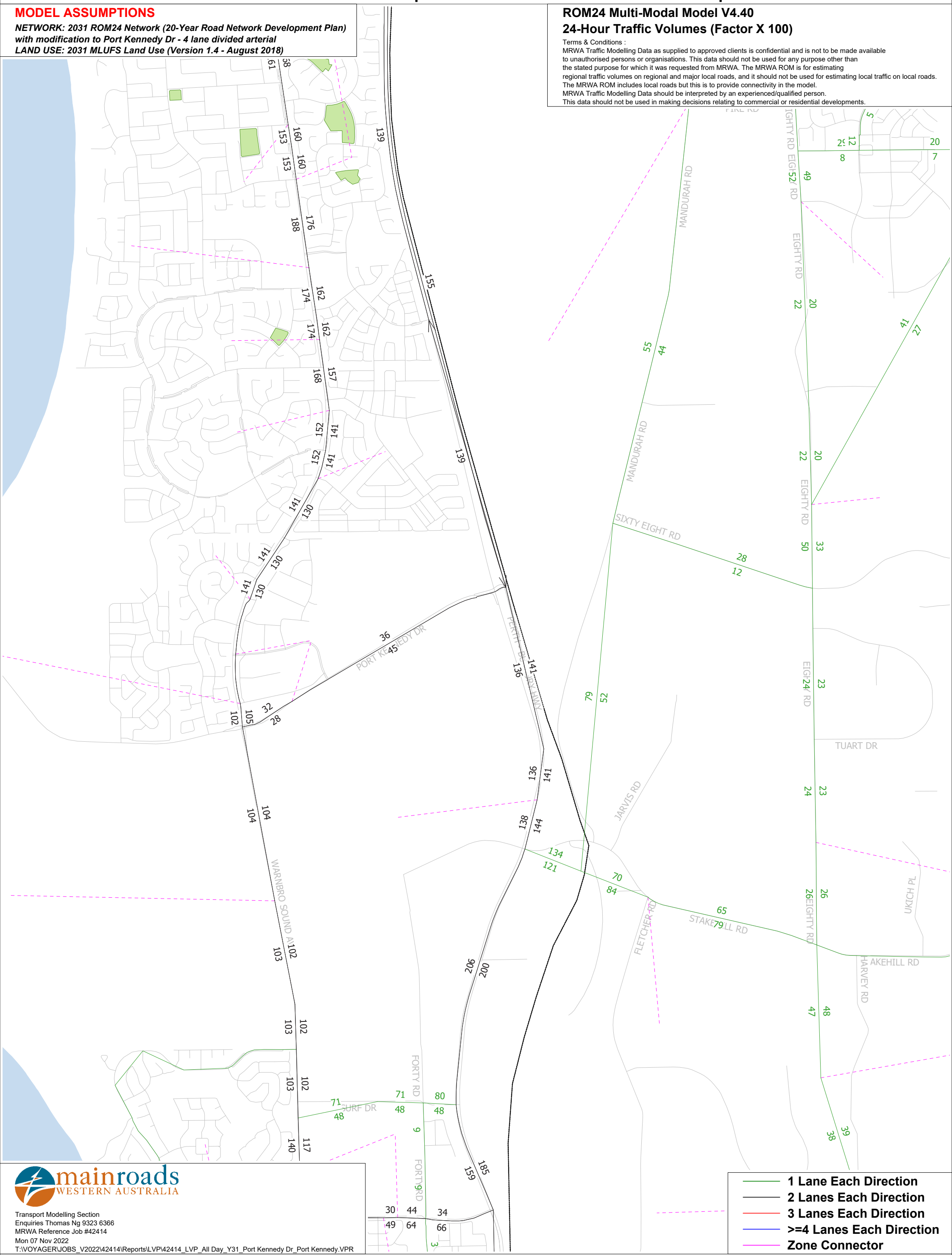

1 Lane Each Direction
2 Lanes Each Direction
3 Lanes Each Direction
>=4 Lanes Each Direction
Zone Connector

mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Thomas Ng 9323 6366
MRWA Reference Job #42414
Mon 07 Nov 2022
T:\VOYAGER\JOBS_V2022\42414\Reports\LVP\42414_LVP_All Day_Y31_Port Kennedy Dr_Port Kennedy.VPR

cube (Licensed to)

2036 ROM24 Scenario - Link Volume Plot for Port Kennedy Dr, Port Kennedy Traffic Assessment
All Day
MLUFS Version 1.4 land use assumption with 20-Year Road Network Development Plan

MODEL ASSUMPTIONS

NETWORK: 2036 ROM24 Network (20-Year Road Network Development Plan) with modification to Port Kennedy Dr - 4 lane divided arterial
LAND USE: 2036 MLUFS Land Use (Version 1.4 - August 2018)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model.
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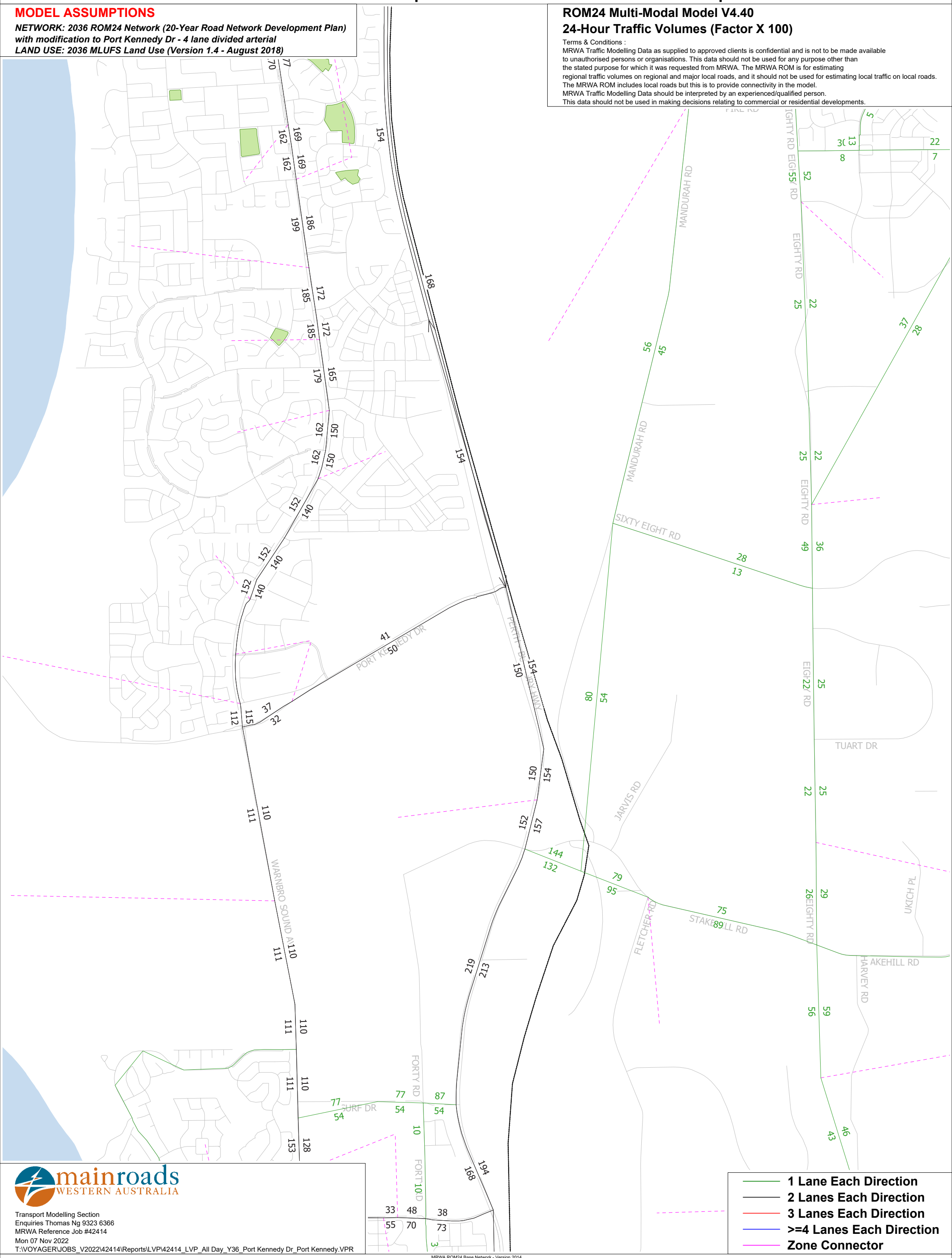


mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Thomas Ng 9323 6366
MRWA Reference Job #42414
Mon 07 Nov 2022
T:\VOYAGER\JOBS_V2022\42414\Reports\LVP\42414_LVP_All Day_Y36_Port Kennedy Dr_Port Kennedy.VPR

APPENDIX F

SIDRA Detailed Results

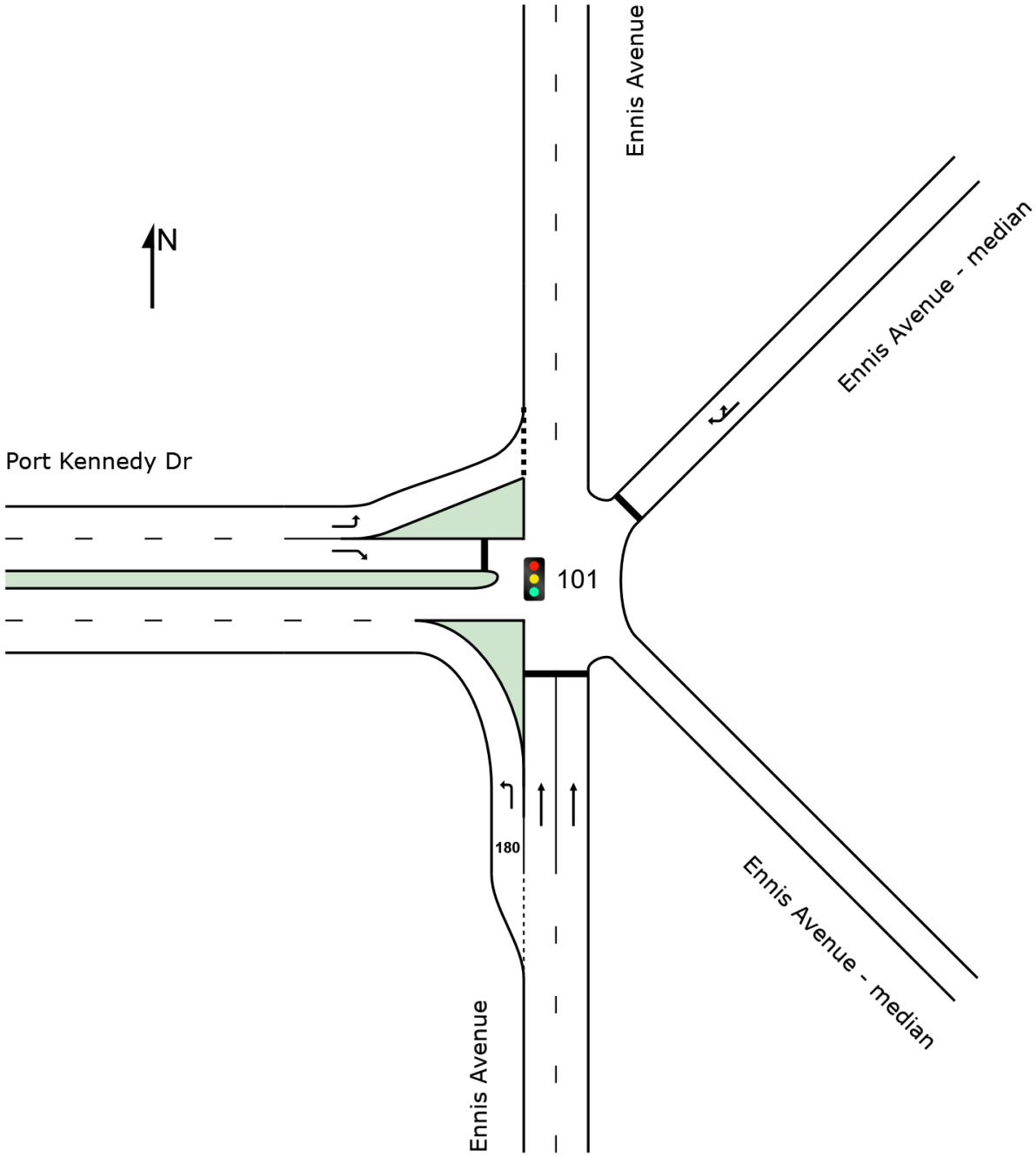
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Existing Layout – Base Traffic 2022, 2026 and 2036 – No development

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak Existing - Calibrated (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak Existing - Calibrated (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 87 seconds (Site User-Given Phase Times)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	255	9.1	255	9.1	0.143	7.5	LOS A	0.0	0.0	0.00	0.59	0.00	60.0
2	T1	All MCs	1221	2.7	1221	2.7	* 0.827	31.6	LOS C	26.6	201.0	0.98	0.93	1.08	47.2
Approach			1476	3.8	1476	3.8	0.827	27.4	LOS C	26.6	201.0	0.81	0.87	0.90	48.9
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	189	5.0	189	5.0	* 0.697	47.4	LOS D	8.2	63.6	1.00	0.85	1.09	35.6
26b	R3	All MCs	1	0.0	1	0.0	0.697	48.4	LOS D	8.2	63.6	1.00	0.85	1.09	37.5
Approach			191	5.0	191	5.0	0.697	47.4	LOS D	8.2	63.6	1.00	0.85	1.09	35.6
West: Port Kennedy Dr															
10	L2	All MCs	279	7.5	279	7.5	0.352	15.2	LOS B	5.5	43.6	0.58	0.76	0.58	53.9
12a	R1	All MCs	242	11.7	242	11.7	* 0.734	45.3	LOS D	10.4	90.6	1.00	0.88	1.10	36.1
Approach			521	9.5	521	9.5	0.734	29.2	LOS C	10.4	90.6	0.78	0.81	0.82	43.9
All Vehicles			2187	5.2	2187	5.2	0.827	29.6	LOS C	26.6	201.0	0.82	0.86	0.90	46.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak Existing - Calibrated (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site User-Given Phase Times)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	319	4.6	319	4.6	0.174	7.6	LOS A	0.0	0.0	0.00	0.60	0.00	61.5
2	T1	All MCs	689	2.0	689	2.0	* 0.641	31.9	LOS C	14.0	104.8	0.94	0.80	0.94	47.1
Approach			1008	2.8	1008	2.8	0.641	24.2	LOS C	14.0	104.8	0.64	0.74	0.64	50.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	383	1.9	383	1.9	* 0.899	55.5	LOS E	19.8	148.2	1.00	1.02	1.32	32.9
26b	R3	All MCs	1	0.0	1	0.0	0.899	56.5	LOS E	19.8	148.2	1.00	1.02	1.32	34.7
Approach			384	1.9	384	1.9	0.899	55.5	LOS E	19.8	148.2	1.00	1.02	1.32	32.9
West: Port Kennedy Dr															
10	L2	All MCs	208	5.6	208	5.6	0.203	10.3	LOS B	2.3	18.3	0.36	0.70	0.36	58.9
12a	R1	All MCs	311	2.0	311	2.0	* 0.730	43.4	LOS D	13.4	101.1	0.99	0.87	1.05	37.4
Approach			519	3.4	519	3.4	0.730	30.1	LOS C	13.4	101.1	0.73	0.80	0.78	43.8
All Vehicles			1912	2.8	1912	2.8	0.899	32.1	LOS C	19.8	148.2	0.74	0.81	0.82	44.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak Existing ROM 2026 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.161	7.5	LOS A	0.0	0.0	0.00	0.59	0.00	60.0
2	T1	All MCs	1347	2.7	1347	2.7	* 0.863	34.6	LOS C	31.9	241.0	0.99	0.98	1.13	45.5
Approach			1634	3.8	1634	3.8	0.863	29.8	LOS C	31.9	241.0	0.82	0.91	0.93	47.3
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.813	52.7	LOS D	10.2	78.8	1.00	0.93	1.23	33.7
26b	R3	All MCs	1	0.0	1	0.0	0.813	53.7	LOS D	10.2	78.8	1.00	0.93	1.23	35.6
Approach			215	5.0	215	5.0	0.813	52.7	LOS D	10.2	78.8	1.00	0.93	1.23	33.7
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.419	17.0	LOS B	7.2	57.1	0.64	0.78	0.64	52.4
12a	R1	All MCs	273	11.7	273	11.7	* 0.855	53.2	LOS D	13.4	116.6	1.00	0.98	1.28	33.2
Approach			586	9.5	586	9.5	0.855	33.8	LOS C	13.4	116.6	0.81	0.87	0.94	41.3
All Vehicles			2435	5.3	2435	5.3	0.863	32.8	LOS C	31.9	241.0	0.83	0.90	0.96	44.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak Existing ROM 2026 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.196	7.6	LOS A	0.0	0.0	0.00	0.60	0.00	61.5
2	T1	All MCs	761	2.0	761	2.0	* 0.888	43.6	LOS D	17.8	133.9	1.00	1.04	1.33	40.9
Approach			1120	2.8	1120	2.8	0.888	32.1	LOS C	17.8	133.9	0.68	0.90	0.91	45.5
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.900	50.1	LOS D	20.1	150.9	1.00	1.03	1.34	34.8
26b	R3	All MCs	1	0.0	1	0.0	0.900	51.1	LOS D	20.1	150.9	1.00	1.03	1.34	36.5
Approach			433	1.9	433	1.9	0.900	50.1	LOS D	20.1	150.9	1.00	1.03	1.34	34.8
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.236	11.0	LOS B	2.8	22.0	0.43	0.71	0.43	58.1
12a	R1	All MCs	349	2.0	349	2.0	* 0.859	47.0	LOS D	15.4	116.3	1.00	0.98	1.28	35.9
Approach			584	3.4	584	3.4	0.859	32.6	LOS C	15.4	116.3	0.77	0.87	0.94	42.4
All Vehicles			2137	2.8	2137	2.8	0.900	35.9	LOS D	20.1	150.9	0.77	0.92	1.00	42.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak Existing ROM 2036 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	385	9.1	385	9.1	0.216	7.6	LOS A	0.0	0.0	0.00	0.59	0.00	59.9
2	T1	All MCs	1725	2.7	1725	2.7	* 0.983	79.3	LOS E	85.5	646.8	1.00	1.18	1.25	30.0
Approach			2111	3.8	2111	3.8	0.983	67.4	LOS E	85.5	646.8	0.82	1.08	1.02	32.8
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	286	5.0	286	5.0	* 0.988	112.1	LOS F	27.1	209.5	1.00	1.08	1.45	21.0
26b	R3	All MCs	1	0.0	1	0.0	0.988	113.1	LOS F	27.1	209.5	1.00	1.08	1.45	22.6
Approach			287	5.0	287	5.0	0.988	112.1	LOS F	27.1	209.5	1.00	1.08	1.45	21.0
West: Port Kennedy Dr															
10	L2	All MCs	422	7.5	422	7.5	0.672	42.8	LOS D	23.8	189.6	0.91	0.92	0.91	37.3
12a	R1	All MCs	366	11.7	366	11.7	* 0.988	109.4	LOS F	35.0	304.6	1.00	1.10	1.42	21.2
Approach			788	9.5	788	9.5	0.988	73.7	LOS E	35.0	304.6	0.95	1.00	1.15	27.6
All Vehicles			3186	5.3	3186	5.3	0.988	72.2	LOS E	85.5	646.8	0.87	1.06	1.09	30.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

PHASING SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak Existing ROM 2036 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog
Phase Times determined by the program
Phase Sequence: Leading Right Turn
Input Phase Sequence: A, B, C
Output Phase Sequence: A, B, C
Reference Phase: Phase A

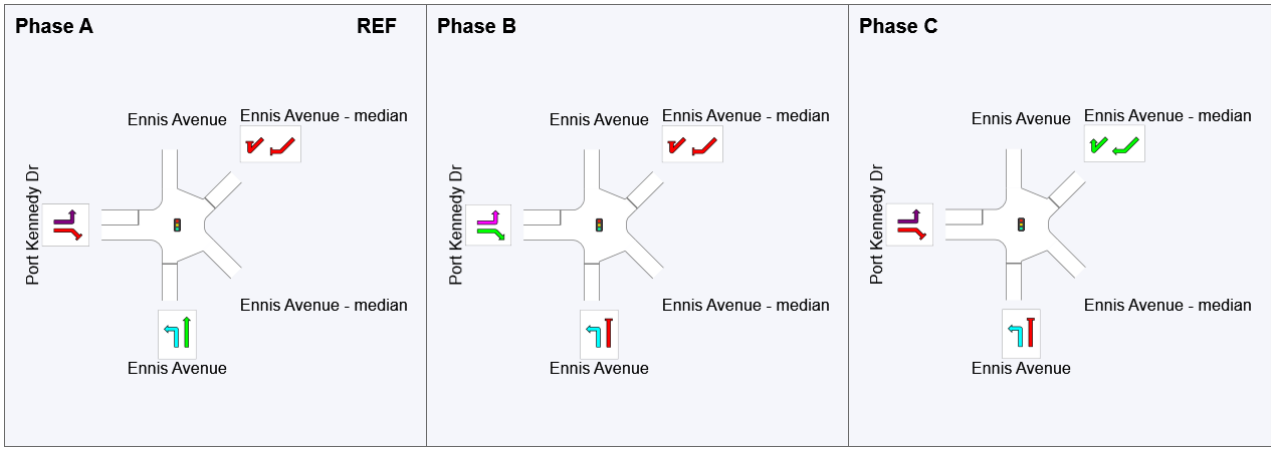
Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	84	122
Green Time (sec)	77	31	22
Phase Time (sec)	84	37	29
Phase Split	56%	25%	19%
Phase Frequency (%)	100.0[4]	100.0[4]	100.0[4]

See the Timing Analysis report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Minor Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

4 Phase Frequency specified by the user (phase times not specified).

Output Phase Sequence



REF: Reference Phase
VAR: Variable Phase

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak Existing ROM 2036 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	482	4.6	482	4.6	0.263	7.6	LOS A	0.0	0.0	0.00	0.60	0.00	61.5
2	T1	All MCs	974	2.0	974	2.0	* 0.953	83.3	LOS F	43.6	327.1	1.00	1.11	1.27	28.4
Approach			1456	2.9	1456	2.9	0.953	58.2	LOS E	43.6	327.1	0.67	0.94	0.85	34.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	580	1.9	580	1.9	* 0.936	78.6	LOS E	48.4	362.6	1.00	1.02	1.20	26.7
26b	R3	All MCs	1	0.0	1	0.0	0.936	79.7	LOS E	48.4	362.6	1.00	1.02	1.20	28.4
Approach			581	1.9	581	1.9	0.936	78.6	LOS E	48.4	362.6	1.00	1.02	1.20	26.7
West: Port Kennedy Dr															
10	L2	All MCs	315	5.6	315	5.6	0.334	16.0	LOS B	8.8	69.0	0.47	0.74	0.47	53.5
12a	R1	All MCs	469	2.0	469	2.0	* 0.943	86.4	LOS F	40.3	305.5	1.00	1.03	1.25	25.1
Approach			784	3.4	784	3.4	0.943	58.2	LOS E	40.3	305.5	0.79	0.91	0.94	32.0
All Vehicles			2821	2.8	2821	2.8	0.953	62.4	LOS E	48.4	362.6	0.77	0.95	0.95	31.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

PHASING SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak Existing ROM 2036 Basecase - PCT (Site Folder: Port Kennedy Dr Ennis Ave Existing Layout)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog
Phase Times determined by the program
Phase Sequence: Leading Right Turn
Input Phase Sequence: A, B, C
Output Phase Sequence: A, B, C
Reference Phase: Phase A

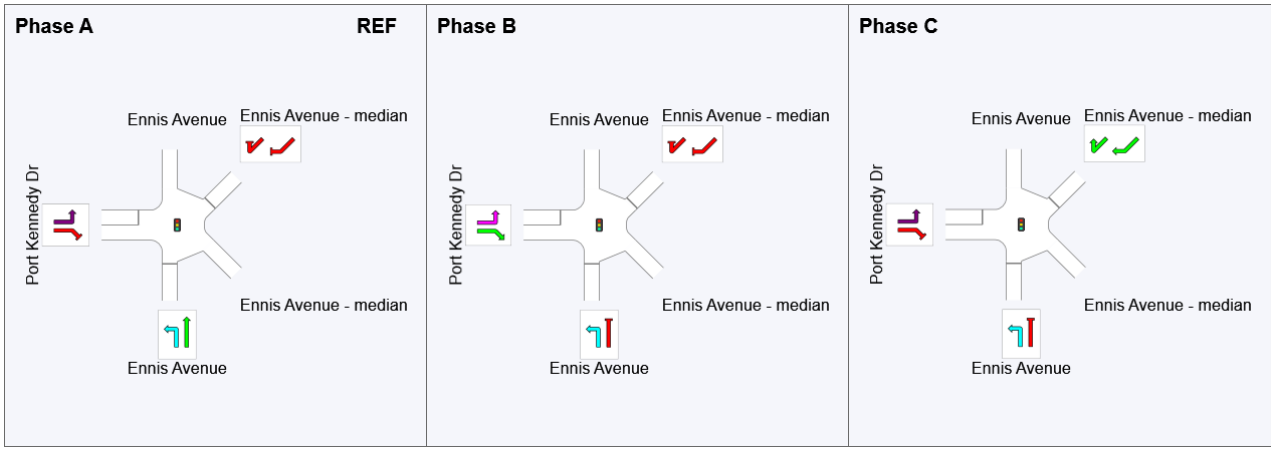
Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	52	98
Green Time (sec)	45	39	46
Phase Time (sec)	52	45	53
Phase Split	35%	30%	35%
Phase Frequency (%)	100.0[4]	100.0[4]	100.0[4]

See the Timing Analysis report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Minor Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

4 Phase Frequency specified by the user (phase times not specified).

Output Phase Sequence



REF: Reference Phase
VAR: Variable Phase

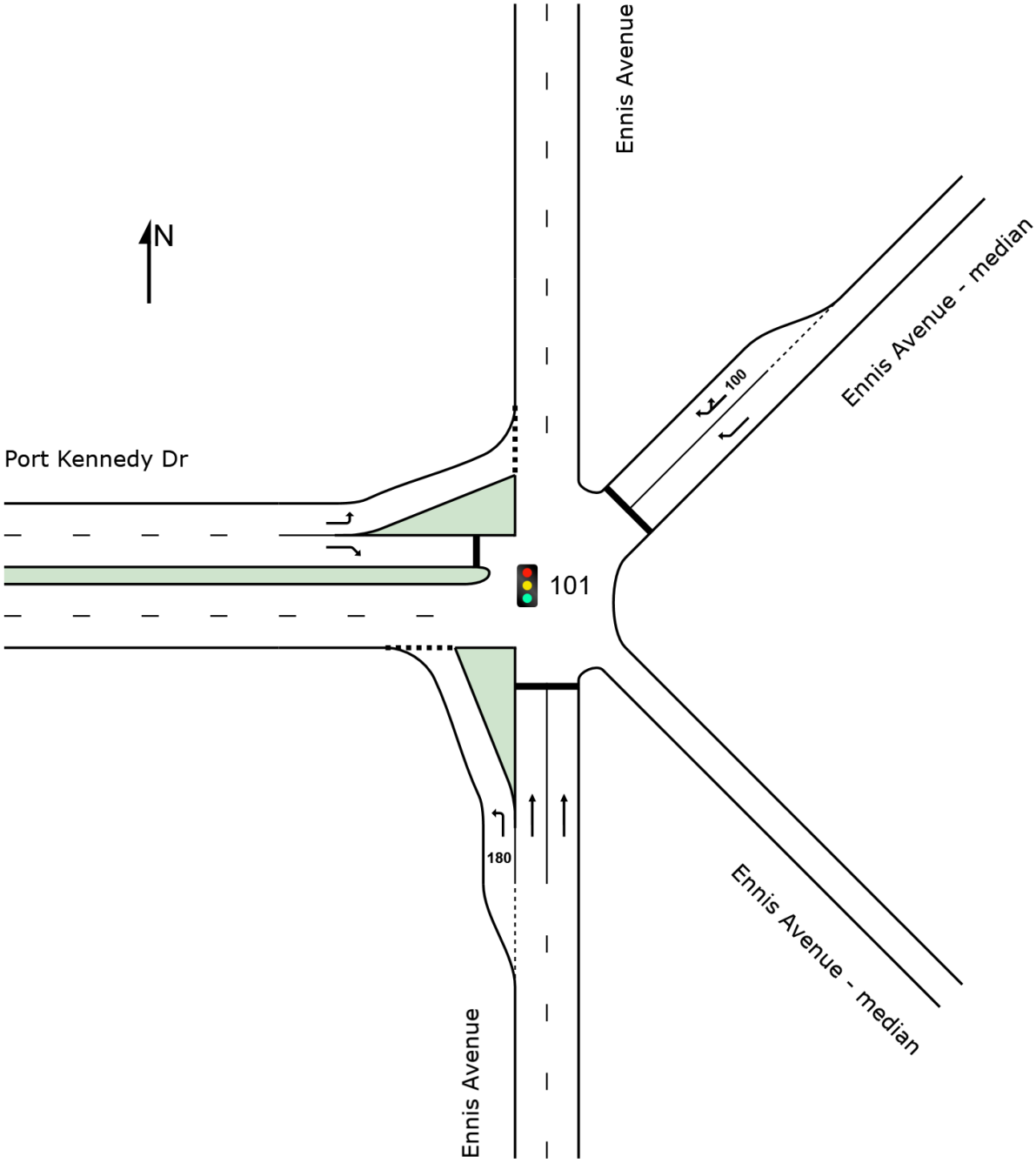
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive,
Base Traffic 2026 and 2036
Option 1: Double Right Turn Lanes on Ennis Ave Only

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.198	8.6	LOS A	1.7	14.5	0.25	0.66	0.25	60.2
2	T1	All MCs	1347	2.7	1347	2.7	* 0.861	31.2	LOS C	28.1	212.2	0.98	0.98	1.15	47.5
Approach			1634	3.8	1634	3.8	0.861	27.2	LOS C	28.1	212.2	0.86	0.93	0.99	49.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.760	50.5	LOS D	4.6	35.7	1.00	0.88	1.26	34.4
26b	R3	All MCs	1	0.0	1	0.0	0.760	51.6	LOS D	4.6	35.7	1.00	0.88	1.26	36.3
Approach			215	5.0	215	5.0	0.760	50.5	LOS D	4.6	35.7	1.00	0.88	1.26	34.5
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.409	16.6	LOS B	6.5	51.7	0.66	0.78	0.66	52.7
12a	R1	All MCs	273	11.7	273	11.7	* 0.806	45.1	LOS D	11.4	99.6	1.00	0.94	1.21	36.1
Approach			586	9.5	586	9.5	0.806	29.8	LOS C	11.4	99.6	0.82	0.85	0.92	43.5
All Vehicles			2435	5.3	2435	5.3	0.861	29.9	LOS C	28.1	212.2	0.86	0.90	1.00	46.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.273	9.5	LOS A	2.7	20.4	0.39	0.69	0.39	59.8
2	T1	All MCs	761	2.0	761	2.0	* 0.894	35.5	LOS D	13.8	103.2	1.00	1.07	1.45	45.0
Approach			1120	2.8	1120	2.8	0.894	27.2	LOS C	13.8	103.2	0.80	0.95	1.11	48.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.843	40.3	LOS D	7.3	54.9	1.00	0.98	1.41	38.8
26b	R3	All MCs	1	0.0	1	0.0	0.843	41.3	LOS D	7.3	54.9	1.00	0.98	1.41	40.5
Approach			433	1.9	433	1.9	0.843	40.3	LOS D	7.3	54.9	1.00	0.98	1.41	38.8
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.239	11.0	LOS B	2.4	18.5	0.50	0.72	0.50	58.1
12a	R1	All MCs	349	2.0	349	2.0	* 0.908	44.1	LOS D	13.0	98.7	1.00	1.10	1.53	37.1
Approach			584	3.4	584	3.4	0.908	30.8	LOS C	13.0	98.7	0.80	0.95	1.12	43.4
All Vehicles			2137	2.8	2137	2.8	0.908	30.8	LOS C	13.8	103.2	0.84	0.95	1.17	45.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	385	9.1	385	9.1	0.253	16.7	LOS B	4.1	34.0	0.20	0.65	0.20	59.9
2	T1	All MCs	1725	2.7	1725	2.7	* 0.923	50.9	LOS D	70.0	529.5	1.00	1.01	1.10	38.6
Approach			2111	3.8	2111	3.8	0.923	44.6	LOS D	70.0	529.5	0.85	0.94	0.94	41.0
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	286	5.0	286	5.0	* 0.880	90.4	LOS F	11.6	89.9	1.00	0.96	1.29	24.3
26b	R3	All MCs	1	0.0	1	0.0	0.880	91.4	LOS F	11.6	89.8	1.00	0.95	1.29	26.0
Approach			287	5.0	287	5.0	0.880	90.4	LOS F	11.6	89.9	1.00	0.96	1.29	24.3
West: Port Kennedy Dr															
10	L2	All MCs	422	7.5	422	7.5	0.650	41.8	LOS D	23.3	185.2	0.90	0.92	0.90	37.7
12a	R1	All MCs	366	11.7	366	11.7	* 0.896	79.4	LOS E	29.4	255.9	1.00	0.98	1.19	26.3
Approach			788	9.5	788	9.5	0.896	59.3	LOS E	29.4	255.9	0.94	0.95	1.03	31.4
All Vehicles			3186	5.3	3186	5.3	0.923	52.4	LOS D	70.0	529.5	0.89	0.94	0.99	36.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 100 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	482	4.6	482	4.6	0.353	11.3	LOS B	6.1	47.3	0.37	0.72	0.37	58.1
2	T1	All MCs	974	2.0	974	2.0	* 0.876	46.3	LOS D	26.4	198.4	1.00	1.01	1.20	39.7
Approach			1456	2.9	1456	2.9	0.876	34.7	LOS C	26.4	198.4	0.79	0.91	0.92	44.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	580	1.9	580	1.9	* 0.888	61.0	LOS E	16.2	121.8	1.00	1.00	1.31	31.2
26b	R3	All MCs	1	0.0	1	0.0	0.888	62.1	LOS E	16.2	121.7	1.00	1.00	1.31	32.9
Approach			581	1.9	581	1.9	0.888	61.0	LOS E	16.2	121.8	1.00	1.00	1.31	31.2
West: Port Kennedy Dr															
10	L2	All MCs	315	5.6	315	5.6	0.325	13.8	LOS B	6.0	47.3	0.50	0.74	0.50	55.4
12a	R1	All MCs	469	2.0	469	2.0	* 0.871	52.1	LOS D	25.1	189.9	1.00	0.97	1.20	34.0
Approach			784	3.4	784	3.4	0.871	36.7	LOS D	25.1	189.9	0.80	0.88	0.92	40.3
All Vehicles			2821	2.8	2821	2.8	0.888	40.7	LOS D	26.4	198.4	0.84	0.92	1.00	39.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

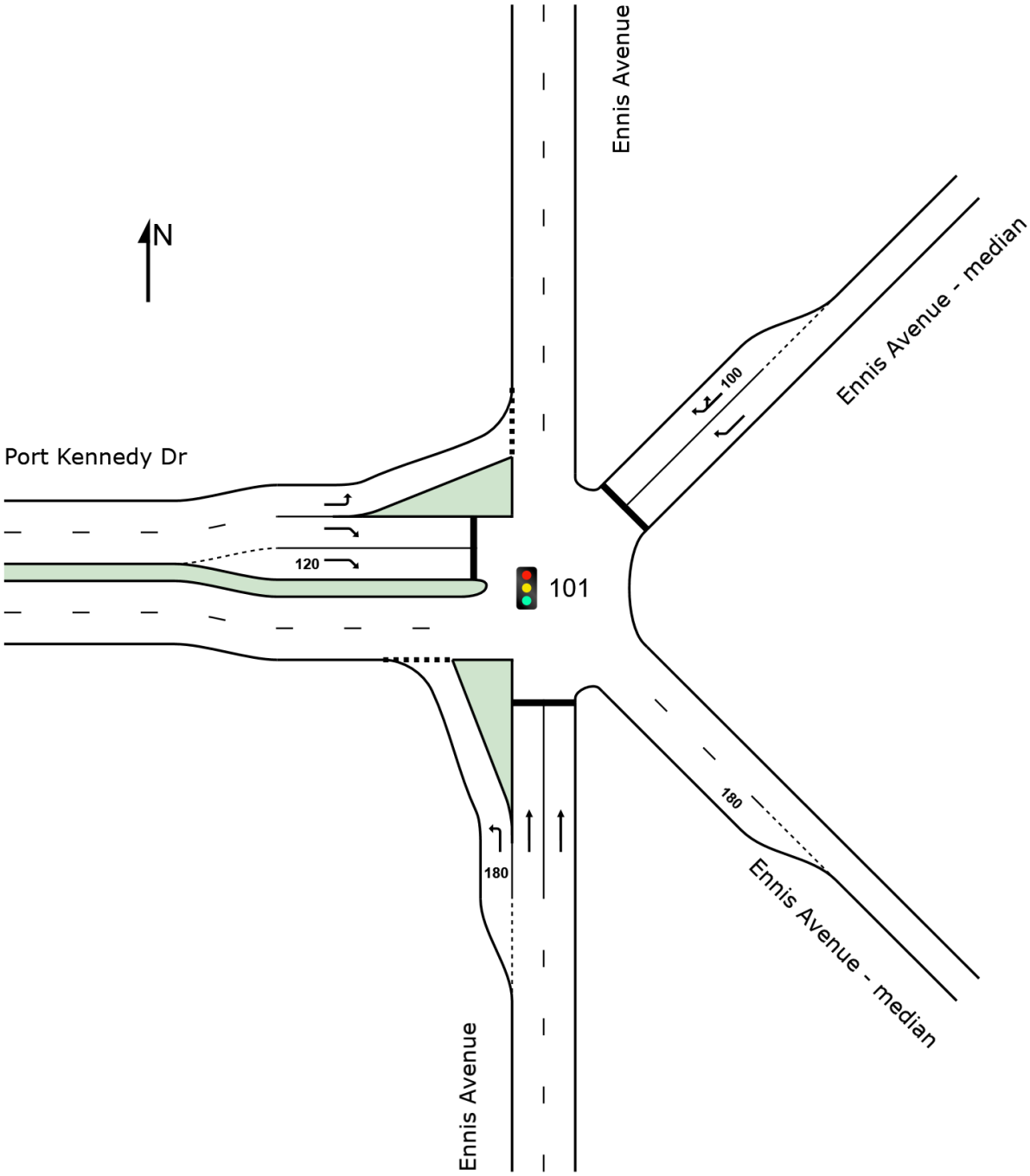
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Base Traffic 2026 and 2036 Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Drive

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.203	8.6	LOS A	1.6	13.4	0.28	0.67	0.28	60.1
2	T1	All MCs	1347	2.7	1347	2.7	* 0.803	22.4	LOS C	22.2	167.6	0.94	0.90	1.03	53.6
Approach			1634	3.8	1634	3.8	0.803	19.9	LOS B	22.2	167.6	0.82	0.86	0.90	54.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.665	43.2	LOS D	3.9	30.4	1.00	0.83	1.15	37.4
26b	R3	All MCs	1	0.0	1	0.0	0.665	44.2	LOS D	3.9	30.4	1.00	0.83	1.15	39.2
Approach			215	5.0	215	5.0	0.665	43.2	LOS D	3.9	30.4	1.00	0.83	1.15	37.4
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.459	15.6	LOS B	5.8	45.8	0.68	0.78	0.68	53.5
12a	R1	All MCs	273	11.7	273	11.7	* 0.756	44.0	LOS D	5.1	44.5	1.00	0.89	1.25	36.8
Approach			586	9.5	586	9.5	0.756	28.8	LOS C	5.8	45.8	0.83	0.83	0.95	44.2
All Vehicles			2435	5.3	2435	5.3	0.803	24.1	LOS C	22.2	167.6	0.84	0.85	0.93	50.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.276	9.5	LOS A	2.7	20.9	0.40	0.70	0.40	59.7
2	T1	All MCs	761	2.0	761	2.0	* 0.726	23.8	LOS C	11.0	82.3	0.97	0.87	1.06	52.6
Approach			1120	2.8	1120	2.8	0.726	19.2	LOS B	11.0	82.3	0.78	0.81	0.85	54.5
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.749	36.1	LOS D	6.8	50.9	1.00	0.90	1.20	40.8
26b	R3	All MCs	1	0.0	1	0.0	0.749	37.1	LOS D	6.8	50.8	1.00	0.90	1.20	42.5
Approach			433	1.9	433	1.9	0.749	36.1	LOS D	6.8	50.9	1.00	0.90	1.20	40.8
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.254	10.7	LOS B	2.2	17.6	0.48	0.72	0.48	58.4
12a	R1	All MCs	349	2.0	349	2.0	* 0.681	35.8	LOS D	5.4	40.6	1.00	0.85	1.13	41.2
Approach			584	3.4	584	3.4	0.681	25.7	LOS C	5.4	40.6	0.79	0.80	0.87	46.7
All Vehicles			2137	2.8	2137	2.8	0.749	24.4	LOS C	11.0	82.3	0.83	0.83	0.93	49.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	385	9.1	385	9.1	0.267	8.8	LOS A	2.9	24.4	0.26	0.67	0.26	59.9
2	T1	All MCs	1725	2.7	1725	2.7	* 0.893	32.7	LOS C	41.4	313.5	0.98	1.01	1.14	46.6
Approach			2111	3.8	2111	3.8	0.893	28.4	LOS C	41.4	313.5	0.85	0.95	0.98	48.4
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	286	5.0	286	5.0	* 0.858	58.3	LOS E	7.2	55.6	1.00	0.96	1.39	31.9
26b	R3	All MCs	1	0.0	1	0.0	0.858	59.4	LOS E	7.2	55.5	1.00	0.96	1.39	33.8
Approach			287	5.0	287	5.0	0.858	58.3	LOS E	7.2	55.6	1.00	0.96	1.39	31.9
West: Port Kennedy Dr															
10	L2	All MCs	422	7.5	422	7.5	0.708	25.4	LOS C	14.5	115.6	0.90	0.86	0.92	46.3
12a	R1	All MCs	366	11.7	366	11.7	* 0.831	55.0	LOS E	8.9	77.6	1.00	0.96	1.29	32.8
Approach			788	9.5	788	9.5	0.831	39.2	LOS D	14.5	115.6	0.95	0.91	1.09	38.9
All Vehicles			3186	5.3	3186	5.3	0.893	33.7	LOS C	41.4	313.5	0.89	0.94	1.05	44.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	482	4.6	482	4.6	0.377	10.6	LOS B	5.0	38.9	0.44	0.72	0.44	58.6
2	T1	All MCs	974	2.0	974	2.0	* 0.858	33.2	LOS C	18.9	141.9	1.00	1.01	1.25	46.3
Approach			1456	2.9	1456	2.9	0.858	25.8	LOS C	18.9	141.9	0.81	0.91	0.98	49.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	580	1.9	580	1.9	* 0.813	41.0	LOS D	10.8	81.2	1.00	0.95	1.24	38.5
26b	R3	All MCs	1	0.0	1	0.0	0.813	42.0	LOS D	10.8	81.1	1.00	0.95	1.24	40.2
Approach			581	1.9	581	1.9	0.813	41.0	LOS D	10.8	81.2	1.00	0.95	1.24	38.5
West: Port Kennedy Dr															
10	L2	All MCs	315	5.6	315	5.6	0.367	12.8	LOS B	4.5	35.4	0.57	0.75	0.57	56.4
12a	R1	All MCs	469	2.0	469	2.0	* 0.854	45.6	LOS D	9.2	69.7	1.00	0.99	1.37	36.7
Approach			784	3.4	784	3.4	0.854	32.4	LOS C	9.2	69.7	0.83	0.89	1.05	42.7
All Vehicles			2821	2.8	2821	2.8	0.858	30.7	LOS C	18.9	141.9	0.86	0.91	1.05	45.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

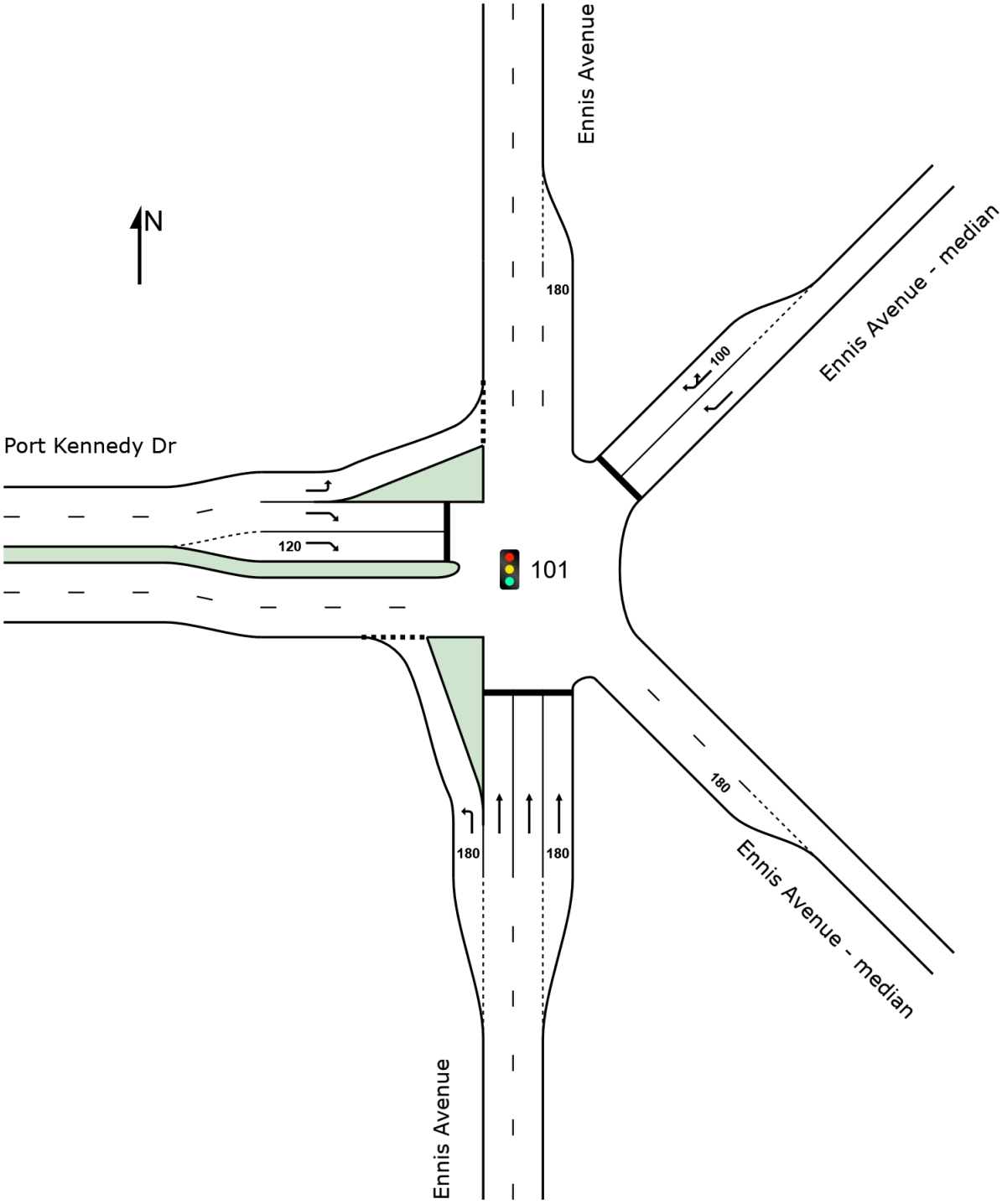
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Base Traffic 2026 and 2036 Option 3: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr, Auxiliary Thru Lane

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Basecase - Modfications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modfications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.211	8.8	LOS A	1.6	13.2	0.32	0.68	0.32	59.9
2	T1	All MCs	1347	2.7	1347	2.7	* 0.689	20.2	LOS C	11.9	90.2	0.92	0.82	0.96	55.7
Approach			1634	3.8	1634	3.8	0.689	18.2	LOS B	11.9	90.2	0.82	0.79	0.85	56.4
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.570	36.4	LOS D	3.3	25.4	1.00	0.79	1.05	40.6
26b	R3	All MCs	1	0.0	1	0.0	0.570	38.9	LOS D	3.3	25.3	1.00	0.79	1.05	42.3
Approach			215	5.0	215	5.0	0.570	36.5	LOS D	3.3	25.4	1.00	0.79	1.05	40.6
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.382	11.5	LOS B	3.6	28.4	0.55	0.75	0.55	57.4
12a	R1	All MCs	273	11.7	273	11.7	* 0.648	36.4	LOS D	4.2	36.6	1.00	0.83	1.12	40.4
Approach			586	9.5	586	9.5	0.648	23.0	LOS C	4.2	36.6	0.76	0.79	0.82	48.0
All Vehicles			2435	5.3	2435	5.3	0.689	21.0	LOS C	11.9	90.2	0.82	0.79	0.86	52.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 50 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.291	9.7	LOS A	2.5	19.1	0.45	0.71	0.45	59.6
2	T1	All MCs	761	2.0	761	2.0	* 0.717	23.8	LOS C	6.5	48.7	0.99	0.88	1.16	52.8
Approach			1120	2.8	1120	2.8	0.717	19.2	LOS B	6.5	48.7	0.82	0.82	0.93	54.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.702	30.3	LOS C	5.6	41.8	1.00	0.87	1.16	44.2
26b	R3	All MCs	1	0.0	1	0.0	0.702	31.8	LOS C	5.6	41.7	1.00	0.87	1.16	45.6
Approach			433	1.9	433	1.9	0.702	30.3	LOS C	5.6	41.8	1.00	0.87	1.16	44.2
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.235	9.9	LOS A	1.7	13.0	0.47	0.71	0.47	59.3
12a	R1	All MCs	349	2.0	349	2.0	* 0.757	33.2	LOS C	4.7	35.9	1.00	0.90	1.29	42.7
Approach			584	3.4	584	3.4	0.757	23.8	LOS C	4.7	35.9	0.79	0.83	0.96	48.1
All Vehicles			2137	2.8	2137	2.8	0.757	22.7	LOS C	6.5	48.7	0.85	0.83	0.98	50.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Basecase - Modfications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	385	9.1	385	9.1	0.288	9.0	LOS A	2.4	20.1	0.36	0.69	0.36	59.6
2	T1	All MCs	1725	2.7	1725	2.7	* 0.868	29.6	LOS C	19.7	149.0	1.00	1.03	1.29	49.1
Approach			2111	3.8	2111	3.8	0.868	25.9	LOS C	19.7	149.0	0.88	0.97	1.12	50.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	286	5.0	286	5.0	* 0.762	39.0	LOS D	4.7	36.2	1.00	0.90	1.29	39.4
26b	R3	All MCs	1	0.0	1	0.0	0.762	42.7	LOS D	4.7	36.1	1.00	0.90	1.29	41.1
Approach			287	5.0	287	5.0	0.762	39.0	LOS D	4.7	36.2	1.00	0.90	1.29	39.4
West: Port Kennedy Dr															
10	L2	All MCs	422	7.5	422	7.5	0.550	14.4	LOS B	6.7	53.6	0.72	0.80	0.72	54.6
12a	R1	All MCs	366	11.7	366	11.7	* 0.870	43.0	LOS D	6.4	56.0	1.00	1.02	1.53	37.4
Approach			788	9.5	788	9.5	0.870	27.7	LOS C	6.7	56.0	0.85	0.90	1.10	45.0
All Vehicles			3186	5.3	3186	5.3	0.870	27.5	LOS C	19.7	149.0	0.89	0.94	1.13	48.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Basecase - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	482	4.6	482	4.6	0.394	10.4	LOS B	4.7	36.1	0.48	0.73	0.48	58.8
2	T1	All MCs	974	2.0	974	2.0	* 0.813	30.1	LOS C	10.6	79.2	1.00	0.96	1.26	48.4
Approach			1456	2.9	1456	2.9	0.813	23.6	LOS C	10.6	79.2	0.83	0.88	1.00	51.2
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	580	1.9	580	1.9	* 0.755	33.8	LOS C	8.9	66.9	1.00	0.90	1.17	42.1
26b	R3	All MCs	1	0.0	1	0.0	0.755	35.6	LOS D	8.9	66.8	1.00	0.90	1.17	43.7
Approach			581	1.9	581	1.9	0.755	33.8	LOS C	8.9	66.9	1.00	0.90	1.17	42.1
West: Port Kennedy Dr															
10	L2	All MCs	315	5.6	315	5.6	0.321	10.5	LOS B	3.0	23.5	0.49	0.73	0.49	58.6
12a	R1	All MCs	469	2.0	469	2.0	* 0.813	38.4	LOS D	7.7	58.3	1.00	0.95	1.32	40.1
Approach			784	3.4	784	3.4	0.813	27.2	LOS C	7.7	58.3	0.79	0.86	0.98	45.9
All Vehicles			2821	2.8	2821	2.8	0.813	26.7	LOS C	10.6	79.2	0.85	0.88	1.03	47.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

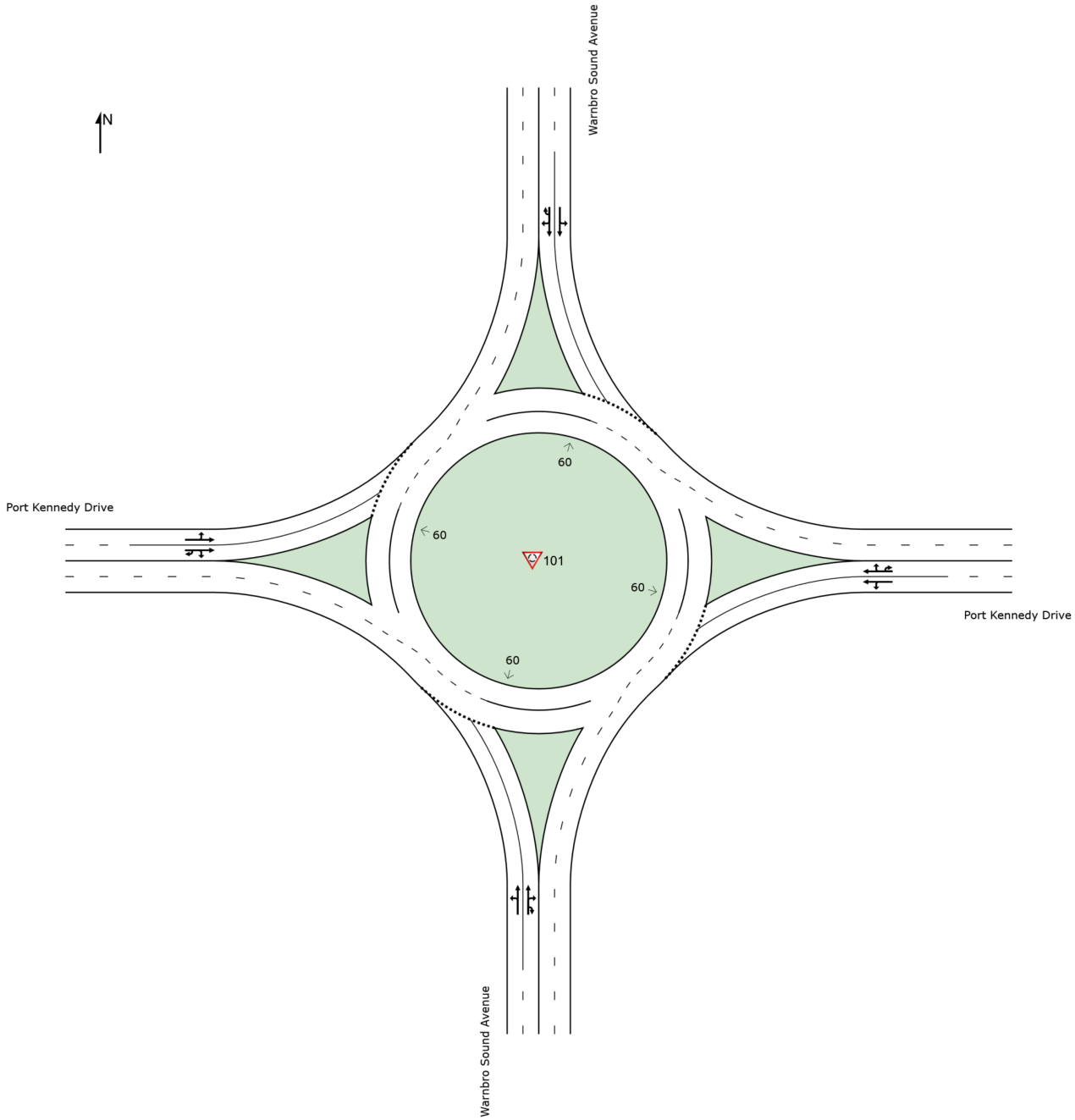
SIDRA Analysis, Port Kennedy Drive/Warnbro Sound Avenue, Existing Layout – Base Traffic 2022, 2026 and 2036 – No development

SITE LAYOUT

Site: 101 [Port Kennedy Existing Am Peak (Site Folder: Port Kennedy and Warnbro Sound Ave)]

New Site
Site Category: (None)
Roundabout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Existing Am Peak (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	52	0.0	52	0.0	0.250	4.2	LOS A	1.3	9.8	0.37	0.41	0.37	58.0
2	T1	All MCs	551	3.0	551	3.0	0.250	4.8	LOS A	1.3	9.8	0.38	0.45	0.38	61.0
3	R2	All MCs	80	0.0	80	0.0	0.250	12.5	LOS B	1.3	9.5	0.39	0.50	0.39	61.2
3u	U	All MCs	1	0.0	1	0.0	0.250	13.3	LOS B	1.3	9.5	0.39	0.50	0.39	55.9
Approach			683	2.4	683	2.4	0.250	5.7	LOS A	1.3	9.8	0.38	0.45	0.38	60.7
East: Port Kennedy Drive															
4	L2	All MCs	23	4.0	23	4.0	0.080	5.7	LOS A	0.4	2.7	0.43	0.50	0.43	63.2
5	T1	All MCs	85	3.0	85	3.0	0.080	6.4	LOS A	0.4	2.7	0.43	0.50	0.43	60.0
6	R2	All MCs	107	0.0	107	0.0	0.096	14.5	LOS B	0.4	3.1	0.45	0.70	0.45	56.5
6u	U	All MCs	1	0.0	1	0.0	0.096	13.7	LOS B	0.4	3.1	0.45	0.70	0.45	53.8
Approach			217	1.6	217	1.6	0.096	10.4	LOS B	0.4	3.1	0.44	0.60	0.44	58.4
North: Warnbro Sound Avenue															
7	L2	All MCs	109	9.0	109	9.0	0.183	4.5	LOS A	0.9	7.1	0.41	0.45	0.41	61.8
8	T1	All MCs	315	6.0	315	6.0	0.183	5.0	LOS A	0.9	7.1	0.42	0.48	0.42	60.6
9	R2	All MCs	26	8.0	26	8.0	0.183	12.9	LOS B	0.9	6.8	0.43	0.50	0.43	55.6
9u	U	All MCs	13	0.0	13	0.0	0.183	13.5	LOS B	0.9	6.8	0.43	0.50	0.43	55.8
Approach			463	6.7	463	6.7	0.183	5.6	LOS A	0.9	7.1	0.42	0.47	0.42	60.4
West: Port Kennedy Drive															
10	L2	All MCs	36	0.0	36	0.0	0.124	3.9	LOS A	0.6	4.3	0.54	0.41	0.54	57.3
11	T1	All MCs	161	1.0	161	1.0	0.124	4.1	LOS A	0.6	4.3	0.54	0.48	0.54	58.8
12	R2	All MCs	74	0.0	74	0.0	0.124	11.8	LOS B	0.5	4.0	0.56	0.65	0.56	53.7
12u	U	All MCs	1	0.0	1	0.0	0.124	14.6	LOS B	0.5	4.0	0.56	0.65	0.56	51.2
Approach			272	0.6	272	0.6	0.124	6.2	LOS A	0.6	4.3	0.55	0.52	0.55	57.1
All Vehicles			1635	3.2	1635	3.2	0.250	6.4	LOS A	1.3	9.8	0.42	0.49	0.42	59.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Existing Pm Peak (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	58	0.0	58	0.0	0.224	4.5	LOS A	1.2	8.9	0.46	0.44	0.46	57.4
2	T1	All MCs	447	2.0	447	2.0	0.224	5.1	LOS A	1.2	8.9	0.47	0.48	0.47	60.5
3	R2	All MCs	59	0.0	59	0.0	0.224	12.8	LOS B	1.1	8.5	0.48	0.52	0.48	60.8
3u	U	All MCs	1	0.0	1	0.0	0.224	13.7	LOS B	1.1	8.5	0.48	0.52	0.48	55.6
Approach			565	1.6	565	1.6	0.224	5.9	LOS A	1.2	8.9	0.47	0.48	0.47	60.2
East: Port Kennedy Drive															
4	L2	All MCs	163	0.0	163	0.0	0.235	6.4	LOS A	1.2	8.7	0.59	0.60	0.59	62.6
5	T1	All MCs	149	1.0	149	1.0	0.235	7.4	LOS A	1.2	8.7	0.60	0.63	0.60	58.3
6	R2	All MCs	181	1.0	181	1.0	0.235	15.8	LOS B	1.1	8.1	0.62	0.77	0.62	56.4
6u	U	All MCs	1	0.0	1	0.0	0.235	15.0	LOS B	1.1	8.1	0.62	0.77	0.62	54.0
Approach			495	0.7	495	0.7	0.235	10.2	LOS B	1.2	8.7	0.60	0.67	0.60	58.9
North: Warnbro Sound Avenue															
7	L2	All MCs	106	4.0	106	4.0	0.309	4.3	LOS A	1.7	13.0	0.37	0.41	0.37	63.0
8	T1	All MCs	724	2.0	724	2.0	0.309	4.8	LOS A	1.7	13.0	0.39	0.43	0.39	61.3
9	R2	All MCs	23	0.0	23	0.0	0.309	12.5	LOS B	1.7	12.6	0.40	0.44	0.40	56.7
9u	U	All MCs	3	0.0	3	0.0	0.309	13.3	LOS B	1.7	12.6	0.40	0.44	0.40	56.7
Approach			857	2.2	857	2.2	0.309	5.0	LOS A	1.7	13.0	0.39	0.43	0.39	61.4
West: Port Kennedy Drive															
10	L2	All MCs	36	4.0	36	4.0	0.087	3.9	LOS A	0.4	3.1	0.52	0.42	0.52	57.3
11	T1	All MCs	82	1.0	82	1.0	0.087	3.8	LOS A	0.4	3.1	0.52	0.45	0.52	59.3
12	R2	All MCs	71	4.0	71	4.0	0.087	11.8	LOS B	0.4	2.9	0.55	0.69	0.55	51.8
12u	U	All MCs	1	0.0	1	0.0	0.087	14.4	LOS B	0.4	2.9	0.55	0.69	0.55	50.2
Approach			189	2.7	189	2.7	0.087	6.9	LOS A	0.4	3.1	0.53	0.53	0.53	55.8
All Vehicles			2106	1.7	2106	1.7	0.309	6.6	LOS A	1.7	13.0	0.47	0.51	0.47	59.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Am Peak - 2026 (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	56	5.0	56	5.0	0.281	4.4	LOS A	1.5	11.6	0.40	0.42	0.40	57.7
2	T1	All MCs	596	5.0	596	5.0	0.281	4.9	LOS A	1.5	11.6	0.41	0.46	0.41	60.7
3	R2	All MCs	91	5.0	91	5.0	0.281	12.7	LOS B	1.5	11.3	0.42	0.51	0.42	59.8
3u	U	All MCs	1	0.0	1	0.0	0.281	13.4	LOS B	1.5	11.3	0.42	0.51	0.42	55.7
Approach			743	5.0	743	5.0	0.281	5.9	LOS A	1.5	11.6	0.41	0.46	0.41	60.3
East: Port Kennedy Drive															
4	L2	All MCs	25	5.0	25	5.0	0.092	5.8	LOS A	0.4	3.3	0.45	0.51	0.45	63.0
5	T1	All MCs	96	5.0	96	5.0	0.092	6.6	LOS A	0.4	3.3	0.45	0.51	0.45	59.8
6	R2	All MCs	117	5.0	117	5.0	0.111	14.8	LOS B	0.5	3.8	0.47	0.70	0.47	55.3
6u	U	All MCs	1	0.0	1	0.0	0.111	13.8	LOS B	0.5	3.8	0.47	0.70	0.47	53.7
Approach			239	5.0	239	5.0	0.111	10.5	LOS B	0.5	3.8	0.46	0.61	0.46	57.7
North: Warnbro Sound Avenue															
7	L2	All MCs	123	5.0	123	5.0	0.203	4.6	LOS A	1.0	7.8	0.43	0.46	0.43	62.6
8	T1	All MCs	340	5.0	340	5.0	0.203	5.2	LOS A	1.0	7.8	0.45	0.49	0.45	60.4
9	R2	All MCs	29	5.0	29	5.0	0.203	12.9	LOS B	1.0	7.5	0.46	0.51	0.46	55.5
9u	U	All MCs	13	0.0	13	0.0	0.203	13.6	LOS B	1.0	7.5	0.46	0.51	0.46	55.6
Approach			505	4.9	505	4.9	0.203	5.7	LOS A	1.0	7.8	0.44	0.48	0.44	60.5
West: Port Kennedy Drive															
10	L2	All MCs	39	2.0	39	2.0	0.145	4.1	LOS A	0.7	5.2	0.57	0.43	0.57	57.0
11	T1	All MCs	181	2.0	181	2.0	0.145	4.3	LOS A	0.7	5.2	0.58	0.49	0.58	58.4
12	R2	All MCs	79	2.0	79	2.0	0.145	12.1	LOS B	0.6	4.8	0.59	0.67	0.59	53.2
12u	U	All MCs	1	0.0	1	0.0	0.145	14.8	LOS B	0.6	4.8	0.59	0.67	0.59	51.1
Approach			300	2.0	300	2.0	0.145	6.3	LOS A	0.7	5.2	0.58	0.53	0.58	56.7
All Vehicles			1787	4.5	1787	4.5	0.281	6.5	LOS A	1.5	11.6	0.46	0.50	0.46	59.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Pm Peak - 2026 (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	53	5.0	53	5.0	0.252	4.7	LOS A	1.4	10.6	0.49	0.45	0.49	57.1
2	T1	All MCs	484	5.0	484	5.0	0.252	5.3	LOS A	1.4	10.6	0.50	0.49	0.50	60.1
3	R2	All MCs	66	5.0	66	5.0	0.252	13.2	LOS B	1.3	10.1	0.52	0.54	0.52	59.3
3u	U	All MCs	1	0.0	1	0.0	0.252	13.8	LOS B	1.3	10.1	0.52	0.54	0.52	55.3
Approach			604	5.0	604	5.0	0.252	6.1	LOS A	1.4	10.6	0.50	0.49	0.50	59.8
East: Port Kennedy Drive															
4	L2	All MCs	177	5.0	177	5.0	0.278	6.8	LOS A	1.4	11.1	0.64	0.63	0.64	62.1
5	T1	All MCs	167	5.0	167	5.0	0.278	7.7	LOS A	1.4	11.1	0.64	0.66	0.64	58.1
6	R2	All MCs	196	5.0	196	5.0	0.278	16.3	LOS B	1.3	10.2	0.66	0.79	0.66	55.5
6u	U	All MCs	1	0.0	1	0.0	0.278	15.3	LOS B	1.3	10.2	0.66	0.79	0.66	53.8
Approach			541	5.0	541	5.0	0.278	10.5	LOS B	1.4	11.1	0.65	0.69	0.65	58.2
North: Warnbro Sound Avenue															
7	L2	All MCs	120	5.0	120	5.0	0.348	4.4	LOS A	2.0	15.5	0.41	0.43	0.41	62.5
8	T1	All MCs	784	5.0	784	5.0	0.348	5.0	LOS A	2.0	15.5	0.42	0.44	0.42	61.0
9	R2	All MCs	25	5.0	25	5.0	0.348	12.7	LOS B	1.9	15.1	0.44	0.46	0.44	56.3
9u	U	All MCs	3	0.0	3	0.0	0.348	13.4	LOS B	1.9	15.1	0.44	0.46	0.44	56.5
Approach			933	5.0	933	5.0	0.348	5.1	LOS A	2.0	15.5	0.42	0.44	0.42	61.0
West: Port Kennedy Drive															
10	L2	All MCs	39	4.0	39	4.0	0.100	4.1	LOS A	0.5	3.6	0.55	0.43	0.55	57.1
11	T1	All MCs	92	1.0	92	1.0	0.100	4.0	LOS A	0.5	3.6	0.56	0.46	0.56	59.1
12	R2	All MCs	77	4.0	77	4.0	0.100	12.0	LOS B	0.4	3.4	0.57	0.71	0.57	51.7
12u	U	All MCs	1	0.0	1	0.0	0.100	14.6	LOS B	0.4	3.4	0.57	0.71	0.57	50.2
Approach			208	2.7	208	2.7	0.100	7.0	LOS A	0.5	3.6	0.56	0.55	0.56	55.7
All Vehicles			2286	4.8	2286	4.8	0.348	6.8	LOS A	2.0	15.5	0.51	0.52	0.51	59.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Am Peak - 2036 (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	68	5.0	68	5.0	0.362	4.7	LOS A	2.1	16.0	0.47	0.44	0.47	57.2
2	T1	All MCs	726	5.0	726	5.0	0.362	5.2	LOS A	2.1	16.0	0.49	0.48	0.49	60.2
3	R2	All MCs	122	5.0	122	5.0	0.362	13.1	LOS B	2.0	15.4	0.50	0.54	0.50	59.2
3u	U	All MCs	1	0.0	1	0.0	0.362	13.7	LOS B	2.0	15.4	0.50	0.54	0.50	55.2
Approach			918	5.0	918	5.0	0.362	6.2	LOS A	2.1	16.0	0.49	0.49	0.49	59.8
East: Port Kennedy Drive															
4	L2	All MCs	32	5.0	32	5.0	0.128	6.0	LOS A	0.6	4.8	0.51	0.53	0.51	62.5
5	T1	All MCs	128	5.0	128	5.0	0.128	6.8	LOS A	0.6	4.8	0.51	0.53	0.51	59.4
6	R2	All MCs	142	5.0	142	5.0	0.145	15.2	LOS B	0.7	5.2	0.53	0.73	0.53	55.1
6u	U	All MCs	1	0.0	1	0.0	0.145	14.2	LOS B	0.7	5.2	0.53	0.73	0.53	53.5
Approach			303	5.0	303	5.0	0.145	10.7	LOS B	0.7	5.2	0.52	0.62	0.52	57.5
North: Warnbro Sound Avenue															
7	L2	All MCs	165	5.0	165	5.0	0.269	4.9	LOS A	1.4	11.0	0.51	0.49	0.51	62.1
8	T1	All MCs	415	5.0	415	5.0	0.269	5.6	LOS A	1.4	11.0	0.53	0.52	0.53	60.0
9	R2	All MCs	36	5.0	36	5.0	0.269	13.4	LOS B	1.3	10.4	0.54	0.54	0.54	55.1
9u	U	All MCs	13	0.0	13	0.0	0.269	14.0	LOS B	1.3	10.4	0.54	0.54	0.54	55.3
Approach			628	4.9	628	4.9	0.269	6.0	LOS A	1.4	11.0	0.53	0.51	0.53	60.1
West: Port Kennedy Drive															
10	L2	All MCs	47	2.0	47	2.0	0.206	4.6	LOS A	1.1	8.0	0.65	0.48	0.65	56.5
11	T1	All MCs	243	2.0	243	2.0	0.206	4.7	LOS A	1.1	8.0	0.66	0.54	0.66	57.9
12	R2	All MCs	97	2.0	97	2.0	0.206	12.8	LOS B	1.0	7.3	0.67	0.71	0.67	52.8
12u	U	All MCs	1	0.0	1	0.0	0.206	15.5	LOS B	1.0	7.3	0.67	0.71	0.67	50.8
Approach			388	2.0	388	2.0	0.206	6.8	LOS A	1.1	8.0	0.66	0.57	0.66	56.3
All Vehicles			2238	4.4	2238	4.4	0.362	6.9	LOS A	2.1	16.0	0.53	0.53	0.53	58.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Pm Peak - 2036 (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	64	5.0	64	5.0	0.335	5.1	LOS A	1.9	15.0	0.58	0.48	0.58	56.6
2	T1	All MCs	591	5.0	591	5.0	0.335	5.7	LOS A	1.9	15.0	0.59	0.52	0.59	59.5
3	R2	All MCs	89	5.0	89	5.0	0.335	13.6	LOS B	1.8	14.1	0.61	0.58	0.61	58.6
3u	U	All MCs	1	0.0	1	0.0	0.335	14.3	LOS B	1.8	14.1	0.61	0.58	0.61	54.8
Approach			745	5.0	745	5.0	0.335	6.6	LOS A	1.9	15.0	0.59	0.53	0.59	59.1
East: Port Kennedy Drive															
4	L2	All MCs	214	5.0	214	5.0	0.393	7.5	LOS A	2.3	17.9	0.75	0.70	0.78	61.4
5	T1	All MCs	225	5.0	225	5.0	0.393	8.6	LOS A	2.3	17.9	0.75	0.73	0.79	57.4
6	R2	All MCs	239	5.0	239	5.0	0.393	17.6	LOS B	2.1	16.4	0.75	0.86	0.83	54.8
6u	U	All MCs	1	0.0	1	0.0	0.393	16.5	LOS B	2.1	16.4	0.75	0.86	0.83	53.2
Approach			679	5.0	679	5.0	0.393	11.4	LOS B	2.3	17.9	0.75	0.77	0.80	57.5
North: Warnbro Sound Avenue															
7	L2	All MCs	161	5.0	161	5.0	0.451	4.8	LOS A	2.8	22.0	0.51	0.46	0.51	61.9
8	T1	All MCs	956	5.0	956	5.0	0.451	5.4	LOS A	2.8	22.0	0.52	0.48	0.52	60.3
9	R2	All MCs	32	5.0	32	5.0	0.451	13.2	LOS B	2.7	21.2	0.54	0.49	0.54	55.7
9u	U	All MCs	3	0.0	3	0.0	0.451	13.8	LOS B	2.7	21.2	0.54	0.49	0.54	55.9
Approach			1152	5.0	1152	5.0	0.451	5.5	LOS A	2.8	22.0	0.52	0.48	0.52	60.4
West: Port Kennedy Drive															
10	L2	All MCs	47	4.0	47	4.0	0.141	4.5	LOS A	0.7	5.4	0.63	0.47	0.63	56.6
11	T1	All MCs	123	1.0	123	1.0	0.141	4.4	LOS A	0.7	5.4	0.64	0.51	0.64	58.6
12	R2	All MCs	94	4.0	94	4.0	0.141	12.6	LOS B	0.7	5.0	0.65	0.74	0.65	51.6
12u	U	All MCs	1	0.0	1	0.0	0.141	15.2	LOS B	0.7	5.0	0.65	0.74	0.65	50.0
Approach			265	2.6	265	2.6	0.141	7.4	LOS A	0.7	5.4	0.64	0.59	0.64	55.5
All Vehicles			2841	4.8	2841	4.8	0.451	7.4	LOS A	2.8	22.0	0.61	0.57	0.62	58.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

SIDRA Analysis, Port Kennedy Drive/Warnbro Sound Avenue, Existing Layout –2026 and 2036 – With development

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Am Peak - 2026 - with development (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	56	5.0	56	5.0	0.335	4.7	LOS A	1.9	14.7	0.48	0.45	0.48	57.2
2	T1	All MCs	596	5.0	596	5.0	0.335	5.3	LOS A	1.9	14.7	0.49	0.49	0.49	59.9
3	R2	All MCs	182	5.0	182	5.0	0.335	13.1	LOS B	1.8	14.1	0.51	0.59	0.51	58.2
3u	U	All MCs	1	0.0	1	0.0	0.335	13.8	LOS B	1.8	14.1	0.51	0.59	0.51	54.4
Approach			835	5.0	835	5.0	0.335	7.0	LOS A	1.9	14.7	0.50	0.51	0.50	59.3
East: Port Kennedy Drive															
4	L2	All MCs	51	5.0	51	5.0	0.148	6.5	LOS A	0.7	5.7	0.53	0.57	0.53	62.6
5	T1	All MCs	99	5.0	99	5.0	0.148	7.3	LOS A	0.7	5.7	0.53	0.57	0.53	59.4
6	R2	All MCs	201	5.0	201	5.0	0.159	14.7	LOS B	0.9	6.6	0.51	0.68	0.51	55.2
6u	U	All MCs	1	0.0	1	0.0	0.159	13.7	LOS B	0.9	6.6	0.51	0.68	0.51	53.6
Approach			352	5.0	352	5.0	0.159	11.4	LOS B	0.9	6.6	0.52	0.63	0.52	57.2
North: Warnbro Sound Avenue															
7	L2	All MCs	427	5.0	427	5.0	0.343	5.0	LOS A	1.9	14.7	0.53	0.54	0.53	62.5
8	T1	All MCs	340	5.0	340	5.0	0.343	5.9	LOS A	1.9	14.7	0.56	0.54	0.56	59.5
9	R2	All MCs	29	5.0	29	5.0	0.343	13.5	LOS B	1.8	14.0	0.56	0.54	0.56	55.3
9u	U	All MCs	13	0.0	13	0.0	0.343	14.2	LOS B	1.8	14.0	0.56	0.54	0.56	55.4
Approach			809	4.9	809	4.9	0.343	5.8	LOS A	1.9	14.7	0.54	0.54	0.54	60.8
West: Port Kennedy Drive															
10	L2	All MCs	39	2.0	39	2.0	0.165	4.6	LOS A	0.8	6.3	0.64	0.48	0.64	56.5
11	T1	All MCs	192	2.0	192	2.0	0.165	4.7	LOS A	0.8	6.3	0.65	0.54	0.65	58.0
12	R2	All MCs	79	2.0	79	2.0	0.165	12.7	LOS B	0.8	5.7	0.66	0.70	0.66	52.8
12u	U	All MCs	1	0.0	1	0.0	0.165	15.4	LOS B	0.8	5.7	0.66	0.70	0.66	50.8
Approach			311	2.0	311	2.0	0.165	6.8	LOS A	0.8	6.3	0.65	0.57	0.65	56.4
All Vehicles			2306	4.6	2306	4.6	0.343	7.2	LOS A	1.9	14.7	0.54	0.55	0.54	59.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Pm Peak - 2026 - with development (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	53	5.0	53	5.0	0.388	6.3	LOS A	2.6	20.0	0.78	0.59	0.78	55.4
2	T1	All MCs	484	5.0	484	5.0	0.388	7.1	LOS A	2.6	20.0	0.78	0.64	0.79	58.1
3	R2	All MCs	139	5.0	139	5.0	0.388	15.5	LOS B	2.4	18.3	0.78	0.75	0.81	56.5
3u	U	All MCs	1	0.0	1	0.0	0.388	16.1	LOS B	2.4	18.3	0.78	0.75	0.81	52.9
Approach			677	5.0	677	5.0	0.388	8.8	LOS A	2.6	20.0	0.78	0.66	0.79	57.5
East: Port Kennedy Drive															
4	L2	All MCs	304	5.0	304	5.0	0.599	10.7	LOS B	4.4	34.4	0.82	0.88	1.06	60.1
5	T1	All MCs	181	5.0	181	5.0	0.599	11.3	LOS B	4.9	37.9	0.82	0.88	1.05	56.8
6	R2	All MCs	620	5.0	620	5.0	0.599	17.6	LOS B	4.9	37.9	0.81	0.88	1.00	54.2
6u	U	All MCs	1	0.0	1	0.0	0.599	16.6	LOS B	4.9	37.9	0.81	0.88	1.00	52.6
Approach			1106	5.0	1106	5.0	0.599	14.7	LOS B	4.9	37.9	0.81	0.88	1.03	56.0
North: Warnbro Sound Avenue															
7	L2	All MCs	361	5.0	361	5.0	0.462	4.8	LOS A	3.0	22.9	0.52	0.49	0.52	62.1
8	T1	All MCs	784	5.0	784	5.0	0.462	5.5	LOS A	3.0	22.9	0.54	0.49	0.54	60.3
9	R2	All MCs	27	5.0	27	5.0	0.462	13.2	LOS B	2.8	22.0	0.55	0.50	0.55	55.7
9u	U	All MCs	3	0.0	3	0.0	0.462	13.9	LOS B	2.8	22.0	0.55	0.50	0.55	55.8
Approach			1176	5.0	1176	5.0	0.462	5.5	LOS A	3.0	22.9	0.53	0.49	0.53	60.7
West: Port Kennedy Drive															
10	L2	All MCs	39	4.0	39	4.0	0.141	5.9	LOS A	0.8	6.3	0.77	0.62	0.77	55.8
11	T1	All MCs	99	1.0	99	1.0	0.141	5.9	LOS A	0.8	6.3	0.77	0.64	0.77	57.8
12	R2	All MCs	77	4.0	77	4.0	0.141	14.5	LOS B	0.7	5.5	0.76	0.81	0.76	50.5
12u	U	All MCs	1	0.0	1	0.0	0.141	17.1	LOS B	0.7	5.5	0.76	0.81	0.76	49.0
Approach			216	2.6	216	2.6	0.141	9.0	LOS A	0.8	6.3	0.76	0.70	0.76	54.5
All Vehicles			3175	4.8	3175	4.8	0.599	9.6	LOS A	4.9	37.9	0.70	0.68	0.78	57.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Am Peak - 2036 - with development (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	68	5.0	68	5.0	0.423	5.0	LOS A	2.6	20.0	0.56	0.47	0.56	56.7
2	T1	All MCs	726	5.0	726	5.0	0.423	5.6	LOS A	2.6	20.0	0.57	0.52	0.57	59.5
3	R2	All MCs	214	5.0	214	5.0	0.423	13.5	LOS B	2.5	19.0	0.59	0.61	0.59	57.9
3u	U	All MCs	1	0.0	1	0.0	0.423	14.2	LOS B	2.5	19.0	0.59	0.61	0.59	54.2
Approach			1009	5.0	1009	5.0	0.423	7.2	LOS A	2.6	20.0	0.57	0.54	0.57	58.9
East: Port Kennedy Drive															
4	L2	All MCs	57	5.0	57	5.0	0.194	6.9	LOS A	1.0	7.8	0.59	0.60	0.59	62.1
5	T1	All MCs	132	5.0	132	5.0	0.194	7.7	LOS A	1.1	8.4	0.59	0.60	0.59	58.8
6	R2	All MCs	226	5.0	226	5.0	0.194	15.0	LOS B	1.1	8.4	0.57	0.70	0.57	55.1
6u	U	All MCs	1	0.0	1	0.0	0.194	14.0	LOS B	1.1	8.4	0.57	0.70	0.57	53.5
Approach			416	5.0	416	5.0	0.194	11.6	LOS B	1.1	8.4	0.58	0.66	0.58	57.0
North: Warnbro Sound Avenue															
7	L2	All MCs	469	5.0	469	5.0	0.422	5.4	LOS A	2.5	19.4	0.62	0.58	0.62	61.9
8	T1	All MCs	415	5.0	415	5.0	0.422	6.4	LOS A	2.5	19.4	0.64	0.59	0.65	59.1
9	R2	All MCs	36	5.0	36	5.0	0.422	14.2	LOS B	2.4	18.5	0.64	0.59	0.66	54.8
9u	U	All MCs	13	0.0	13	0.0	0.422	14.8	LOS B	2.4	18.5	0.64	0.59	0.66	54.9
Approach			933	4.9	933	4.9	0.422	6.3	LOS A	2.5	19.4	0.63	0.59	0.64	60.2
West: Port Kennedy Drive															
10	L2	All MCs	47	2.0	47	2.0	0.236	5.1	LOS A	1.3	9.8	0.73	0.53	0.73	56.0
11	T1	All MCs	253	2.0	253	2.0	0.236	5.3	LOS A	1.3	9.8	0.73	0.59	0.73	57.5
12	R2	All MCs	97	2.0	97	2.0	0.236	13.5	LOS B	1.2	8.7	0.73	0.75	0.73	52.4
12u	U	All MCs	1	0.0	1	0.0	0.236	16.1	LOS B	1.2	8.7	0.73	0.75	0.73	50.4
Approach			398	2.0	398	2.0	0.236	7.3	LOS A	1.3	9.8	0.73	0.62	0.73	55.9
All Vehicles			2756	4.5	2756	4.5	0.423	7.6	LOS A	2.6	20.0	0.62	0.58	0.62	58.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Pm Peak - 2036 - with development (Site Folder: Port Kennedy and Warnbro Sound Ave)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Warnbro Sound Avenue															
1	L2	All MCs	64	5.0	64	5.0	0.533	8.2	LOS A	4.5	34.6	0.90	0.79	1.03	54.7
2	T1	All MCs	591	5.0	591	5.0	0.533	9.1	LOS A	4.5	34.6	0.89	0.82	1.04	57.2
3	R2	All MCs	162	5.0	162	5.0	0.533	17.9	LOS B	4.0	30.6	0.88	0.89	1.06	55.3
3u	U	All MCs	1	0.0	1	0.0	0.533	18.4	LOS B	4.0	30.6	0.88	0.89	1.06	51.9
Approach			818	5.0	818	5.0	0.533	10.8	LOS B	4.5	34.6	0.89	0.83	1.04	56.6
East: Port Kennedy Drive															
4	L2	All MCs	343	5.0	343	5.0	0.777	16.1	LOS B	7.5	57.8	0.94	1.07	1.52	55.5
5	T1	All MCs	239	5.0	239	5.0	0.777	16.1	LOS B	8.7	67.1	0.94	1.06	1.51	52.4
6	R2	All MCs	663	5.0	663	5.0	0.777	21.8	LOS C	8.7	67.1	0.95	1.05	1.47	51.8
6u	U	All MCs	1	0.0	1	0.0	0.777	20.7	LOS C	8.7	67.1	0.95	1.05	1.47	50.4
Approach			1246	5.0	1246	5.0	0.777	19.1	LOS B	8.7	67.1	0.94	1.06	1.49	52.8
North: Warnbro Sound Avenue															
7	L2	All MCs	402	5.0	402	5.0	0.575	5.5	LOS A	4.4	33.7	0.63	0.56	0.66	61.4
8	T1	All MCs	956	5.0	956	5.0	0.575	6.4	LOS A	4.4	33.7	0.65	0.59	0.70	59.6
9	R2	All MCs	34	5.0	34	5.0	0.575	14.3	LOS B	4.3	33.5	0.66	0.61	0.72	55.0
9u	U	All MCs	3	0.0	3	0.0	0.575	14.9	LOS B	4.3	33.5	0.66	0.61	0.72	55.2
Approach			1395	5.0	1395	5.0	0.575	6.3	LOS A	4.4	33.7	0.64	0.58	0.69	59.9
West: Port Kennedy Drive															
10	L2	All MCs	47	4.0	47	4.0	0.203	6.8	LOS A	1.3	9.7	0.84	0.69	0.84	55.4
11	T1	All MCs	131	1.0	131	1.0	0.203	6.8	LOS A	1.3	9.7	0.84	0.71	0.84	57.3
12	R2	All MCs	94	4.0	94	4.0	0.203	15.7	LOS B	1.1	8.3	0.81	0.85	0.81	49.9
12u	U	All MCs	1	0.0	1	0.0	0.203	18.2	LOS B	1.1	8.3	0.81	0.85	0.81	48.4
Approach			273	2.5	273	2.5	0.203	9.9	LOS A	1.3	9.7	0.83	0.75	0.83	54.1
All Vehicles			3732	4.8	3732	4.8	0.777	11.8	LOS B	8.7	67.1	0.81	0.81	1.04	56.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

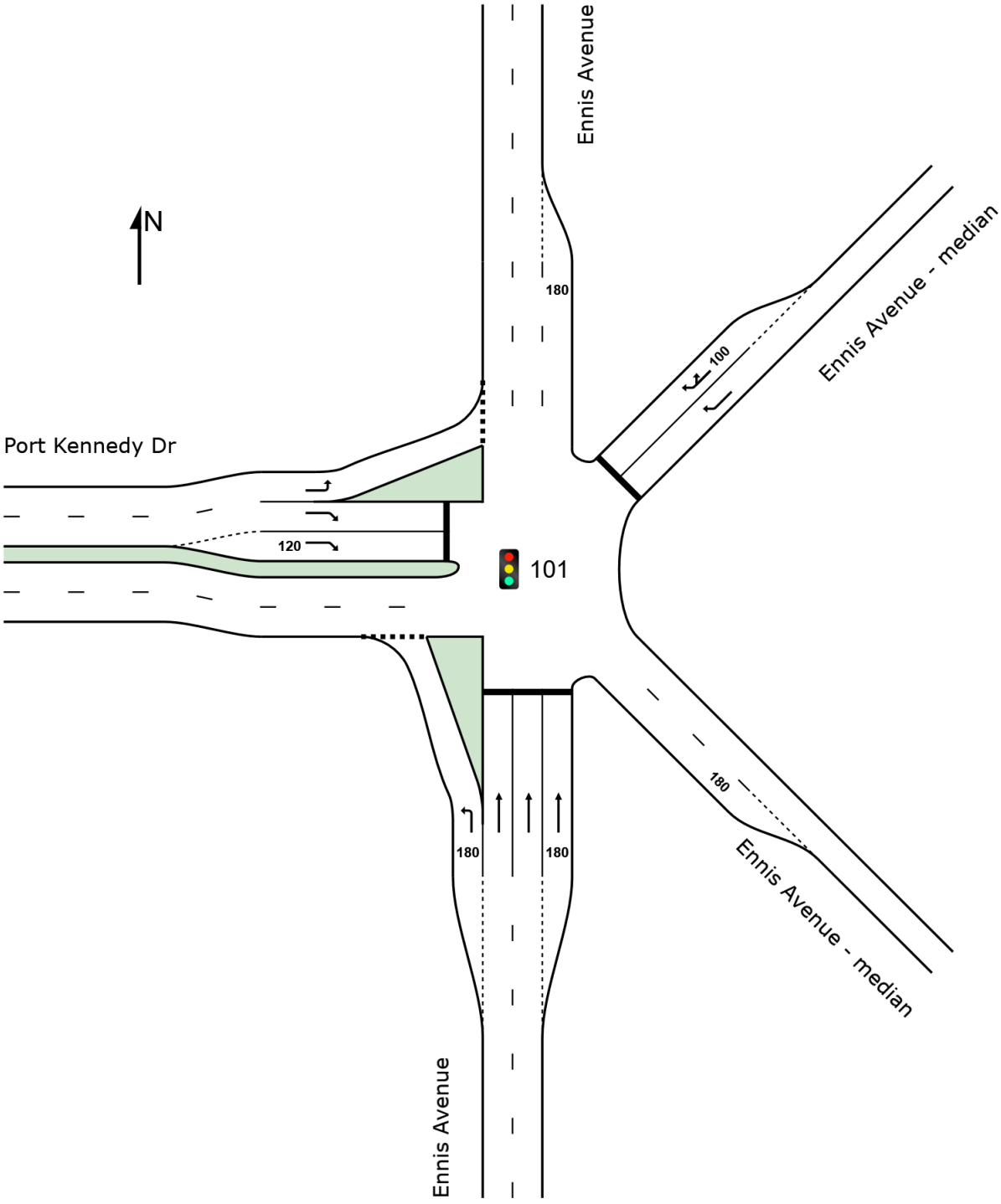
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, Proposed Layout Option 3, 2026 and 2036 – With Development

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 with Development - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru - With Developm)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 with Development - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru - With Developm)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	540	9.1	540	9.1	0.449	10.8	LOS B	5.1	42.7	0.49	0.74	0.49	57.8
2	T1	All MCs	1347	2.7	1347	2.7	* 0.904	36.4	LOS D	16.8	126.8	1.00	1.10	1.46	44.8
Approach			1887	4.5	1887	4.5	0.904	29.1	LOS C	16.8	126.8	0.86	1.00	1.18	47.7
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	568	5.0	568	5.0	* 0.824	37.4	LOS D	9.4	72.5	1.00	0.97	1.31	40.1
26b	R3	All MCs	1	0.0	1	0.0	0.824	39.8	LOS D	9.4	72.5	1.00	0.97	1.31	41.9
Approach			569	5.0	569	5.0	0.824	37.4	LOS D	9.4	72.5	1.00	0.97	1.31	40.1
West: Port Kennedy Dr															
10	L2	All MCs	412	7.5	412	7.5	0.482	12.6	LOS B	5.5	43.8	0.64	0.77	0.64	56.2
12a	R1	All MCs	343	11.7	343	11.7	* 0.817	40.2	LOS D	5.8	50.1	1.00	0.96	1.39	38.6
Approach			755	9.5	755	9.5	0.817	25.2	LOS C	5.8	50.1	0.80	0.86	0.98	46.6
All Vehicles			3212	5.8	3212	5.8	0.904	29.6	LOS C	16.8	126.8	0.87	0.96	1.16	46.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 with Development - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru - With Developm)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	560	4.6	560	4.6	0.463	12.4	LOS B	6.8	52.3	0.52	0.77	0.52	57.0
2	T1	All MCs	761	2.0	761	2.0	* 0.809	36.2	LOS D	9.6	71.7	1.00	0.94	1.25	44.8
Approach			1321	3.1	1321	3.1	0.809	26.1	LOS C	9.6	71.7	0.80	0.87	0.94	49.0
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	713	1.9	713	1.9	* 0.811	38.8	LOS D	13.1	98.1	1.00	0.94	1.20	39.7
26b	R3	All MCs	1	0.0	1	0.0	0.811	40.3	LOS D	13.1	98.0	1.00	0.94	1.20	41.3
Approach			714	1.9	714	1.9	0.811	38.8	LOS D	13.1	98.1	1.00	0.94	1.20	39.7
West: Port Kennedy Dr															
10	L2	All MCs	729	5.6	729	5.6	0.661	11.1	LOS B	10.2	80.2	0.61	0.79	0.61	58.0
12a	R1	All MCs	703	2.0	703	2.0	* 0.799	38.6	LOS D	12.7	96.4	1.00	0.94	1.19	40.1
Approach			1433	3.8	1433	3.8	0.799	24.6	LOS C	12.7	96.4	0.80	0.86	0.89	47.6
All Vehicles			3467	3.2	3467	3.2	0.811	28.1	LOS C	13.1	98.1	0.84	0.88	0.98	46.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 with Development - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru - With Developm)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	639	9.1	639	9.1	0.514	12.8	LOS B	7.8	65.2	0.50	0.78	0.50	56.0
2	T1	All MCs	1725	2.7	1725	2.7	* 0.891	39.6	LOS D	26.3	198.6	1.00	1.05	1.26	43.3
Approach			2364	4.4	2364	4.4	0.891	32.4	LOS C	26.3	198.6	0.87	0.98	1.06	45.9
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	641	5.0	641	5.0	* 0.851	47.1	LOS D	14.0	108.5	1.00	0.99	1.27	35.9
26b	R3	All MCs	1	0.0	1	0.0	0.851	50.7	LOS D	14.0	108.4	1.00	0.99	1.27	37.7
Approach			642	5.0	642	5.0	0.851	47.1	LOS D	14.0	108.5	1.00	0.99	1.27	35.9
West: Port Kennedy Dr															
10	L2	All MCs	520	7.5	520	7.5	0.676	16.8	LOS B	12.5	99.5	0.78	0.83	0.78	52.5
12a	R1	All MCs	437	11.7	437	11.7	* 0.883	53.4	LOS D	10.1	87.7	1.00	1.03	1.43	33.5
Approach			957	9.5	957	9.5	0.883	33.5	LOS C	12.5	99.5	0.88	0.92	1.07	41.7
All Vehicles			3963	5.7	3963	5.7	0.891	35.0	LOS D	26.3	198.6	0.89	0.96	1.10	43.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 with Development - Modifications (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right into out of PK + Auxiliary Thru - With Developm)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	683	4.6	683	4.6	0.573	16.2	LOS B	11.8	90.6	0.60	0.83	0.60	53.5
2	T1	All MCs	974	2.0	974	2.0	* 0.861	46.6	LOS D	16.0	120.1	1.00	0.99	1.26	39.8
Approach			1657	3.1	1657	3.1	0.861	34.1	LOS C	16.0	120.1	0.83	0.93	0.99	44.2
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	861	1.9	861	1.9	* 0.840	46.1	LOS D	20.1	151.1	1.00	0.95	1.17	36.4
26b	R3	All MCs	1	0.0	1	0.0	0.840	47.9	LOS D	20.1	151.0	1.00	0.95	1.17	38.1
Approach			862	1.9	862	1.9	0.840	46.1	LOS D	20.1	151.1	1.00	0.95	1.17	36.5
West: Port Kennedy Dr															
10	L2	All MCs	809	5.6	809	5.6	0.762	13.9	LOS B	20.0	157.1	0.75	0.84	0.75	55.2
12a	R1	All MCs	823	2.0	823	2.0	* 0.875	51.5	LOS D	20.4	154.3	1.00	1.00	1.25	34.7
Approach			1633	3.8	1633	3.8	0.875	32.9	LOS C	20.4	157.1	0.88	0.92	1.00	42.6
All Vehicles			4152	3.1	4152	3.1	0.875	36.1	LOS D	20.4	157.1	0.89	0.93	1.03	41.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

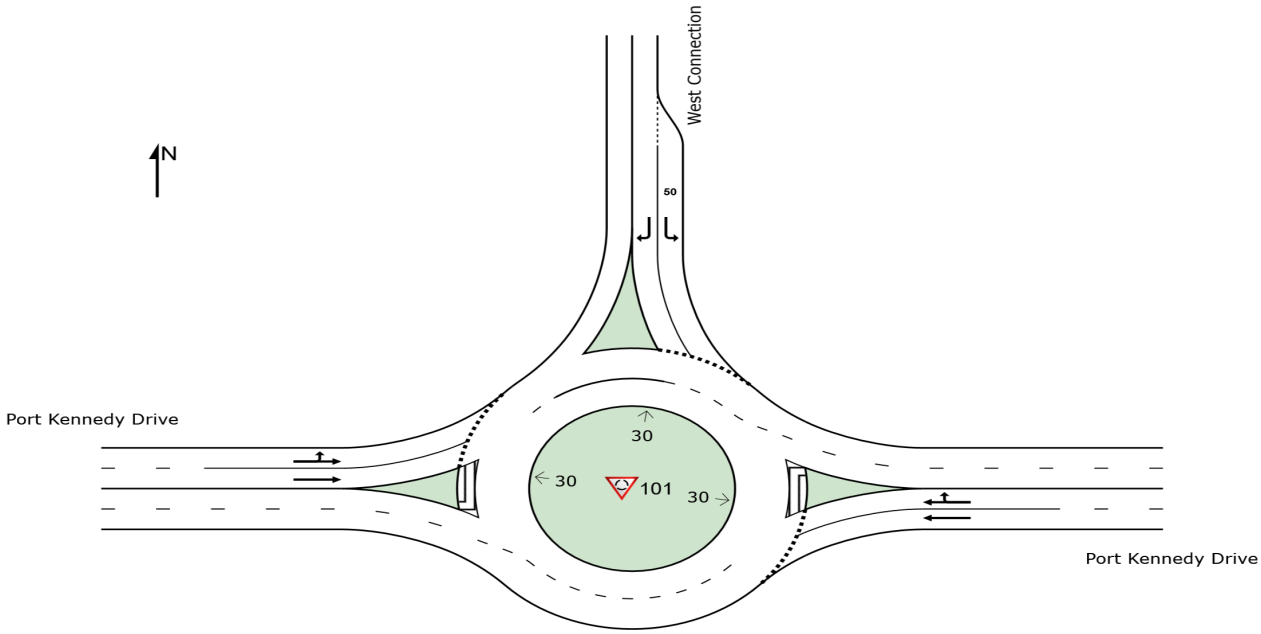
SIDRA Analysis, Western Connection, Port Kennedy Drive Proposed Roundabout
–2026 and 2036 – With development

SITE LAYOUT

Site: 101 [Port Kennedy Drive West Connection Pm Peak 2026 Full Development (Site Folder: Port Kennedy Roundabouts)]

New Site
Site Category: (None)
Roundabout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive West Connection Am Peak 2026 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	544	3.5	544	3.5	0.283	6.3	LOS A	2.0	16.8	0.26	0.48	0.26	60.9
6	R2	All MCs	289	3.5	289	3.5	0.283	12.3	LOS B	2.0	16.3	0.28	0.60	0.28	43.8
Approach			834	3.5	834	3.5	0.283	8.4	LOS A	2.0	16.8	0.27	0.52	0.27	55.8
North: West Connection															
7	L2	All MCs	80	3.5	80	3.5	0.093	4.8	LOS A	0.4	3.5	0.60	0.63	0.60	47.3
9	R2	All MCs	68	3.0	68	3.0	0.096	10.4	LOS B	0.4	3.4	0.61	0.75	0.61	48.8
Approach			148	3.3	148	3.3	0.096	7.4	LOS A	0.4	3.5	0.60	0.68	0.60	48.2
West: Port Kennedy Drive															
10	L2	All MCs	246	3.0	246	3.0	0.408	7.2	LOS A	3.1	25.7	0.58	0.56	0.58	55.3
11	T1	All MCs	745	3.0	745	3.0	0.408	8.0	LOS A	3.1	25.7	0.59	0.57	0.59	59.8
Approach			992	3.0	992	3.0	0.408	7.8	LOS A	3.1	25.7	0.59	0.57	0.59	58.8
All Vehicles			1974	3.2	1974	3.2	0.408	8.0	LOS A	3.1	25.7	0.46	0.56	0.46	56.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive West Connection Pm Peak 2026 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	1012	3.5	1012	3.5	0.564	8.7	LOS A	5.0	41.5	0.73	0.67	0.74	57.2
6	R2	All MCs	229	3.5	229	3.5	0.564	15.4	LOS B	5.0	41.4	0.74	0.72	0.79	42.2
Approach			1241	3.5	1241	3.5	0.564	10.0	LOS A	5.0	41.5	0.73	0.68	0.75	55.0
North: West Connection															
7	L2	All MCs	403	3.5	403	3.5	0.458	5.9	LOS A	2.7	22.6	0.71	0.73	0.78	46.4
9	R2	All MCs	344	3.0	344	3.0	0.467	11.8	LOS B	2.7	22.2	0.72	0.84	0.83	47.5
Approach			747	3.3	747	3.3	0.467	8.6	LOS A	2.7	22.6	0.71	0.78	0.80	47.1
West: Port Kennedy Drive															
10	L2	All MCs	196	3.0	196	3.0	0.365	6.8	LOS A	2.9	23.9	0.55	0.54	0.55	55.4
11	T1	All MCs	711	3.0	711	3.0	0.365	7.4	LOS A	2.9	23.9	0.56	0.54	0.56	60.0
Approach			906	3.0	906	3.0	0.365	7.3	LOS A	2.9	23.9	0.56	0.54	0.56	59.1
All Vehicles			2895	3.3	2895	3.3	0.564	8.8	LOS A	5.0	41.5	0.67	0.66	0.71	54.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive West Connection Am Peak 2036 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	716	3.5	716	3.5	0.341	6.4	LOS A	2.6	21.9	0.29	0.48	0.29	60.6
6	R2	All MCs	289	3.5	289	3.5	0.341	12.3	LOS B	2.6	21.3	0.30	0.58	0.30	44.4
Approach			1005	3.5	1005	3.5	0.341	8.1	LOS A	2.6	21.9	0.29	0.51	0.29	56.7
North: West Connection															
7	L2	All MCs	80	3.5	80	3.5	0.106	5.3	LOS A	0.5	4.1	0.66	0.68	0.66	46.8
9	R2	All MCs	68	3.0	68	3.0	0.113	11.1	LOS B	0.5	4.0	0.67	0.80	0.67	48.2
Approach			148	3.3	148	3.3	0.113	8.0	LOS A	0.5	4.1	0.67	0.74	0.67	47.6
West: Port Kennedy Drive															
10	L2	All MCs	246	3.0	246	3.0	0.492	7.4	LOS A	4.1	33.7	0.62	0.57	0.62	54.9
11	T1	All MCs	947	3.0	947	3.0	0.492	8.2	LOS A	4.1	33.7	0.64	0.58	0.64	59.4
Approach			1194	3.0	1194	3.0	0.492	8.0	LOS A	4.1	33.7	0.64	0.58	0.64	58.5
All Vehicles			2347	3.2	2347	3.2	0.492	8.0	LOS A	4.1	33.7	0.49	0.56	0.49	57.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive West Connection Pm Peak 2036 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	1283	3.5	1283	3.5	0.693	10.5	LOS B	8.4	69.8	0.83	0.75	0.95	56.4
6	R2	All MCs	229	3.5	229	3.5	0.693	17.4	LOS B	8.1	68.0	0.85	0.79	1.00	41.3
Approach			1513	3.5	1513	3.5	0.693	11.6	LOS B	8.4	69.8	0.83	0.76	0.96	54.6
North: West Connection															
7	L2	All MCs	403	3.5	403	3.5	0.518	7.1	LOS A	3.3	27.2	0.78	0.84	0.94	44.7
9	R2	All MCs	344	3.0	344	3.0	0.548	13.7	LOS B	3.4	27.7	0.80	0.94	1.00	46.0
Approach			747	3.3	747	3.3	0.548	10.1	LOS B	3.4	27.7	0.79	0.89	0.97	45.5
West: Port Kennedy Drive															
10	L2	All MCs	196	3.0	196	3.0	0.449	6.9	LOS A	3.9	32.3	0.60	0.55	0.60	55.0
11	T1	All MCs	911	3.0	911	3.0	0.449	7.6	LOS A	3.9	32.3	0.62	0.55	0.62	59.6
Approach			1106	3.0	1106	3.0	0.449	7.5	LOS A	3.9	32.3	0.62	0.55	0.62	58.8
All Vehicles			3366	3.3	3366	3.3	0.693	9.9	LOS A	8.4	69.8	0.75	0.72	0.85	54.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

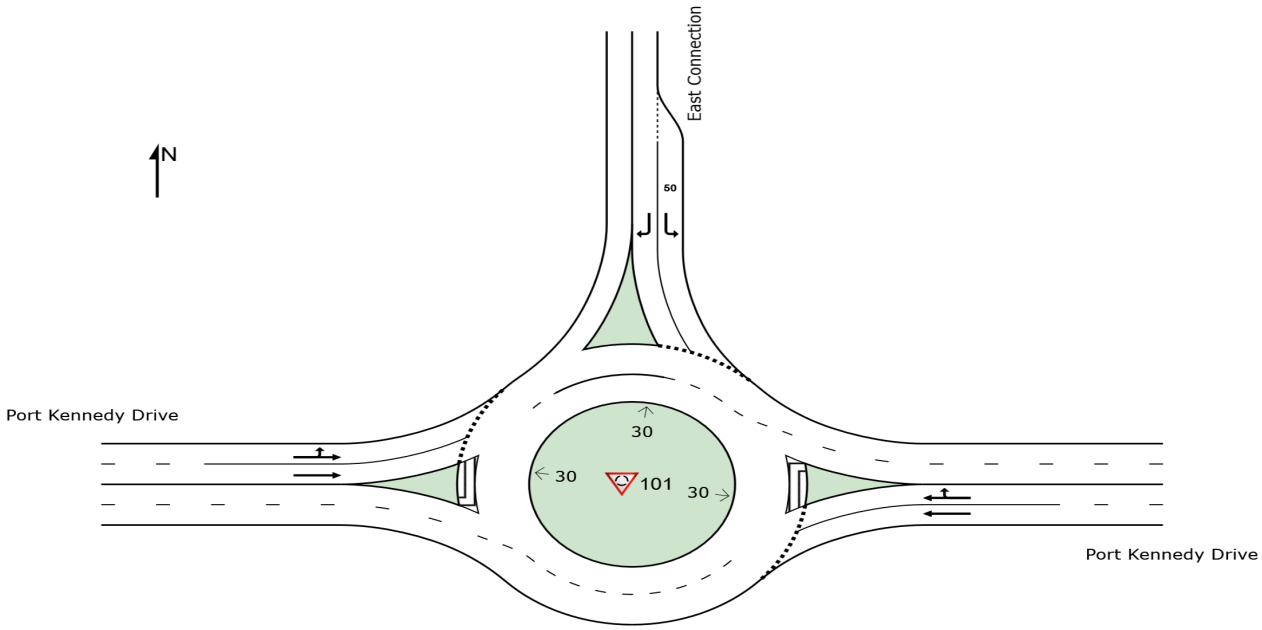
SIDRA Analysis, Eastern Connection, Port Kennedy Drive Proposed Roundabout –2026 and 2036 – With development

SITE LAYOUT

Site: 101 [Port Kennedy Drive East Connection Am Peak 2036 Full Development (Site Folder: Port Kennedy Roundabouts)]

New Site
Site Category: (None)
Roundabout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive East Connection Am Peak 2026 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	789	3.5	789	3.5	0.363	6.2	LOS A	2.6	22.0	0.20	0.48	0.20	56.1
6	R2	All MCs	319	3.5	319	3.5	0.363	12.1	LOS B	2.5	21.3	0.21	0.59	0.21	44.9
Approach			1108	3.5	1108	3.5	0.363	7.9	LOS A	2.6	22.0	0.20	0.52	0.20	52.8
North: East Connection															
7	L2	All MCs	88	3.5	88	3.5	0.098	4.5	LOS A	0.4	3.6	0.57	0.60	0.57	47.5
9	R2	All MCs	44	3.0	44	3.0	0.065	10.4	LOS B	0.3	2.2	0.58	0.74	0.58	40.8
Approach			133	3.3	133	3.3	0.098	6.5	LOS A	0.4	3.6	0.57	0.65	0.57	44.8
West: Port Kennedy Drive															
10	L2	All MCs	159	3.0	159	3.0	0.343	7.4	LOS A	2.7	22.5	0.58	0.54	0.58	46.7
11	T1	All MCs	666	3.2	666	3.2	0.343	8.1	LOS A	2.7	22.5	0.59	0.55	0.59	53.5
Approach			825	3.2	825	3.2	0.343	8.0	LOS A	2.7	22.5	0.59	0.55	0.59	52.3
All Vehicles			2066	3.4	2066	3.4	0.363	7.9	LOS A	2.7	22.5	0.38	0.54	0.38	52.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive East Connection Pm Peak 2026 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	1020	3.5	1020	3.5	0.513	7.6	LOS A	4.2	35.3	0.53	0.60	0.53	53.2
6	R2	All MCs	254	3.5	254	3.5	0.513	13.7	LOS B	3.9	32.8	0.55	0.66	0.55	43.8
Approach			1274	3.5	1274	3.5	0.513	8.8	LOS A	4.2	35.3	0.53	0.61	0.53	51.3
North: East Connection															
7	L2	All MCs	445	3.5	445	3.5	0.593	8.0	LOS A	4.0	33.4	0.82	0.91	1.05	43.5
9	R2	All MCs	221	3.0	221	3.0	0.403	13.0	LOS B	2.0	16.5	0.75	0.90	0.86	38.4
Approach			666	3.3	666	3.3	0.593	9.6	LOS A	4.0	33.4	0.80	0.91	0.99	41.5
West: Port Kennedy Drive															
10	L2	All MCs	126	3.0	126	3.0	0.452	7.1	LOS A	4.0	32.8	0.61	0.54	0.61	46.3
11	T1	All MCs	987	3.2	987	3.2	0.452	7.8	LOS A	4.0	32.8	0.62	0.55	0.62	53.2
Approach			1114	3.2	1114	3.2	0.452	7.7	LOS A	4.0	32.8	0.62	0.55	0.62	52.5
All Vehicles			3054	3.3	3054	3.3	0.593	8.6	LOS A	4.2	35.3	0.62	0.65	0.66	49.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive East Connection Pm Peak 2036 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	1292	3.5	1292	3.5	0.624	7.9	LOS A	6.1	50.7	0.60	0.62	0.60	52.6
6	R2	All MCs	254	3.5	254	3.5	0.624	14.1	LOS B	5.7	47.2	0.62	0.67	0.63	43.6
Approach			1545	3.5	1545	3.5	0.624	8.9	LOS A	6.1	50.7	0.60	0.63	0.60	51.2
North: East Connection															
7	L2	All MCs	445	3.5	445	3.5	0.679	10.1	LOS B	5.0	41.5	0.89	1.02	1.24	41.0
9	R2	All MCs	221	3.0	221	3.0	0.471	14.6	LOS B	2.5	20.3	0.81	0.97	0.98	37.0
Approach			666	3.3	666	3.3	0.679	11.6	LOS B	5.0	41.5	0.86	1.00	1.16	39.5
West: Port Kennedy Drive															
10	L2	All MCs	126	3.0	126	3.0	0.537	7.3	LOS A	5.1	42.5	0.66	0.56	0.66	45.8
11	T1	All MCs	1187	3.2	1187	3.2	0.537	8.0	LOS A	5.1	42.5	0.68	0.57	0.68	52.6
Approach			1314	3.2	1314	3.2	0.537	7.9	LOS A	5.1	42.5	0.68	0.57	0.68	52.0
All Vehicles			3525	3.3	3525	3.3	0.679	9.0	LOS A	6.1	50.7	0.68	0.68	0.74	49.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Drive East Connection Am Peak 2036 Full Development (Site Folder: Port Kennedy Roundabouts)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
East: Port Kennedy Drive															
5	T1	All MCs	961	3.5	961	3.5	0.419	6.3	LOS A	3.4	28.2	0.22	0.48	0.22	56.0
6	R2	All MCs	319	3.5	319	3.5	0.419	12.2	LOS B	3.2	27.1	0.23	0.58	0.23	45.3
Approach			1280	3.5	1280	3.5	0.419	7.7	LOS A	3.4	28.2	0.22	0.51	0.22	53.3
North: East Connection															
7	L2	All MCs	88	3.5	88	3.5	0.111	5.0	LOS A	0.5	4.2	0.64	0.66	0.64	47.0
9	R2	All MCs	44	3.0	44	3.0	0.075	11.1	LOS B	0.3	2.5	0.64	0.79	0.64	40.2
Approach			133	3.3	133	3.3	0.111	7.0	LOS A	0.5	4.2	0.64	0.71	0.64	44.3
West: Port Kennedy Drive															
10	L2	All MCs	159	3.0	159	3.0	0.428	7.6	LOS A	3.7	30.3	0.62	0.55	0.62	46.3
11	T1	All MCs	868	3.2	868	3.2	0.428	8.3	LOS A	3.7	30.3	0.64	0.56	0.64	53.1
Approach			1027	3.2	1027	3.2	0.428	8.2	LOS A	3.7	30.3	0.63	0.56	0.63	52.1
All Vehicles			2440	3.4	2440	3.4	0.428	7.9	LOS A	3.7	30.3	0.42	0.54	0.42	52.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

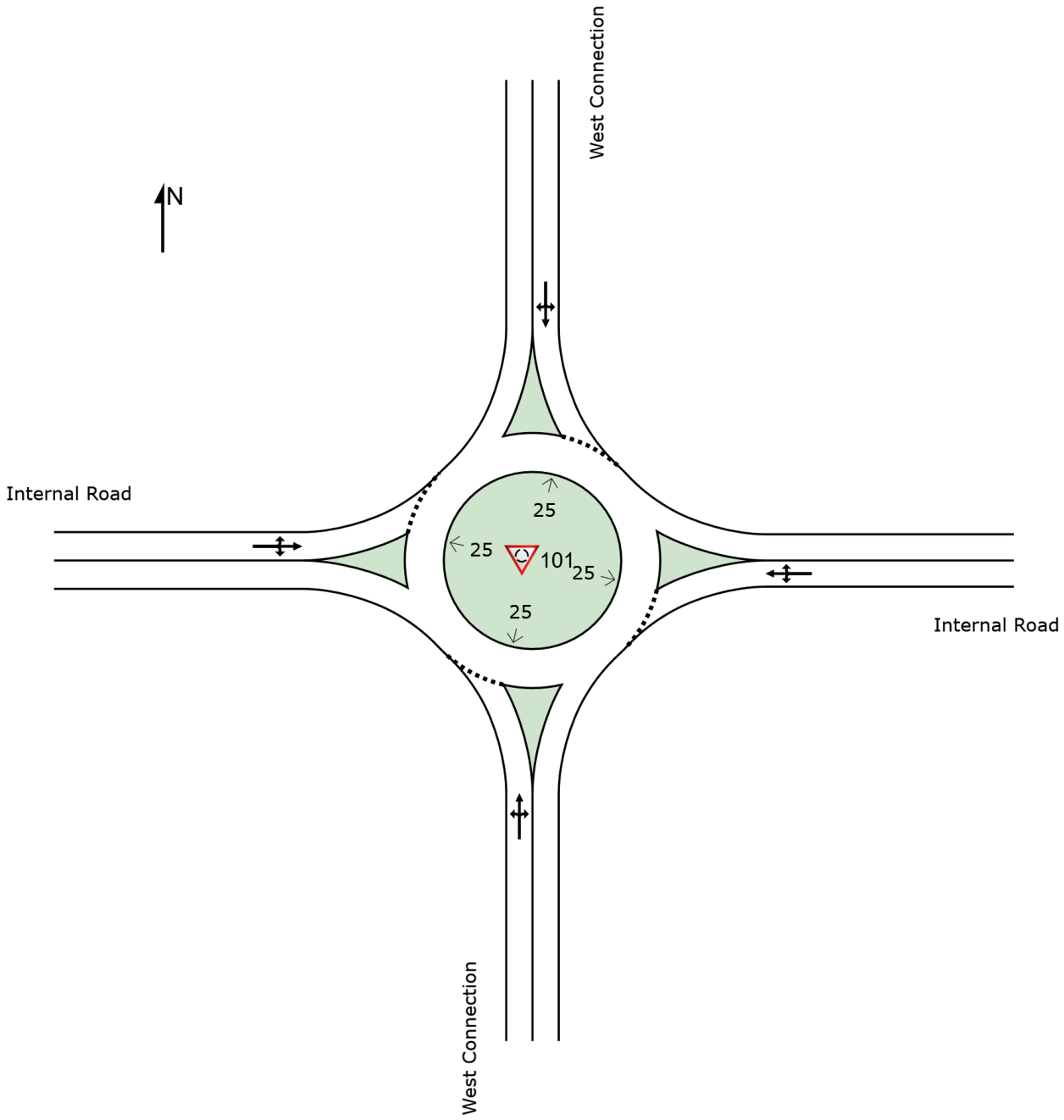
SIDRA Analysis, Internal 4 way Roundabout on Western Connection, Full development

SITE LAYOUT

Site: 101 [West Connection Internal Roundabout Am Peak 2036 Full Development (Site Folder: Internal Intersections)]

New Site
Site Category: (None)
Roundabout

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [West Connection Internal Roundabout Am Peak 2036 Full Development (Site Folder: Internal Intersections)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: West Connection															
1	L2	All MCs	161	3.5	161	3.5	0.368	2.8	LOS A	2.7	22.5	0.19	0.39	0.19	40.7
5	T1	All MCs	241	3.5	241	3.5	0.368	2.4	LOS A	2.7	22.5	0.19	0.39	0.19	43.7
6	R2	All MCs	134	3.5	134	3.5	0.368	7.6	LOS A	2.7	22.5	0.19	0.39	0.19	41.7
Approach			536	3.5	536	3.5	0.368	3.8	LOS A	2.7	22.5	0.19	0.39	0.19	42.5
East: Internal Road															
7	L2	All MCs	37	3.5	37	3.5	0.050	3.3	LOS A	0.3	2.2	0.31	0.44	0.31	41.9
5	T1	All MCs	11	3.5	11	3.5	0.050	2.9	LOS A	0.3	2.2	0.31	0.44	0.31	42.9
9	R2	All MCs	11	3.5	11	3.5	0.050	8.1	LOS A	0.3	2.2	0.31	0.44	0.31	43.4
Approach			58	3.5	58	3.5	0.050	4.1	LOS A	0.3	2.2	0.31	0.44	0.31	42.4
North: West Connection															
10	L2	All MCs	11	3.5	11	3.5	0.081	3.7	LOS A	0.4	3.5	0.39	0.43	0.39	44.0
11	T1	All MCs	66	3.5	66	3.5	0.081	3.3	LOS A	0.4	3.5	0.39	0.43	0.39	43.3
9	R2	All MCs	11	3.5	11	3.5	0.081	8.5	LOS A	0.4	3.5	0.39	0.43	0.39	41.9
Approach			87	3.5	87	3.5	0.081	4.0	LOS A	0.4	3.5	0.39	0.43	0.39	43.2
West: Internal Road															
10	L2	All MCs	11	3.5	11	3.5	0.071	4.8	LOS A	0.4	3.0	0.51	0.62	0.51	39.9
11	T1	All MCs	11	3.5	11	3.5	0.071	4.4	LOS A	0.4	3.0	0.51	0.62	0.51	39.5
12	R2	All MCs	44	3.5	44	3.5	0.071	9.6	LOS A	0.4	3.0	0.51	0.62	0.51	35.5
Approach			65	3.5	65	3.5	0.071	8.0	LOS A	0.4	3.0	0.51	0.62	0.51	37.1
All Vehicles			746	3.5	746	3.5	0.368	4.2	LOS A	2.7	22.5	0.25	0.42	0.25	42.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [West Connection Internal Roundabout Pm Peak 2036 Full Development (Site Folder: Internal Intersections)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: West Connection															
1	L2	All MCs	127	3.5	127	3.5	0.297	2.8	LOS A	2.2	18.1	0.19	0.39	0.19	40.7
5	T1	All MCs	192	3.5	192	3.5	0.297	2.4	LOS A	2.2	18.1	0.19	0.39	0.19	43.7
6	R2	All MCs	106	3.5	106	3.5	0.297	7.6	LOS A	2.2	18.1	0.19	0.39	0.19	41.7
Approach			425	3.5	425	3.5	0.297	3.8	LOS A	2.2	18.1	0.19	0.39	0.19	42.5
East: Internal Road															
7	L2	All MCs	186	3.5	186	3.5	0.286	7.2	LOS A	1.8	15.1	0.75	0.67	0.75	38.8
5	T1	All MCs	11	3.5	11	3.5	0.286	6.8	LOS A	1.8	15.1	0.75	0.67	0.75	39.7
9	R2	All MCs	11	3.5	11	3.5	0.286	12.0	LOS B	1.8	15.1	0.75	0.67	0.75	41.0
Approach			207	3.5	207	3.5	0.286	7.4	LOS A	1.8	15.1	0.75	0.67	0.75	39.0
North: West Connection															
10	L2	All MCs	11	3.5	11	3.5	0.390	5.4	LOS A	2.6	22.0	0.65	0.55	0.65	42.9
11	T1	All MCs	336	3.5	336	3.5	0.390	5.1	LOS A	2.6	22.0	0.65	0.55	0.65	42.0
9	R2	All MCs	11	3.5	11	3.5	0.390	10.2	LOS B	2.6	22.0	0.65	0.55	0.65	40.7
Approach			357	3.5	357	3.5	0.390	5.2	LOS A	2.6	22.0	0.65	0.55	0.65	42.0
West: Internal Road															
10	L2	All MCs	11	3.5	11	3.5	0.251	4.7	LOS A	1.4	11.9	0.53	0.63	0.53	39.1
11	T1	All MCs	11	3.5	11	3.5	0.251	4.3	LOS A	1.4	11.9	0.53	0.63	0.53	38.6
12	R2	All MCs	224	3.5	224	3.5	0.251	9.5	LOS A	1.4	11.9	0.53	0.63	0.53	34.6
Approach			245	3.5	245	3.5	0.251	9.0	LOS A	1.4	11.9	0.53	0.63	0.53	35.0
All Vehicles			1235	3.5	1235	3.5	0.390	5.9	LOS A	2.6	22.0	0.48	0.53	0.48	40.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

SIDRA Analysis, Internal T-junction on Eastern Connection, Full development

MOVEMENT SUMMARY

Site: 101 [East Connection - Internal Junction Am Peak 2036 Full Development (Site Folder: Internal Intersections)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: East Connection															
1	L2	All MCs	96	0.0	96	0.0	0.187	4.6	LOS A	0.0	0.0	0.00	0.15	0.00	45.2
2	T1	All MCs	263	0.0	263	0.0	0.187	0.0	LOS A	0.0	0.0	0.00	0.15	0.00	48.1
Approach			359	0.0	359	0.0	0.187	1.2	NA	0.0	0.0	0.00	0.15	0.00	47.4
North: East Connection															
8	T1	All MCs	73	0.0	73	0.0	0.046	0.0	LOS A	0.1	0.6	0.13	0.15	0.13	48.3
9	R2	All MCs	11	0.0	11	0.0	0.046	7.5	LOS A	0.1	0.6	0.13	0.15	0.13	46.2
Approach			83	0.0	83	0.0	0.046	1.0	NA	0.1	0.6	0.13	0.15	0.13	48.0
West: West East Internal Road															
10	L2	All MCs	11	0.0	11	0.0	0.038	5.4	LOS A	0.1	0.9	0.37	0.60	0.37	41.9
12	R2	All MCs	26	0.0	26	0.0	0.038	6.1	LOS A	0.1	0.9	0.37	0.60	0.37	39.0
Approach			37	0.0	37	0.0	0.038	5.9	LOS A	0.1	0.9	0.37	0.60	0.37	40.0
All Vehicles			479	0.0	479	0.0	0.187	1.5	NA	0.1	0.9	0.05	0.18	0.05	46.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
Two-Way Sign Control Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

MOVEMENT SUMMARY

Site: 101 [East Connection - Internal Junction Pm Peak 2036 Full Development (Site Folder: Internal Intersections)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: East Connection															
1	L2	All MCs	76	0.0	76	0.0	0.148	4.6	LOS A	0.0	0.0	0.00	0.14	0.00	45.2
2	T1	All MCs	208	0.0	208	0.0	0.148	0.0	LOS A	0.0	0.0	0.00	0.14	0.00	48.1
Approach			284	0.0	284	0.0	0.148	1.2	NA	0.0	0.0	0.00	0.14	0.00	47.4
North: East Connection															
8	T1	All MCs	366	0.0	366	0.0	0.196	0.0	LOS A	0.1	0.7	0.03	0.03	0.03	49.6
9	R2	All MCs	11	0.0	11	0.0	0.196	6.7	LOS A	0.1	0.7	0.03	0.03	0.03	47.1
Approach			377	0.0	377	0.0	0.196	0.2	NA	0.1	0.7	0.03	0.03	0.03	49.5
West: West East Internal Road															
10	L2	All MCs	11	0.0	11	0.0	0.199	5.3	LOS A	0.7	5.1	0.51	0.75	0.51	40.4
12	R2	All MCs	134	0.0	134	0.0	0.199	7.9	LOS A	0.7	5.1	0.51	0.75	0.51	37.2
Approach			144	0.0	144	0.0	0.199	7.7	LOS A	0.7	5.1	0.51	0.75	0.51	37.5
All Vehicles			805	0.0	805	0.0	0.199	1.9	NA	0.7	5.1	0.11	0.20	0.11	46.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA (TWSC): Level of Service is not defined for major road approaches or the intersection as a whole for Two-Way Sign Control (HCM LOS rule).
Two-Way Sign Control Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Gap.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

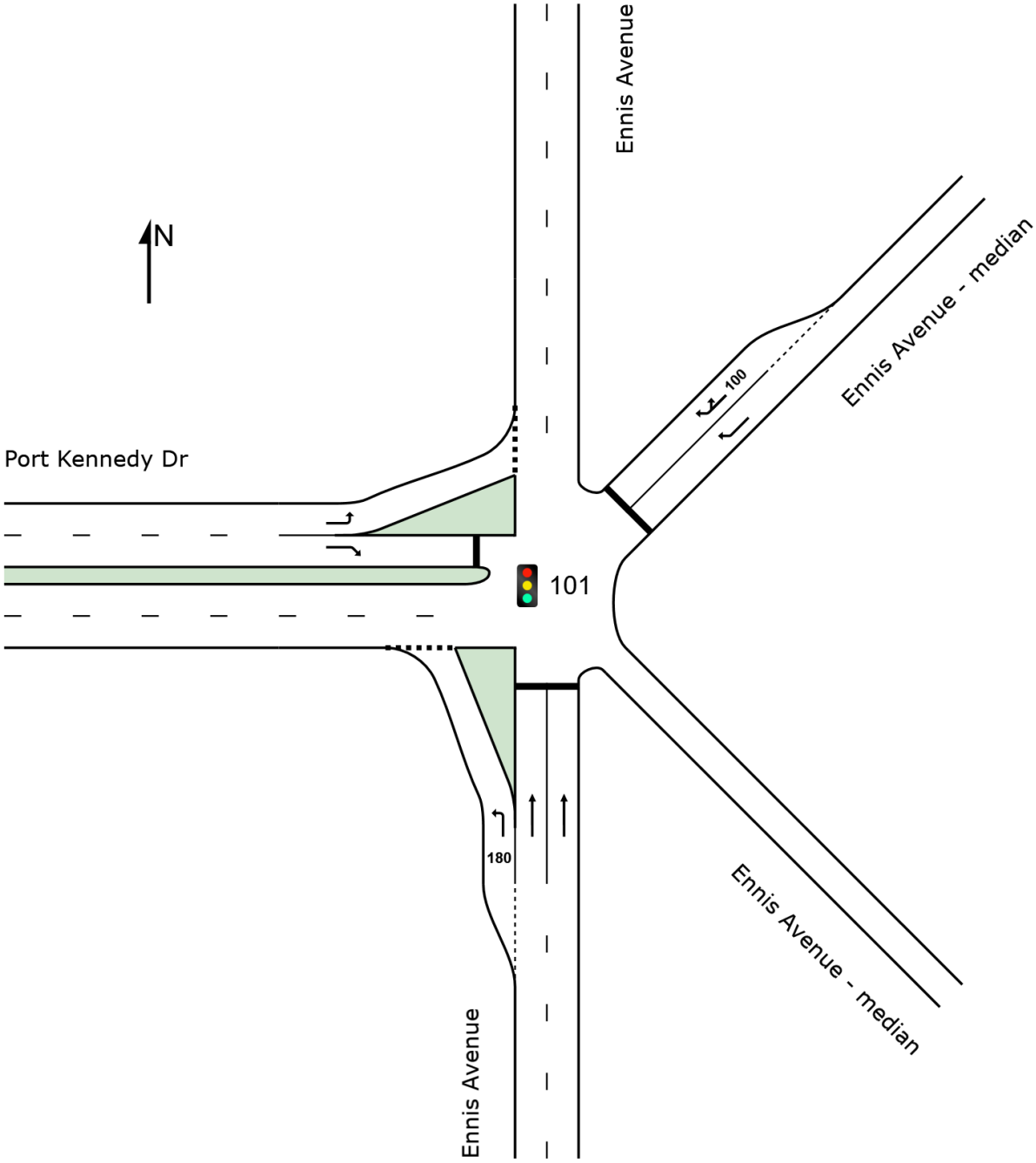
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2026
Option 1: Double Right Turn Lanes on Ennis Ave Only – Stage 1 and 2 traffic

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.198	8.6	LOS A	1.7	14.5	0.25	0.66	0.25	60.2
2	T1	All MCs	1347	2.7	1347	2.7	* 0.861	31.2	LOS C	28.1	212.2	0.98	0.98	1.15	47.5
Approach			1634	3.8	1634	3.8	0.861	27.2	LOS C	28.1	212.2	0.86	0.93	0.99	49.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.760	50.5	LOS D	4.6	35.7	1.00	0.88	1.26	34.4
26b	R3	All MCs	1	0.0	1	0.0	0.760	51.6	LOS D	4.6	35.7	1.00	0.88	1.26	36.3
Approach			215	5.0	215	5.0	0.760	50.5	LOS D	4.6	35.7	1.00	0.88	1.26	34.5
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.409	16.6	LOS B	6.5	51.7	0.66	0.78	0.66	52.7
12a	R1	All MCs	273	11.7	273	11.7	* 0.806	45.1	LOS D	11.4	99.6	1.00	0.94	1.21	36.1
Approach			586	9.5	586	9.5	0.806	29.8	LOS C	11.4	99.6	0.82	0.85	0.92	43.5
All Vehicles			2435	5.3	2435	5.3	0.861	29.9	LOS C	28.1	212.2	0.86	0.90	1.00	46.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.273	9.5	LOS A	2.7	20.4	0.39	0.69	0.39	59.8
2	T1	All MCs	761	2.0	761	2.0	* 0.894	35.5	LOS D	13.8	103.2	1.00	1.07	1.45	45.0
Approach			1120	2.8	1120	2.8	0.894	27.2	LOS C	13.8	103.2	0.80	0.95	1.11	48.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.843	40.3	LOS D	7.3	54.9	1.00	0.98	1.41	38.8
26b	R3	All MCs	1	0.0	1	0.0	0.843	41.3	LOS D	7.3	54.9	1.00	0.98	1.41	40.5
Approach			433	1.9	433	1.9	0.843	40.3	LOS D	7.3	54.9	1.00	0.98	1.41	38.8
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.239	11.0	LOS B	2.4	18.5	0.50	0.72	0.50	58.1
12a	R1	All MCs	349	2.0	349	2.0	* 0.908	44.1	LOS D	13.0	98.7	1.00	1.10	1.53	37.1
Approach			584	3.4	584	3.4	0.908	30.8	LOS C	13.0	98.7	0.80	0.95	1.12	43.4
All Vehicles			2137	2.8	2137	2.8	0.908	30.8	LOS C	13.8	103.2	0.84	0.95	1.17	45.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Stage 1 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	393	9.1	393	9.1	0.279	9.2	LOS A	3.4	28.7	0.29	0.67	0.29	59.5
2	T1	All MCs	1347	2.7	1347	2.7	* 0.885	37.8	LOS D	32.7	247.4	1.00	1.02	1.19	43.7
Approach			1740	4.1	1740	4.1	0.885	31.3	LOS C	32.7	247.4	0.84	0.94	0.99	46.3
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	362	5.0	362	5.0	* 0.867	57.7	LOS E	9.1	70.4	1.00	0.98	1.37	32.1
26b	R3	All MCs	1	0.0	1	0.0	0.867	58.7	LOS E	9.1	70.4	1.00	0.98	1.37	33.9
Approach			363	5.0	363	5.0	0.867	57.7	LOS E	9.1	70.4	1.00	0.98	1.37	32.1
West: Port Kennedy Dr															
10	L2	All MCs	355	7.5	355	7.5	0.460	17.8	LOS B	8.6	68.7	0.68	0.79	0.68	51.7
12a	R1	All MCs	302	11.7	302	11.7	* 0.837	50.5	LOS D	14.5	126.0	1.00	0.96	1.23	34.1
Approach			657	9.5	657	9.5	0.837	32.9	LOS C	14.5	126.0	0.83	0.87	0.93	41.8
All Vehicles			2760	5.5	2760	5.5	0.885	35.2	LOS D	32.7	247.4	0.86	0.93	1.02	42.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Stage 1 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	443	4.6	443	4.6	0.326	10.5	LOS B	5.1	39.6	0.36	0.70	0.36	58.8
2	T1	All MCs	761	2.0	761	2.0	* 0.830	41.3	LOS D	17.7	133.0	1.00	0.96	1.17	42.0
Approach			1204	3.0	1204	3.0	0.830	29.9	LOS C	17.7	133.0	0.77	0.86	0.88	46.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	549	1.9	549	1.9	* 0.858	53.7	LOS D	13.5	101.4	1.00	0.98	1.28	33.5
26b	R3	All MCs	1	0.0	1	0.0	0.858	54.7	LOS D	13.5	101.3	1.00	0.98	1.28	35.3
Approach			551	1.9	551	1.9	0.858	53.7	LOS D	13.5	101.4	1.00	0.98	1.28	33.5
West: Port Kennedy Dr															
10	L2	All MCs	442	5.6	442	5.6	0.416	12.1	LOS B	7.2	56.2	0.50	0.75	0.50	57.0
12a	R1	All MCs	498	2.0	498	2.0	* 0.863	46.3	LOS D	23.8	180.4	1.00	0.97	1.19	36.2
Approach			940	3.7	940	3.7	0.863	30.2	LOS C	23.8	180.4	0.76	0.86	0.87	43.7
All Vehicles			2695	3.0	2695	3.0	0.863	34.9	LOS C	23.8	180.4	0.81	0.89	0.96	42.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Stage 1,2 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 100 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	440	9.1	440	9.1	0.316	9.9	LOS A	4.6	38.8	0.31	0.68	0.31	58.8
2	T1	All MCs	1347	2.7	1347	2.7	* 0.861	36.4	LOS D	33.7	254.8	0.99	0.97	1.10	44.5
Approach			1787	4.3	1787	4.3	0.861	29.9	LOS C	33.7	254.8	0.82	0.90	0.91	47.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	429	5.0	429	5.0	* 0.878	62.5	LOS E	12.0	92.6	1.00	1.00	1.34	30.6
26b	R3	All MCs	1	0.0	1	0.0	0.878	63.5	LOS E	12.0	92.5	1.00	1.00	1.34	32.5
Approach			431	5.0	431	5.0	0.878	62.5	LOS E	12.0	92.6	1.00	1.00	1.34	30.6
West: Port Kennedy Dr															
10	L2	All MCs	373	7.5	373	7.5	0.490	19.1	LOS B	10.4	82.8	0.69	0.80	0.69	50.7
12a	R1	All MCs	315	11.7	315	11.7	* 0.873	57.9	LOS E	17.3	150.4	1.00	0.99	1.27	31.7
Approach			687	9.5	687	9.5	0.873	36.9	LOS D	17.3	150.4	0.83	0.88	0.95	39.8
All Vehicles			2905	5.6	2905	5.6	0.878	36.4	LOS D	33.7	254.8	0.85	0.91	0.98	42.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Stage 1,2 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 100 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	481	4.6	481	4.6	0.356	11.5	LOS B	6.4	49.0	0.38	0.72	0.38	57.8
2	T1	All MCs	761	2.0	761	2.0	* 0.880	50.8	LOS D	20.8	156.4	1.00	1.02	1.25	37.9
Approach			1242	3.0	1242	3.0	0.880	35.6	LOS D	20.8	156.4	0.76	0.90	0.91	43.3
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	602	1.9	602	1.9	* 0.870	58.4	LOS E	16.5	123.4	1.00	0.98	1.27	32.0
26b	R3	All MCs	1	0.0	1	0.0	0.870	59.5	LOS E	16.5	123.3	1.00	0.98	1.27	33.7
Approach			603	1.9	603	1.9	0.870	58.4	LOS E	16.5	123.4	1.00	0.98	1.27	32.0
West: Port Kennedy Dr															
10	L2	All MCs	536	5.6	536	5.6	0.492	12.9	LOS B	10.6	83.3	0.53	0.76	0.53	56.2
12a	R1	All MCs	564	2.0	564	2.0	* 0.889	51.2	LOS D	30.7	232.2	1.00	0.99	1.20	34.3
Approach			1100	3.7	1100	3.7	0.889	32.6	LOS C	30.7	232.2	0.77	0.88	0.88	42.4
All Vehicles			2945	3.1	2945	3.1	0.889	39.1	LOS D	30.7	232.2	0.81	0.91	0.97	40.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

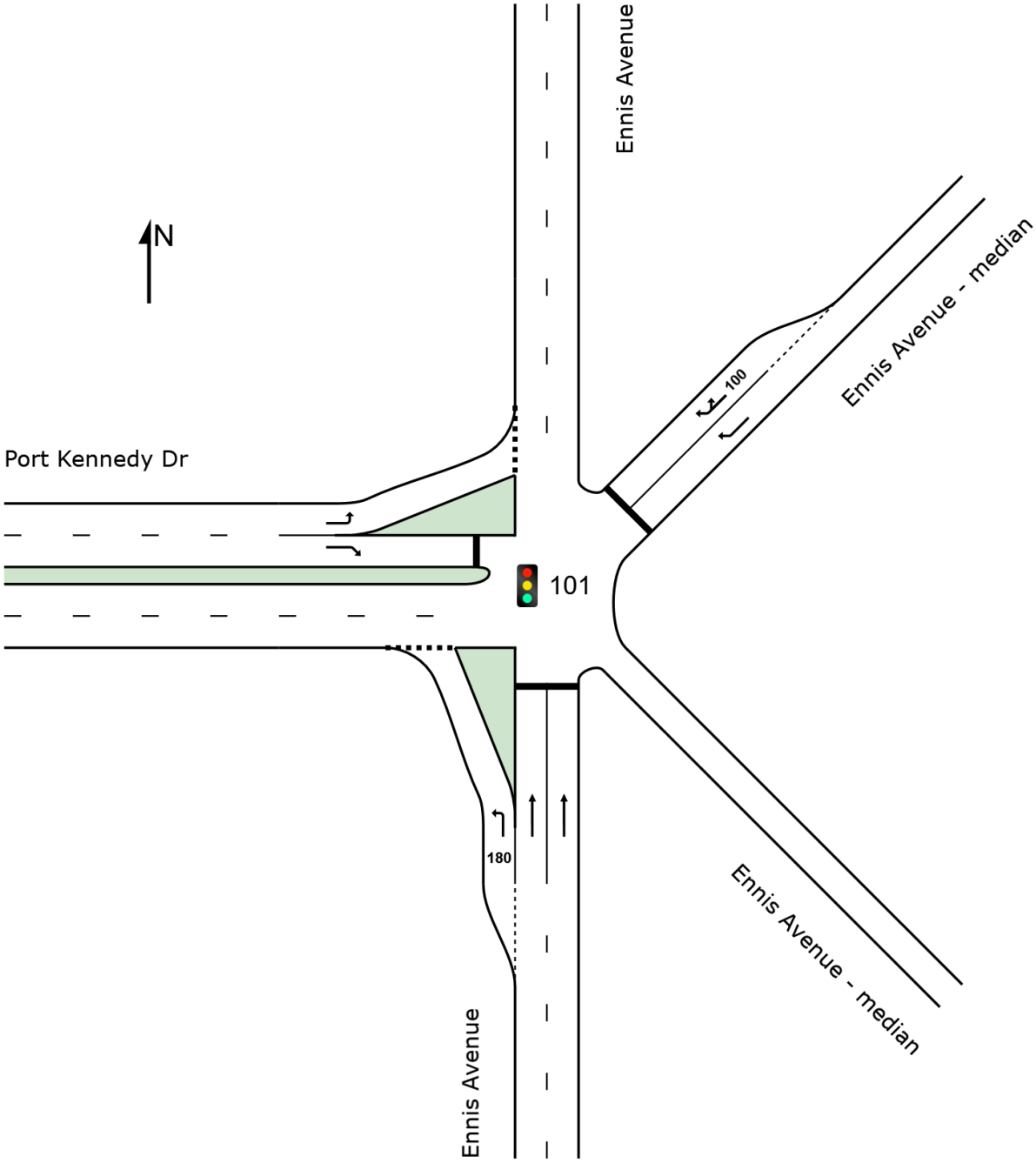
SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2036
Option 1: Double Right Turn Lanes on Ennis Ave Only – Stage 1 and 2

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Stage 1,2 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	385	9.1	385	9.1	0.253	16.7	LOS B	4.1	34.0	0.20	0.65	0.20	59.9
2	T1	All MCs	1725	2.7	1725	2.7	* 0.923	50.9	LOS D	70.0	529.5	1.00	1.01	1.10	38.6
Approach			2111	3.8	2111	3.8	0.923	44.6	LOS D	70.0	529.5	0.85	0.94	0.94	41.0
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	286	5.0	286	5.0	* 0.880	90.4	LOS F	11.6	89.9	1.00	0.96	1.29	24.3
26b	R3	All MCs	1	0.0	1	0.0	0.880	91.4	LOS F	11.6	89.8	1.00	0.95	1.29	26.0
Approach			287	5.0	287	5.0	0.880	90.4	LOS F	11.6	89.9	1.00	0.96	1.29	24.3
West: Port Kennedy Dr															
10	L2	All MCs	422	7.5	422	7.5	0.650	41.8	LOS D	23.3	185.2	0.90	0.92	0.90	37.7
12a	R1	All MCs	366	11.7	366	11.7	* 0.896	79.4	LOS E	29.4	255.9	1.00	0.98	1.19	26.3
Approach			788	9.5	788	9.5	0.896	59.3	LOS E	29.4	255.9	0.94	0.95	1.03	31.4
All Vehicles			3186	5.3	3186	5.3	0.923	52.4	LOS D	70.0	529.5	0.89	0.94	0.99	36.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Basecase - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 100 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	482	4.6	482	4.6	0.353	11.3	LOS B	6.1	47.3	0.37	0.72	0.37	58.1
2	T1	All MCs	974	2.0	974	2.0	* 0.876	46.3	LOS D	26.4	198.4	1.00	1.01	1.20	39.7
Approach			1456	2.9	1456	2.9	0.876	34.7	LOS C	26.4	198.4	0.79	0.91	0.92	44.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	580	1.9	580	1.9	* 0.888	61.0	LOS E	16.2	121.8	1.00	1.00	1.31	31.2
26b	R3	All MCs	1	0.0	1	0.0	0.888	62.1	LOS E	16.2	121.7	1.00	1.00	1.31	32.9
Approach			581	1.9	581	1.9	0.888	61.0	LOS E	16.2	121.8	1.00	1.00	1.31	31.2
West: Port Kennedy Dr															
10	L2	All MCs	315	5.6	315	5.6	0.325	13.8	LOS B	6.0	47.3	0.50	0.74	0.50	55.4
12a	R1	All MCs	469	2.0	469	2.0	* 0.871	52.1	LOS D	25.1	189.9	1.00	0.97	1.20	34.0
Approach			784	3.4	784	3.4	0.871	36.7	LOS D	25.1	189.9	0.80	0.88	0.92	40.3
All Vehicles			2821	2.8	2821	2.8	0.888	40.7	LOS D	26.4	198.4	0.84	0.92	1.00	39.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Stage 1 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	492	9.1	492	9.1	0.334	20.9	LOS C	6.5	54.4	0.26	0.69	0.26	58.6
2	T1	All MCs	1725	2.7	1725	2.7	* 0.987	79.8	LOS E	86.7	655.9	1.00	1.20	1.26	29.7
Approach			2217	4.1	2217	4.1	0.987	66.8	LOS E	86.7	655.9	0.84	1.08	1.04	33.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	435	5.0	435	5.0	* 0.963	104.4	LOS F	19.6	151.3	1.00	1.05	1.42	22.1
26b	R3	All MCs	1	0.0	1	0.0	0.963	105.4	LOS F	19.6	151.1	1.00	1.05	1.42	23.7
Approach			436	5.0	436	5.0	0.963	104.4	LOS F	19.6	151.3	1.00	1.05	1.42	22.1
West: Port Kennedy Dr															
10	L2	All MCs	463	7.5	463	7.5	0.724	45.9	LOS D	25.8	204.8	0.93	0.95	0.93	36.0
12a	R1	All MCs	396	11.7	396	11.7	* 0.997	113.1	LOS F	38.7	336.6	1.00	1.11	1.43	20.7
Approach			859	9.5	859	9.5	0.997	76.9	LOS E	38.7	336.6	0.96	1.02	1.16	26.9
All Vehicles			3512	5.5	3512	5.5	0.997	73.9	LOS E	86.7	655.9	0.89	1.06	1.12	29.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Stage 1 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	566	4.6	566	4.6	0.419	15.3	LOS B	11.6	89.6	0.41	0.77	0.41	54.2
2	T1	All MCs	974	2.0	974	2.0	* 0.920	72.8	LOS E	40.3	302.2	1.00	1.05	1.19	30.9
Approach			1540	3.0	1540	3.0	0.920	51.6	LOS D	40.3	302.2	0.78	0.94	0.90	36.3
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	698	1.9	698	1.9	0.939	94.2	LOS F	30.1	225.9	1.00	1.02	1.29	24.3
26b	R3	All MCs	1	0.0	1	0.0	* 0.939	95.2	LOS F	30.1	225.9	1.00	1.02	1.29	26.0
Approach			699	1.9	699	1.9	0.939	94.2	LOS F	30.1	225.9	1.00	1.02	1.29	24.3
West: Port Kennedy Dr															
10	L2	All MCs	522	5.6	522	5.6	0.512	18.7	LOS B	19.2	150.5	0.60	0.79	0.60	51.3
12a	R1	All MCs	618	2.0	618	2.0	* 0.926	72.8	LOS E	50.2	380.4	1.00	1.00	1.17	28.0
Approach			1140	3.6	1140	3.6	0.926	48.0	LOS D	50.2	380.4	0.82	0.90	0.91	35.4
All Vehicles			3379	3.0	3379	3.0	0.939	59.2	LOS E	50.2	380.4	0.84	0.95	0.99	32.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Stage 1,2 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	539	9.1	539	9.1	0.373	20.4	LOS C	7.7	64.7	0.29	0.70	0.29	57.8
2	T1	All MCs	1725	2.7	1725	2.7	* 1.015	97.8	LOS F	93.2	704.8	1.00	1.29	1.36	26.1
Approach			2264	4.2	2264	4.2	1.015	79.4	LOS E	93.2	704.8	0.83	1.15	1.11	29.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	502	5.0	502	5.0	* 1.001	119.7	LOS F	24.5	189.1	1.00	1.10	1.51	20.0
26b	R3	All MCs	1	0.0	1	0.0	1.001	120.7	LOS F	24.4	188.9	1.00	1.10	1.51	21.5
Approach			503	5.0	503	5.0	1.001	119.7	LOS F	24.5	189.1	1.00	1.10	1.51	20.0
West: Port Kennedy Dr															
10	L2	All MCs	481	7.5	481	7.5	0.748	46.5	LOS D	26.7	212.6	0.94	0.96	0.94	35.8
12a	R1	All MCs	408	11.7	408	11.7	* 1.029	131.1	LOS F	42.0	365.7	1.00	1.16	1.53	18.6
Approach			889	9.5	889	9.5	1.029	85.3	LOS F	42.0	365.7	0.97	1.05	1.21	25.2
All Vehicles			3657	5.6	3657	5.6	1.029	86.4	LOS F	93.2	704.8	0.89	1.12	1.19	26.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Stage 1,2 - Modifications - DRT - Ennis (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Ennis)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 150 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	604	4.6	604	4.6	0.454	16.4	LOS B	13.4	103.5	0.44	0.78	0.44	53.3
2	T1	All MCs	974	2.0	974	2.0	* 0.994	101.4	LOS F	47.4	355.3	1.00	1.20	1.39	24.9
Approach			1578	3.0	1578	3.0	0.994	68.8	LOS E	47.4	355.3	0.79	1.04	1.02	30.8
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	751	1.9	751	1.9	* 1.011	128.1	LOS F	37.6	282.1	1.00	1.13	1.49	19.9
26b	R3	All MCs	1	0.0	1	0.0	1.011	129.1	LOS F	37.6	282.0	1.00	1.13	1.49	21.4
Approach			752	1.9	752	1.9	1.011	128.1	LOS F	37.6	282.1	1.00	1.13	1.49	19.9
West: Port Kennedy Dr															
10	L2	All MCs	616	5.6	616	5.6	0.598	20.7	LOS C	26.2	205.4	0.69	0.82	0.69	49.7
12a	R1	All MCs	684	2.0	684	2.0	* 1.006	105.4	LOS F	67.3	509.4	1.00	1.13	1.37	22.0
Approach			1300	3.7	1300	3.7	1.006	65.3	LOS E	67.3	509.4	0.86	0.98	1.05	29.9
All Vehicles			3629	3.0	3629	3.0	1.011	79.8	LOS E	67.3	509.4	0.86	1.04	1.13	27.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2026
Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr – Stage 1 and 2

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Stage 1 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	443	4.6	443	4.6	0.352	10.2	LOS B	3.9	29.9	0.44	0.71	0.44	59.1
2	T1	All MCs	761	2.0	761	2.0	* 0.830	29.5	LOS C	12.4	93.1	1.00	0.98	1.27	48.6
Approach			1204	3.0	1204	3.0	0.830	22.4	LOS C	12.4	93.1	0.79	0.88	0.96	51.8
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	549	1.9	549	1.9	* 0.858	40.0	LOS D	9.4	70.8	1.00	1.01	1.40	39.0
26b	R3	All MCs	1	0.0	1	0.0	0.858	41.0	LOS D	9.4	70.7	1.00	1.01	1.40	40.7
Approach			551	1.9	551	1.9	0.858	40.0	LOS D	9.4	70.8	1.00	1.01	1.40	39.0
West: Port Kennedy Dr															
10	L2	All MCs	442	5.6	442	5.6	0.469	11.7	LOS B	5.4	42.1	0.60	0.77	0.60	57.3
12a	R1	All MCs	498	2.0	498	2.0	* 0.863	41.1	LOS D	8.6	65.1	1.00	1.01	1.44	38.6
Approach			940	3.7	940	3.7	0.863	27.3	LOS C	8.6	65.1	0.81	0.89	1.04	45.7
All Vehicles			2695	3.0	2695	3.0	0.863	27.7	LOS C	12.4	93.1	0.84	0.91	1.08	46.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	286	9.1	286	9.1	0.203	8.6	LOS A	1.6	13.4	0.28	0.67	0.28	60.1
2	T1	All MCs	1347	2.7	1347	2.7	* 0.803	22.4	LOS C	22.2	167.6	0.94	0.90	1.03	53.6
Approach			1634	3.8	1634	3.8	0.803	19.9	LOS B	22.2	167.6	0.82	0.86	0.90	54.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	214	5.0	214	5.0	* 0.665	43.2	LOS D	3.9	30.4	1.00	0.83	1.15	37.4
26b	R3	All MCs	1	0.0	1	0.0	0.665	44.2	LOS D	3.9	30.4	1.00	0.83	1.15	39.2
Approach			215	5.0	215	5.0	0.665	43.2	LOS D	3.9	30.4	1.00	0.83	1.15	37.4
West: Port Kennedy Dr															
10	L2	All MCs	314	7.5	314	7.5	0.459	15.6	LOS B	5.8	45.8	0.68	0.78	0.68	53.5
12a	R1	All MCs	273	11.7	273	11.7	* 0.756	44.0	LOS D	5.1	44.5	1.00	0.89	1.25	36.8
Approach			586	9.5	586	9.5	0.756	28.8	LOS C	5.8	45.8	0.83	0.83	0.95	44.2
All Vehicles			2435	5.3	2435	5.3	0.803	24.1	LOS C	22.2	167.6	0.84	0.85	0.93	50.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 60 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	359	4.6	359	4.6	0.276	9.5	LOS A	2.7	20.9	0.40	0.70	0.40	59.7
2	T1	All MCs	761	2.0	761	2.0	* 0.726	23.8	LOS C	11.0	82.3	0.97	0.87	1.06	52.6
Approach			1120	2.8	1120	2.8	0.726	19.2	LOS B	11.0	82.3	0.78	0.81	0.85	54.5
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	432	1.9	432	1.9	* 0.749	36.1	LOS D	6.8	50.9	1.00	0.90	1.20	40.8
26b	R3	All MCs	1	0.0	1	0.0	0.749	37.1	LOS D	6.8	50.8	1.00	0.90	1.20	42.5
Approach			433	1.9	433	1.9	0.749	36.1	LOS D	6.8	50.9	1.00	0.90	1.20	40.8
West: Port Kennedy Dr															
10	L2	All MCs	235	5.6	235	5.6	0.254	10.7	LOS B	2.2	17.6	0.48	0.72	0.48	58.4
12a	R1	All MCs	349	2.0	349	2.0	* 0.681	35.8	LOS D	5.4	40.6	1.00	0.85	1.13	41.2
Approach			584	3.4	584	3.4	0.681	25.7	LOS C	5.4	40.6	0.79	0.80	0.87	46.7
All Vehicles			2137	2.8	2137	2.8	0.749	24.4	LOS C	11.0	82.3	0.83	0.83	0.93	49.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Stage 1 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	393	9.1	393	9.1	0.291	9.2	LOS A	3.0	24.7	0.34	0.68	0.34	59.4
2	T1	All MCs	1347	2.7	1347	2.7	* 0.861	28.5	LOS C	25.1	190.3	0.98	0.99	1.18	49.3
Approach			1740	4.1	1740	4.1	0.861	24.1	LOS C	25.1	190.3	0.84	0.92	0.99	51.1
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	362	5.0	362	5.0	* 0.843	46.1	LOS D	7.1	54.9	1.00	0.97	1.39	36.2
26b	R3	All MCs	1	0.0	1	0.0	0.843	47.1	LOS D	7.1	54.9	1.00	0.97	1.39	38.0
Approach			363	5.0	363	5.0	0.843	46.1	LOS D	7.1	54.9	1.00	0.97	1.39	36.2
West: Port Kennedy Dr															
10	L2	All MCs	355	7.5	355	7.5	0.516	16.5	LOS B	6.9	55.3	0.72	0.80	0.72	52.8
12a	R1	All MCs	302	11.7	302	11.7	* 0.837	46.8	LOS D	5.9	51.6	1.00	0.96	1.41	35.7
Approach			657	9.5	657	9.5	0.837	30.4	LOS C	6.9	55.3	0.85	0.87	1.04	43.3
All Vehicles			2760	5.5	2760	5.5	0.861	28.5	LOS C	25.1	190.3	0.86	0.92	1.06	46.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Stage 1,2 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	440	9.1	440	9.1	0.333	9.5	LOS A	3.7	30.6	0.37	0.69	0.37	59.1
2	T1	All MCs	1347	2.7	1347	2.7	* 0.893	33.2	LOS C	27.2	205.9	1.00	1.06	1.28	46.3
Approach			1787	4.3	1787	4.3	0.893	27.4	LOS C	27.2	205.9	0.84	0.97	1.05	48.7
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	429	5.0	429	5.0	* 0.888	48.8	LOS D	8.8	68.3	1.00	1.03	1.50	35.1
26b	R3	All MCs	1	0.0	1	0.0	0.888	49.8	LOS D	8.8	68.2	1.00	1.03	1.50	37.0
Approach			431	5.0	431	5.0	0.888	48.8	LOS D	8.8	68.3	1.00	1.03	1.50	35.1
West: Port Kennedy Dr															
10	L2	All MCs	373	7.5	373	7.5	0.540	16.7	LOS B	7.4	59.1	0.74	0.80	0.74	52.7
12a	R1	All MCs	315	11.7	315	11.7	* 0.873	48.9	LOS D	6.4	55.4	1.00	1.00	1.51	34.9
Approach			687	9.5	687	9.5	0.873	31.4	LOS C	7.4	59.1	0.86	0.89	1.09	42.7
All Vehicles			2905	5.6	2905	5.6	0.893	31.5	LOS C	27.2	205.9	0.87	0.96	1.13	44.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2026 Stage 1,2 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 70 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	481	4.6	481	4.6	0.378	10.8	LOS B	5.1	39.0	0.44	0.72	0.44	58.5
2	T1	All MCs	761	2.0	761	2.0	* 0.797	31.2	LOS C	13.6	102.3	1.00	0.93	1.17	47.6
Approach			1242	3.0	1242	3.0	0.797	23.3	LOS C	13.6	102.3	0.78	0.85	0.89	51.0
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	602	1.9	602	1.9	* 0.844	42.8	LOS D	11.6	87.0	1.00	0.98	1.30	37.7
26b	R3	All MCs	1	0.0	1	0.0	0.844	43.8	LOS D	11.6	87.0	1.00	0.98	1.30	39.5
Approach			603	1.9	603	1.9	0.844	42.8	LOS D	11.6	87.0	1.00	0.98	1.30	37.7
West: Port Kennedy Dr															
10	L2	All MCs	536	5.6	536	5.6	0.552	12.1	LOS B	7.9	61.8	0.60	0.78	0.60	57.0
12a	R1	All MCs	564	2.0	564	2.0	* 0.789	40.2	LOS D	10.3	78.0	1.00	0.93	1.20	39.1
Approach			1100	3.7	1100	3.7	0.789	26.5	LOS C	10.3	78.0	0.81	0.85	0.91	46.2
All Vehicles			2945	3.1	2945	3.1	0.844	28.5	LOS C	13.6	102.3	0.84	0.88	0.98	46.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

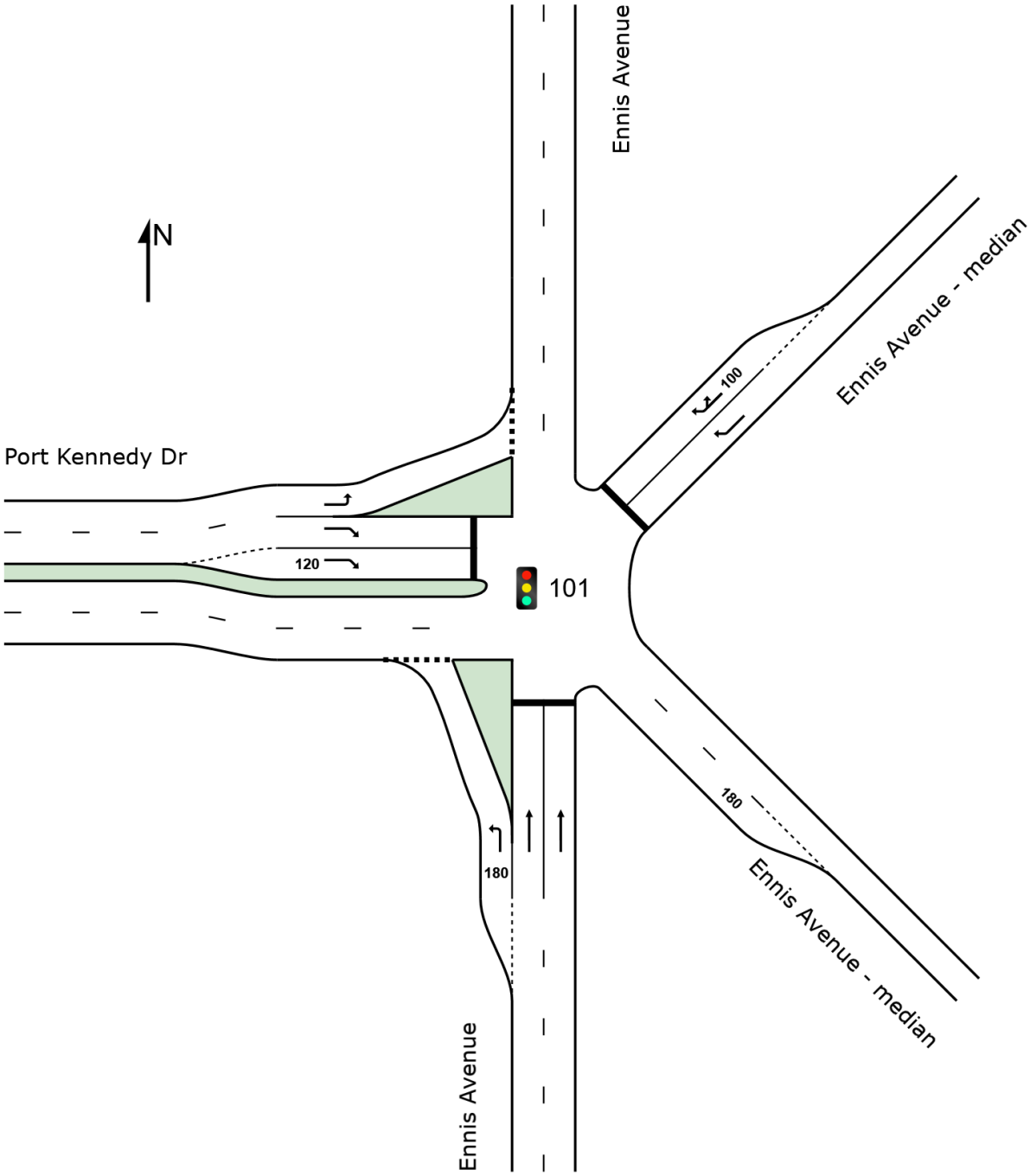
* Critical Movement (Signal Timing)

SITE LAYOUT

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2026 Basecase - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



SIDRA Analysis, Ennis Avenue/Port Kennedy Drive, 2036
Option 2: Double Right Turn Lanes on Ennis Ave and Port Kennedy Dr – Stage 1 and 2

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Stage 1,2 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 90 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	604	4.6	604	4.6	0.479	13.7	LOS B	8.7	67.1	0.50	0.78	0.50	55.7
2	T1	All MCs	974	2.0	974	2.0	* 0.883	43.7	LOS D	24.5	183.7	1.00	1.03	1.24	41.0
Approach			1578	3.0	1578	3.0	0.883	32.2	LOS C	24.5	183.7	0.81	0.93	0.96	45.3
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	751	1.9	751	1.9	* 0.878	52.6	LOS D	18.8	140.8	1.00	1.00	1.28	33.9
26b	R3	All MCs	1	0.0	1	0.0	0.878	53.6	LOS D	18.8	140.7	1.00	1.00	1.28	35.7
Approach			752	1.9	752	1.9	0.878	52.6	LOS D	18.8	140.8	1.00	1.00	1.28	33.9
West: Port Kennedy Dr															
10	L2	All MCs	616	5.6	616	5.6	0.684	16.5	LOS B	16.1	126.6	0.75	0.83	0.75	53.0
12a	R1	All MCs	684	2.0	684	2.0	* 0.889	55.5	LOS E	17.4	132.0	1.00	1.02	1.32	33.1
Approach			1300	3.7	1300	3.7	0.889	37.0	LOS D	17.4	132.0	0.88	0.93	1.05	40.3
All Vehicles			3629	3.0	3629	3.0	0.889	38.2	LOS D	24.5	183.7	0.88	0.95	1.06	40.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Stage 1 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 110 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	492	9.1	492	9.1	0.350	10.2	LOS B	5.7	47.8	0.31	0.70	0.31	58.5
2	T1	All MCs	1725	2.7	1725	2.7	* 0.889	35.7	LOS D	47.8	361.4	0.98	0.98	1.09	44.9
Approach			2217	4.1	2217	4.1	0.889	30.0	LOS C	47.8	361.4	0.83	0.92	0.91	47.2
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	435	5.0	435	5.0	* 0.848	64.0	LOS E	12.8	99.0	1.00	0.96	1.25	30.2
26b	R3	All MCs	1	0.0	1	0.0	0.848	65.1	LOS E	12.8	98.9	1.00	0.96	1.25	32.1
Approach			436	5.0	436	5.0	0.848	64.0	LOS E	12.8	99.0	1.00	0.96	1.25	30.2
West: Port Kennedy Dr															
10	L2	All MCs	463	7.5	463	7.5	0.808	37.5	LOS D	22.9	182.2	0.99	0.95	1.07	39.6
12a	R1	All MCs	396	11.7	396	11.7	* 0.862	66.4	LOS E	11.8	103.0	1.00	0.98	1.29	29.5
Approach			859	9.5	859	9.5	0.862	50.8	LOS D	22.9	182.2	0.99	0.96	1.17	34.2
All Vehicles			3512	5.5	3512	5.5	0.889	39.3	LOS D	47.8	361.4	0.89	0.93	1.02	40.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Pm Peak 2036 Stage 1 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 80 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	566	4.6	566	4.6	0.446	12.5	LOS B	6.9	53.1	0.48	0.76	0.48	56.8
2	T1	All MCs	974	2.0	974	2.0	* 0.892	41.3	LOS D	22.6	169.3	1.00	1.05	1.30	42.1
Approach			1540	3.0	1540	3.0	0.892	30.7	LOS C	22.6	169.3	0.81	0.94	0.99	46.2
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	698	1.9	698	1.9	* 0.908	53.3	LOS D	16.6	124.7	1.00	1.06	1.41	33.7
26b	R3	All MCs	1	0.0	1	0.0	0.908	54.3	LOS D	16.6	124.6	1.00	1.06	1.41	35.4
Approach			699	1.9	699	1.9	0.908	53.3	LOS D	16.6	124.7	1.00	1.06	1.41	33.7
West: Port Kennedy Dr															
10	L2	All MCs	522	5.6	522	5.6	0.584	14.5	LOS B	10.5	82.3	0.67	0.80	0.67	54.8
12a	R1	All MCs	618	2.0	618	2.0	* 0.856	48.3	LOS D	13.6	102.9	1.00	0.99	1.29	35.7
Approach			1140	3.6	1140	3.6	0.856	32.8	LOS C	13.6	102.9	0.85	0.90	1.01	42.5
All Vehicles			3379	3.0	3379	3.0	0.908	36.1	LOS D	22.6	169.3	0.86	0.95	1.09	41.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

MOVEMENT SUMMARY

Site: 101 [Port Kennedy Dr Ennis Ave Am Peak 2036 Stage 1,2 - Modifications - DRT (Site Folder: Port Kennedy Dr Ennis Ave Modifications Double Right Turns)]

Output produced by SIDRA INTERSECTION Version: 9.1.2.202

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 130 seconds (Site Practical Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Ennis Avenue															
1	L2	All MCs	539	9.1	539	9.1	0.386	12.7	LOS B	7.8	65.0	0.33	0.72	0.33	57.3
2	T1	All MCs	1725	2.7	1725	2.7	* 0.896	39.4	LOS D	57.0	431.6	0.97	0.96	1.06	43.1
Approach			2264	4.2	2264	4.2	0.896	33.1	LOS C	57.0	431.6	0.82	0.91	0.89	45.6
NorthEast: Ennis Avenue - median															
26a	R1	All MCs	502	5.0	502	5.0	* 0.867	73.4	LOS E	17.4	134.7	1.00	0.96	1.22	27.9
26b	R3	All MCs	1	0.0	1	0.0	0.867	74.5	LOS E	17.4	134.6	1.00	0.96	1.22	29.6
Approach			503	5.0	503	5.0	0.867	73.4	LOS E	17.4	134.7	1.00	0.96	1.22	27.9
West: Port Kennedy Dr															
10	L2	All MCs	481	7.5	481	7.5	0.892	60.6	LOS E	31.4	249.5	1.00	1.04	1.19	31.1
12a	R1	All MCs	408	11.7	408	11.7	* 0.866	75.8	LOS E	14.2	123.9	1.00	0.97	1.25	27.2
Approach			889	9.5	889	9.5	0.892	67.6	LOS E	31.4	249.5	1.00	1.00	1.22	29.2
All Vehicles			3657	5.6	3657	5.6	0.896	47.0	LOS D	57.0	431.6	0.89	0.94	1.01	37.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Options tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Control Delay: Geometric Delay is included).
Queue Model: SIDRA queue estimation methods are used for Back of Queue and Queue at Start of Green.
Gap-Acceptance Capacity Formula: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Arrival Flows used in performance calculations are adjusted to include any Initial Queued Demand and Upstream Capacity Constraint effects.

* Critical Movement (Signal Timing)

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F. Local Water Management Strategy

Port Kennedy LWMS Stage 2

DevelopmentWA

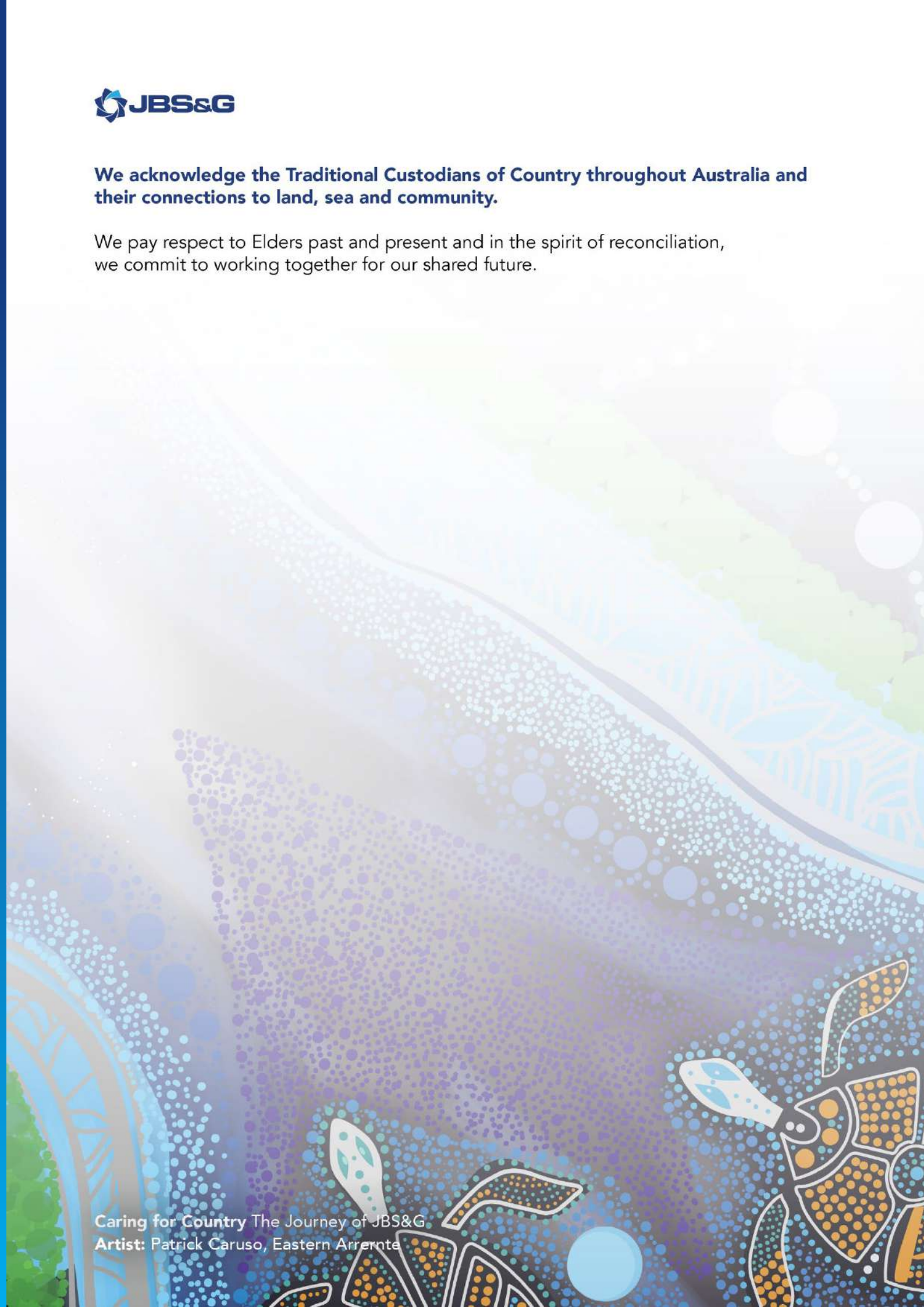
Report Rev 2

JBS&G 65475 | 153,372

21 August 2024

We acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community.

We pay respect to Elders past and present and in the spirit of reconciliation, we commit to working together for our shared future.



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Appendix G Landscaping Plans

Abbreviations

Term	Definition
AAMGL	Average Annual Maximum Groundwater Levels
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AS	Australian Standard
ASS	Acid Sulfate Soils
BC	Biodiversity Conservation
BMP	Best Management Practices
BUWM	Better Urban Water Management
CAMP	Conservation Area Management Plan
CCW	Conservation Category Wetland
DBCA	Department of Biodiversity Conservation and Attractions
DGL	Design Groundwater Level
DWER	Department of Water and Environmental Regulation
DWMS	District Water Management Strategy
EAR	Environmental Assessment Report
EC	Electrical Conductivity
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
EY	Exceedances per Year
FCT	Floristic Community Type
IUWM	Integrated Urban Water Management
LPS	Local Planning Scheme
LWMS	Local Water Management Strategy
MGL	Maximum Groundwater Level
MRS	Metropolitan Region Sc
PEC	Priority Ecological Communities
PKBEP	Port Kennedy Business Enterprise Park
POS	Public Open Space
PRI	Phosphorus Retention Index
PSI	Preliminary Site Investigation
PVC	Polyvinyl Chloride
RL	Relative Level
SCP	Swan Coastal Plain
SCWQIP	Swan Canning Water Quality Improvement Plan
TEC	Threatened Ecological Communities
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen

TP	Total Phosphorus
UFI	Unique Feature Identifier
UWMP	Urban Water Management Plan
WAPC	Western Australian Planning Commission
WC	Wildlife Conservation
WEMP	Water Efficiency Management Plan
WSUD	Water Sensitive Urban Design

Executive Summary

This Local Water Management Strategy (LWMS) has been prepared by JBS&G for DevelopmentWA in support of a Subdivision Guide Plan for the development of Lots 4 and 17 located on the corner of Ennis Avenue and Port Kennedy Drive at Port Kennedy (the site). The site is planned to be developed as an industrial estate with the western portion of the site retained as a Conservation Area due to its high environmental values.

The site contains a number of ephemeral wetlands and examples of a Threatened Ecological Community. As such, water management is important to maintain hydrological regimes and ensure that water quality on the site is managed.

This LWMS outlines how the proposed industrial development will address water use and management at the local planning level and details specific water management measures and strategies to be implemented to manage the water cycle in a sustainable manner. The document has been prepared in accordance with Better Urban Water Management (2008) guidelines on advice from Department of Water and Environmental Regulation (DWER), as outlined in Table A. It also considers the comments by relevant stakeholders and authorities on the first submission.

The site will be developed in a water sensitive manner, using a modular drainage approach that generally manages events up to the 1% Annual Exceedance Probability (AEP) event within the road reserve and drainage reserves through a series of rain gardens and swales. This approach minimises the need for Public Open Space for drainage purposes and infiltrates water as high in the site as possible, in line with the principles of water sensitive urban design.

Stormwater will be retained on lots in events up to the 1% AEP. Design guidelines will support the use of rainwater tanks to collect a portion of roof water on the lots for connection to a non-seasonally dependent water use such as toilet flushing to maximise the use of rainwater. Overflow from the roof water systems and water from cleaner areas such as car parks and access roads will be infiltrated through on-lot swales or soak wells or a mixture of both.

Groundwater levels are not considered to be a constraint to development on the site. Current groundwater levels have been monitored from October 2009 to April 2011 plus a follow up from July to November 2022 (which was considered a relatively wet year), which provides a good level of confidence as to current levels. A minimum 1.5 m separation will be allowed between finished lot levels and the Design Groundwater Level (taken as the Maximum Groundwater Level), to allow for infiltration of stormwater. Additional fill may be required in the eastern part of the site to allow for gravity flow of sewage to the connection to the Water Corporation sewer in Bakewell Drive.

It is considered that through these measures, water can be managed on this site to meet the requirements of the DWER and City of Rockingham.

1. Introduction

DevelopmentWA (formerly LandCorp) is proposing to develop a business park on 67 ha of land at Port Kennedy (the site) within the Port Kennedy Business Enterprise Park (PKBEP) (Figure 1), of which 18 ha will be ceded as a Conservation Reserve. The PKBEP will provide an employment hub for the south-west region, encapsulating a strong sense of place for employees and visitors, whilst preserving and regenerating the environmental values of the site. The City of Rockingham's Local Planning Scheme No.2 requires that developments within the PKBEP "have regard to management of drainage systems and land use to promote groundwater conservation".

This Local Water Management Strategy (LWMS) has been prepared to support the proposed Structure Plan. Urban Water Management Plans (UWMPs) will be prepared for the subsequent subdivision(s) to create light industrial lots.

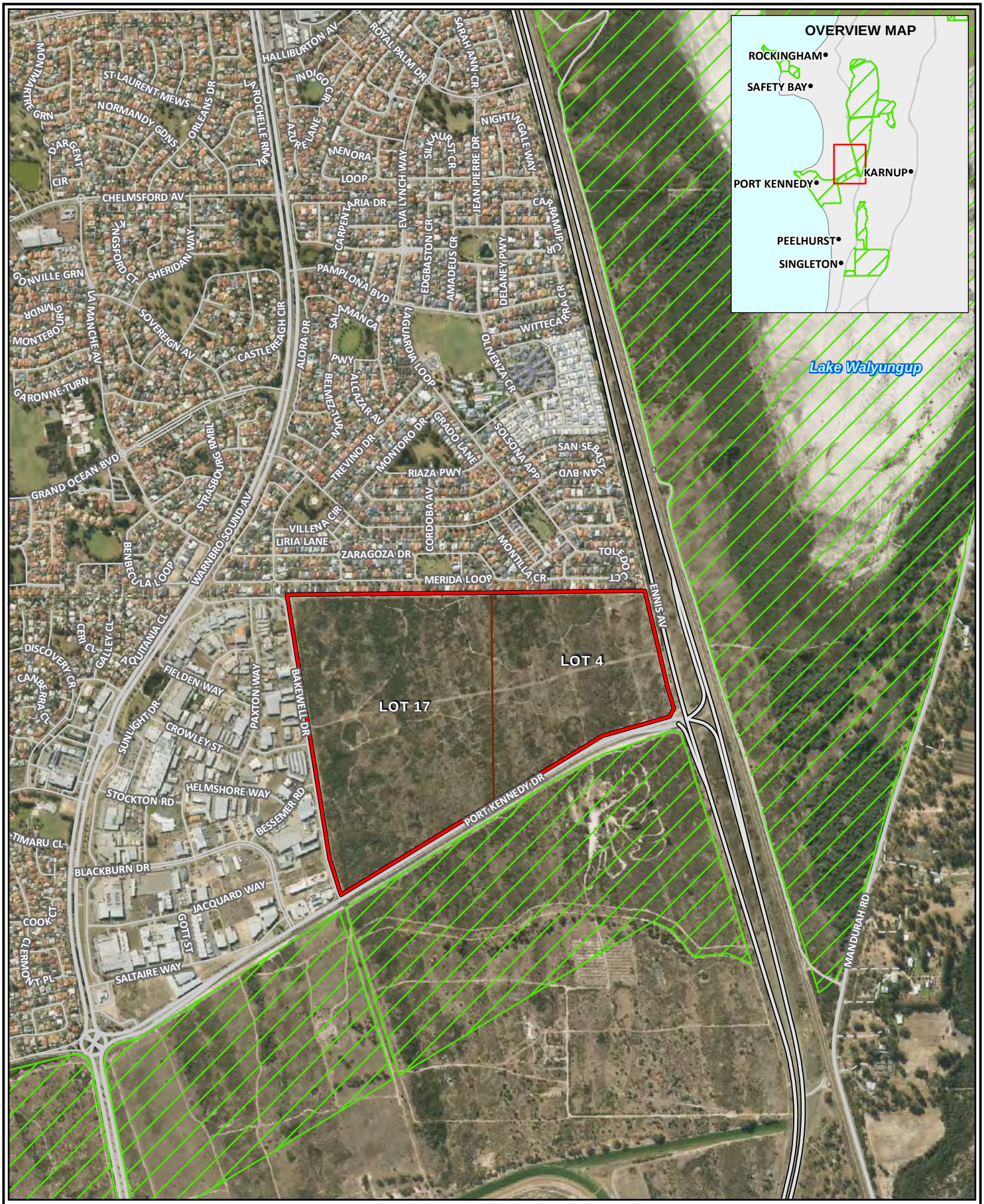
1.1 Total Water Cycle Management – principles and objectives

This LWMS identifies and describes a range of design elements and management measures being considered for the Project. The principal objective of this LWMS is to achieve better urban water management outcomes by designing a development that manages the total water cycle in a sustainable manner and meets objectives for water sensitive urban design. This includes consideration of water conservation and efficiency (water use), water quantity management (groundwater levels and surface water flows), water quality management (groundwater and surface water quality) and disease vector and nuisance insect management.

This LWMS has been prepared in accordance with Better Urban Water Management (BUWM) guidelines (WAPC 2008a) on advice from the Department of Water and Environmental Regulation (DWER). The document is consistent with the relevant State and local guidance on water management including the State Water Plan (DPC 2007), Planning Procedure 1.8 – Water Sensitive Urban Design (CoR undated) and the State Planning Policy 2.9 Water Resources (WAPC 2006). The document aims to meet the principles and objectives of stormwater management in Western Australia, as detailed in the Stormwater Management Manual for Western Australia (DoW 2007).

The BUWM guidelines (WAPC 2008a) also outline the principles of stormwater management as a component of water sensitive urban design (WSUD), which are:

- protect natural systems – protect and enhance natural water systems and their hydrological regimes in urbane developments.
- integrate stormwater treatment into the landscape – use stormwater in the landscape by incorporating multi-use corridors that maximise the visual and recreational amenity of developments.
- protect water quality – protect from draining from urban development and minimise outputs of phosphorous, nitrogen and other pollutants.
- manage run-off and peak flows – reduce peak flows from urban developments by using local detention measures and minimising impervious areas.
- add value while minimising development costs – minimise the drainage infrastructure cost of development.
- A copy of the LWMS checklist has been attached to assist in the review of this document (Appendix A).



Legend

- Project area
- Lot boundary
- Rockingham Lakes Regional Park
- Highways
- Main road
- Minor road
- Pedestrian way
- Track

Scale 1:15,000 at A4

0 150 300 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57354

Client: Development WA

Version: A | Date: 08-Jun-2021

Drawn By: jcrute | Checked By: CT

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

SITE LOCATION

FIGURE 1

strategen JBS&G

File Name: W:\Projects\1)Open\DevelopmentWA\57354 Port Kennedy LWMS revision\GIS\Maps\R01 Rev A\57354_01_SiteLoc.mxd
Image Reference: SLIP Public Services Locate 2019 - 2020.

1.2 Planning Background

The site was previously reserved 'Parks and Recreation' under the Metropolitan Region Scheme (MRS) and was rezoned from 'Parks and Recreation' to 'Industrial' in 1994 (Figure 2). The EPA assessed the planning proposal and specifically the rezoning of the subject site as proposed at the time. The EPA concluded that rezoning the site was environmentally acceptable, provided that land at Lark Hill was secured and managed for conservation purposes as an offset (EPA 1994).

The site is situated within the Western Australian Planning Commission's South Metropolitan Peel Planning Framework (sub regional framework). It is identified within the framework as an industrial area, consistent with the current MRS zoning of the site. Under the *City of Rockingham Local Planning Scheme No.2* (LPS2), the site is currently zoned Port Kennedy Business Enterprise.

The LPS2 objectives of this zone are to:

Promote service commercial and office land uses within the area to service the demands of the locality and in recognition of the Council's regional responsibility to provide light industrial land within the region, encourage the development of light industrial land uses in an orderly and proper manner.

On 6 July 2018 the WAPC conditionally approved the subdivision of the site into two lots of 17.9ha and 49.15ha (WAPC Ref: 156342). The purpose of the 'super lot' subdivision was to create a defined Conservation Lot for the western portion of the site, leaving the balance land for development. DevelopmentWA is in the process of clearing the subdivision conditions to create the new titles.

The proposed Structure Plan, the subject of this LWMS, will provide the necessary design framework to coordinate the future subdivision applications for individual light industrial lots and associated road network.

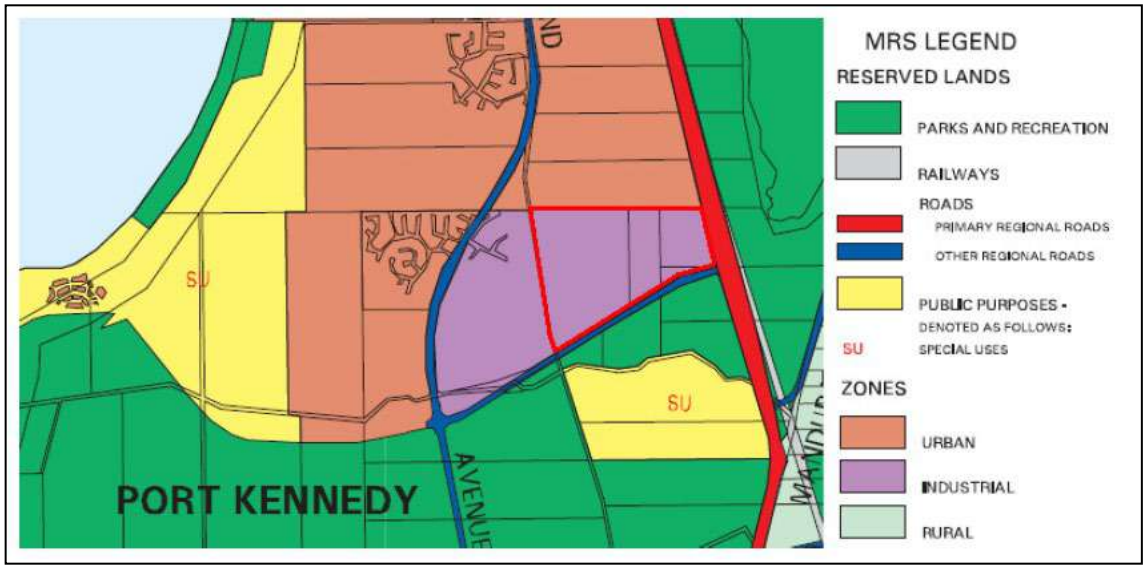


Figure 2 Site context plan

1.3 Previous Studies

Relevant to this LWMS, the following studies have been undertaken for the site:

- RPS Bowman Bishaw Gorham Pty Ltd 2006a, Environmental Constraints Analysis – Lot 4 Mandurah Road and Lot 17 Port Kennedy Drive, Port Kennedy, report prepared for LandCorp (now DevelopmentWA).
- Cardno 2010, Peer Review of Lot 4 Mandurah Road & Lot 17 Port Kennedy Drive, Port Kennedy – Environmental Advice, letter addressed to LandCorp.

- Douglas Partners 2011, Preliminary Geotechnical Investigation – Proposed Industrial and Commercial Development, Port Kennedy Business Park, Port Kennedy, WA, report prepared for Porter Consulting Engineers (Appendix B).
- Jim Davies and Associates (JDA) 2011, *Lot 4 &17 Port Kennedy Drive, Port Kennedy – Pre-Development Annual Monitoring Report 2010 – 2011,* report prepared for LandCorp, Jim Davies and Associates (Appendix C).
- PGV 2020, Port Kennedy Business Park, Environmental Assessment Report, report prepared for DevelopmentWA (Appendix D).
- Porter Consulting Engineers 2021, Engineering Servicing Report, report prepared for DevelopmentWA (Appendix E).

A summary of these reports, as they relate to the LWMS, can be found in Section 3.

The site is planned to be developed as an industrial estate with the western portion of the site retained for conservation. The site is currently zoned industrial under the Metropolitan Region Scheme and 'Port Kennedy Business Enterprise' under LPS No. 2.

The PKBEP represents an untapped opportunity for innovative light industrial development in this region, meeting local industrial land needs, generating local employment, and integrating environmental solutions. To help facilitate this opportunity, the Structure Plan has been prepared as a planning instrument, in accordance with City of Rockingham local planning scheme provisions, to coordinate delivery of industrial land, whist also recognising and addressing the environmental attributes of the site.

1.4 Limitations

As the site is proposed for light industrial development, an allocation of Public Open Space (POS) for active recreation is not required. The drainage system design for the site is based on a modular concept, with events up to including the 1% AEP event managed within the road reserve or designated drainage areas with specified reserve areas. Areas that can manage road reserve runoff have also been identified for open drainage basin around the central reserve area and in the south-west corner of the site. These areas, if required, will assist in managing runoff where there is insufficient distance to an intersection for the bioretention gardens or swales. These areas will be vegetated with native vegetation and will not be irrigated. No irrigated POS is proposed for this development.

A portion of the site (approximately 18.6 ha) has been reserved as a Conservation Area in acknowledgement of its environmental values, particularly wetlands and Threatened Ecological Communities, as discussed in Section 3.6.

The Conservation Area will be rehabilitated to an appropriate standard before being transferred to Department of Biodiversity Conservation and Attractions (DBCA) for management. The site will be fenced to prevent dumping and off-road vehicle access. Pedestrian access will be allowed on formalised and dedicated paths. Consideration will be given to the provision of small-scale amenities such as seating, educational signage, and picnic areas within the Conservation Area at the subdivision stage with the full management outlined in the appropriate report. The landscaping concept plan for the site is shown in Figure 4.

Legend

- Structure Plan Boundary

MRS Reserves

- Parks and Recreation

Local Reserves

- Public Open Space and Drainage

Local Zones

- Port Kennedy Enterprise Zone

Other

- Local Distributor Road 25m Road Reserve
- Local Access Road
- Pedestrian Path
- Dual Use Path
- Principal Shared Path
- Wetland
- Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1
- Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Lot 4 and 17 Port Kennedy Drive, Port Kennedy

Date: 8 Feb 2024 Scale: 1:4000 @ A3 1:2000 @ A1 File: **717-278 ST-1** Staff: MR GW Checked: MR

0 40 80m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

TEC RATING:

- HIGH QUALITY
- MEDIUM QUALITY
- LOW QUALITY

LEGEND

01 ENTRY STATEMENT TO ESTATE WITH SIGNAGE WALL

02 EXISTING PEDESTRIAN ACCESS WAY

03 ENTRY TO BUSHLAND TRACK NETWORK INCLUDING EDUCATIONAL SIGNAGE AND ARTWORK/ INTERPRETATIVE ELEMENT (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

04 RETAINED VEGETATION IN EXISTING CONSERVATION AREA CEDED TO DBCA

05 OPEN MESH FENCE TO CONSERVATION AREA FOR VISUAL PERMEABILITY

06 *GRAVEL PATHWAYS ALONG EXISTING BUSH TRACKS

07 SEATING ON DECKING AT LOOKOUT POINTS WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19A- HOLOCENE SEDGELANDS (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

08 SCREENING NATIVE TREE AND SHRUB PLANTING ALONG BOUNDARY FENCE TO RESIDENCES

09 NEW *GRAVEL PATHWAY CONNECTION

10 VEGETATED SWALE WITH ENDEMIC WETLAND PLANTING AND MELALEUCA TREES WITH REFERENCE TO ADJACENT BUSHLAND SPECIES

11 PEDESTRIAN FOOTPATH NETWORK

12 STORMWATER MANAGEMENT INFRASTRUCTURE (INFILTRATION OR BIORETENTION) IN ROADSIDE TO BE PROVIDED AS PER THE INDICATIVE LOCATIONS SHOWN ON THE CONCEPT DRAINAGE PLAN (BY OTHERS)

13 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS

14 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)- SIGNAGE ENDORSED BY DBCA DESIGN STUDIO

15 *GRAVEL PATHWAYS TO TEC 19B- (HOLOCENE WOODLANDS) WITH REVEGETATION INCLUDING TREE PLANTING THROUGHOUT

16 ARTWORK/ INTERPRETIVE ELEMENT TO STREET CORNER AND DECKING OVER DRAINAGE BASIN

17 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS

18 VEGETATED DRAINAGE SWALE ALONG MEDIAN STRIP TO PORT KENNEDY DRIVE

19 VEGETATED DRAINAGE SWALE ALONG PORT KENNEDY DRIVE WITH BUFFER TREE AND SHRUB PLANTING. RETAIN EXISTING 3M WIDE BIKE PATH.

20 RETAIN EXISTING VERGE TREATMENT/ SWALES TO SOUTH SIDE OF PORT KENNEDY DRIVE

21 STREETSIDE PARKING ADJACENT TO CONSERVATION AREA INTERSPERSED WITH VERGE PLANTINGS - TOTAL 8 NO. PARKING BAYS

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

CONCEPT MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.101 REV N

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

2. Design Criteria

2.1 Key Principles and objectives

The LWMS uses the following documents to define its key principles and objectives:

- Endorsed Planning Procedure 1.8; Water sensitive urban design (CoR undated)
- Water Resources Statement of Planning Policy 2.9 (WAPC 2006)
- Stormwater Management Manual for WA (DWER 2017)
- Decision Process for Stormwater Management in WA (DWER 2017)
- Better Urban Water Management (WAPC 2008a).

The site is not covered by a Drainage and Water Management Plan or a District Water Management Strategy (DWMS).

The key guiding principles of the LWMS are to:

- facilitate implementation of sustainable best practice in urban water management.
- encourage environmentally responsible development.
- provide integration with planning processes and clarity for agencies involved with implementation.
- facilitate adaptive management responses to the monitored outcomes of development.
- minimise public risk.
- maintain the total water cycle of the site.

Summaries of principles and objectives applicable to the LWMS for the Site based on these documents are provided in Table 1.

Table 1: Summary of LWMS principles and objectives

Category	Principles	Objectives
Water use	• Consider all potential water sources in water supply planning. • Integration of water and land use planning. • Sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• Minimise the use of potable water where drinking water quality is not essential.
Groundwater levels and surface flows	• To retain natural drainage systems and protect ecosystem health. • To protect from flooding and waterlogging. • To implement economically viable stormwater systems. • Post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• For ecological protection, 63% AEP event volume and peak flow rates maintained at or below pre-development conditions. • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles.

Category	Principles	Objectives
		• For flood management, manage up to the 1% AEP event within the development area to pre-development flows.
Groundwater and surface water quality	• To maintain or improve groundwater and surface water quality. • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater. • Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• Implement current known best management practice as detailed in the DoW *Stormwater management manual for Western Australia* (DoW 2004 – 2007) and the *Decision process for stormwater management in Western Australia* (DWER 2017), with an emphasis on a treatment train approach including nutrient input source control, use of bioretention systems, and maintaining 63% AEP event post development discharge volumes and peak flow rates at pre-development levels.
Disease vector and nuisance insect management	• To reduce the health risk from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	• Permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of Departments of Water and Health.
Water Dependent Ecosystem protection	• Protect and enhance significant water dependent ecosystems within the subject area and downstream. • Provide new habitat where possible through well designed vegetated stormwater treatment structures.	• Have long term sustainable water dependent ecosystems within and around the subject land.

2.1.1 Water Resources Statement of Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM).

WAPC (2006) defines IUWM (also known as total water cycle management) as promoting *'management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised'*.

IUWM should also promote water conservation measures, reuse and recycling of water and best practice in stormwater management (WAPC 2006).

2.1.2 Stormwater Management Manual for WA

The DWER position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW 2004), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- water quality: to maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- water quantity: to maintain the total water cycle balance within development areas relative to the pre-development conditions.
- water conservation: to maximise the reuse of stormwater.
- ecosystem health: to retain natural drainage systems and protect ecosystem health.
- economic viability: to implement stormwater systems that are economically viable in the long term.
- public health: to minimise the public risk, including risk of injury or loss of life to the community.
- protection of property: to protect the built environment from flooding and waterlogging.
- social values: to ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- development: to ensure the delivery of best practice stormwater management through planning and development of high-quality developed areas in accordance with sustainability and precautionary principles.

The then Department of Environment (now DWER) and Swan River Trust released the *Decision Process for Stormwater Management in WA* in 2005 (updated in 2017) to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.

2.1.3 Better Urban Water Management

This LWMS has been developed to be consistent with the framework and process detailed in the guideline document *Better Urban Water Management* (WAPC 2008a).

This LWMS has been prepared to an appropriate level of detail to support the Local Structure Plan for the development.

Urban Water Management Plan/s (UWMPs) will likely be required to support subdivision applications in due course.

Legend

- Project area
- Topographic contours (mAHD)

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Client: Development WA	
Version: A	Date 8/06/2021
Drawn By: jcrute	Checked By: CT
Scale 1:5,500 at A4	

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

SITE CONDITION PLAN

FIGURE 5

File Name: W:\Projects\1)Open\DevelopmentWA\57354 Port Kennedy LWMS revision\GIS\Maps\R01 Rev A\57354_05_SiteCondition.mxd
Image Reference: www.nearmap.com© - Imagery Date: 26. April 2021.

3. Pre-development environment

3.1 Current condition and adjacent land use

The site consists of undeveloped native vegetation. The area is currently used for passive recreation and off-road vehicle driving in an uncontrolled manner. There is evidence of illegal dumping of waste in some areas.

Land uses around the site are:

- to the north - residential housing
- to the west of the site - light commercial / industrial
- to the south - Rockingham Lakes Regional Park, and then undeveloped land to the east – Ennis Avenue and Mandurah Rail Line and then Rockingham Lakes Regional Park, including Lake Walyungup (**Figure 5**).

The site is mostly flat but contains a series of parallel and alternating dunal ridges reaching up to 12 m AHD on the eastern and western boundaries, with inter-lying depressions between 3 and 6 m AHD. The central part of the site contains a broad depression lying between 4 and 6 mAHD (**Figure 5**).

3.2 Climate

The Port Kennedy area experiences a Mediterranean climate with warm, dry summers and cool, wet winters.

The closest Bureau of Meteorology (BoM) monitoring station to the site is situated at the Kwinana BP Refinery (BoM station 9064) located approximately 15km from the site. Temperature and rainfall data from this station are summarised in **Table 2**. Summer months extend from October to April, with maximum daily temperatures of between 21 and 30°C. The winter months extend from May to September, with mean minimum temperatures of approximately 10°C.

Rainfall around the Port Kennedy area mainly occurs during winter with a mean monthly rainfall of 156 mm in June/July and 8 mm in December. The mean annual rainfall for the area is 743 mm.

Table 2: Climate statistics for Kwinana BP Refinery (1955 to 2011) (BoM Station 9064) (BoM 2020)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Max Temp (°C)	29	29.5	27.8	24.2	21.3	18.8	17.7	18.0	19.2	21.5	24.1	26.8	23.2
Mean Min Temp (°C)	18.8	19.2	17.9	15.5	13.3	11.7	10.6	10.6	11.4	12.7	15.0	17.0	14.5
Mean Rainfall (mm)	11.4	14.8	15.6	43.0	102.3	155.7	154.5	104.7	67.0	39.6	23.3	9.1	745.0

3.3 Geology and Soils

The site is located within the Quindalup Dune System which consists of wind-blown calcium carbonate and quartz beach sand forming dunes or ridges that are generally oriented parallel to the present coast, but which may also occupy blowouts within the Spearwood Dune System (Davidson 1995). The dunes were formed by windblown sand at a time when the coastline was further east of its current location, about 6,000 years ago. The coastline has receded to the west over time.

3.3.1 Geotechnical Studies

A geotechnical study by Douglas Partners (2011) and lithological logs from recent groundwater monitoring bore installation at the site (JDA 2011) indicate that the general soil profile over the entire site consists of 0.5 m brown sandy topsoil overlaying white to cream calcareous sands (Safety Bay Sands) with some minor

shells or rock fragment materials. Douglas Partners (2011) found dark grey organic sand with some fines at a depth of 1.1 m at one location on the western edge of the Conservation Area.

These results are generally consistent with Davidson (1995) mapping of the surface geology of the Perth region. The regional geology of the site is shown in **Figure 6**.

The presence of organic sand on the western boundary of the site is not considered to be a constraint to development from a geotechnical perspective, as construction is not proposed in this area.

The hydraulic conductivity of the Safety Bay Sands is generally high, approximately 15 m/day (DoW 2010). The high permeability of the Safety Bay Sands indicates ground infiltration should not be a constraint.

A copy of the geotechnical study can be found in Appendix B.

3.3.2 Acid Sulfate Soils

Some soils can contain sulfidic minerals that when oxidised produce highly acidic compounds. These are referred to as Acid Sulfate Soils (ASS). When ASSs are exposed to air and water, the iron sulphides can oxidise to produce sulphuric acid, iron precipitates and groundwater with elevated concentrations of dissolved metals such as aluminium, iron and arsenic. Areas associated with ASS are generally wetlands or recently formed landscapes with shallow groundwater. Land development activities such as sewer installation, which involve the dewatering and excavation of saturated soil from below the natural range of watertable variation, have the potential to facilitate acid formation, resulting in harm to the environment and infrastructure.

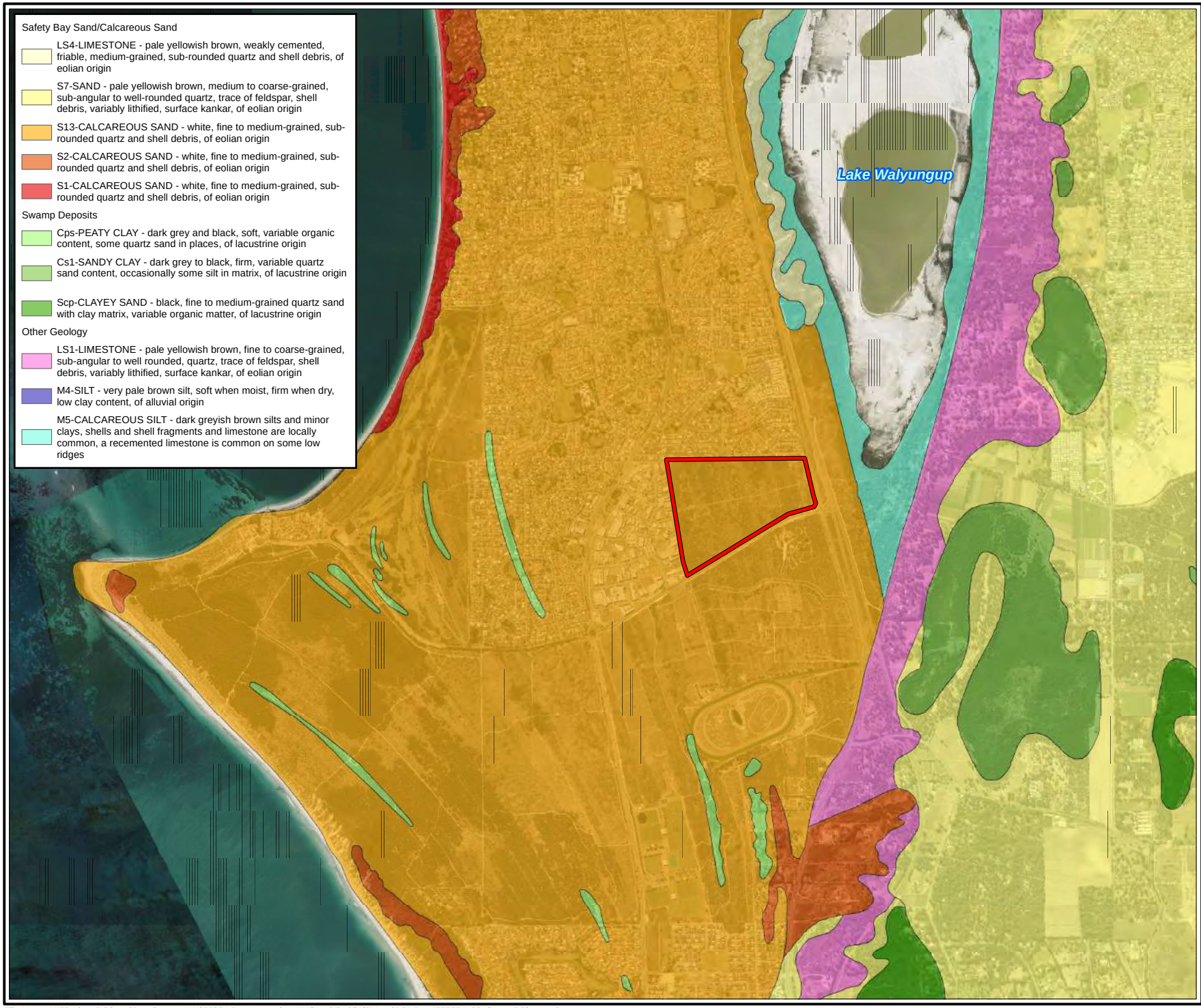
Australian Soil Resource Information System (CSIRO 2020) Atlas of Australian Sulfate Soils indicates there is 'no known risk' of ASS occurring within the site. Lake Walyungup, to the east of the site, is located within a 'high to moderate risk of ASS occurring within 3 m of natural soil surface'. The site is located approximately 320 m to the west of this potential ASS zone. As the site is not wholly or partially within an area of high to moderate risk, an ASS investigation is not required. Site-specific ASS work has therefore not been conducted on the site.

The presence of organic sand at depth on the western boundary of the site may be indicative of ASS or potential ASS occurring in this area, as organic soils are often indicative of high sulfide levels. Should earthworks or dewatering be proposed in this area, additional ASS investigations may be required.

3.3.3 Soil Contamination

A search was conducted on the DWER database of known contaminated sites (DWER 2020a). The search did not find any known contaminated sites that occur within the site. A Preliminary Site Investigation (PSI) has not been undertaken for the site.

The site is not known to have previously supported development; however, there has been illegal dumping of waste occurring around paths and tracks. This practice carries the potential risk of site contamination. A walkover inspection indicated that materials such as tyres, fridges, tins of paint/chemicals and building materials had been dumped on the site. The potential for the illegal dumping to represent a risk of contamination is likely to require investigation at subsequent development stages.



Legend

Project area

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Job No: 57354

Client: Development WA

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Scale 1:40,000 at A4

0 500 1,000
metres

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GEOTECHNICAL PLAN

FIGURE 6

File Name: W:\Projects\1)Open\DevelopmentWA\57354 Port Kennedy LWMS revision\GIS\Maps\R01 Rev A\57354_06_GeotechPlan.mxd
Image Reference: SLIP Public Services Locate 2019 - 2020.

3.4 Groundwater

The superficial aquifer is the primary aquifer of concern for the development of the site. The superficial aquifer is a complex unconfined aquifer with a maximum thickness of approximately 70 m with an average thickness of between 45 and 20 m (Davidson 1995). The average aquifer transmissivity for the superficial aquifer has been estimated at approximately 600 m²/day with a saturated thickness of 20 m (Davidson 1995).

3.4.1 Regional Groundwater

Regional groundwater flows in the Port Kennedy area are shown in the 1997 and 2004 Perth Groundwater Atlases (WRC 1997 and DoE 2004). Both are based on monitoring data obtained from DoW groundwater monitoring bores. The 1997 Atlas is considered to represent maximum groundwater levels. The 2004 Atlas is based on groundwater levels in May 2003 and is considered to represent an approximate annual minimum groundwater level.

The 1997 atlas shows a groundwater mound with a level of 4.4 mAHD approximately aligned with the western boundary of the site (WRC 1997) (**Figure 7**). Groundwater to the east of this mound flows in an easterly direction, towards Lake Walyungup. Groundwater to the west flows in a westerly direction, towards the Indian Ocean. The 2004 Atlas is less detailed but shows a groundwater mound in the area with an apparently similar groundwater divide and flow directions (DoE 2004). This mound is shown in a similar location and with similar flow directions in Davidson (1995) and is referred to as the 'Safety Bay Mound'. Davidson (1995) is also based on DoW groundwater monitoring data.

Regional groundwater levels in the area have been stable or shown a decrease in summer but not winter water levels since the 1970s (DoW 2008).

Groundwater monitoring in the Port Kennedy area was undertaken by Semeniuk (2007) between 1991 and 2001. This project focused on specific wetlands and did not analyse regional flow directions.

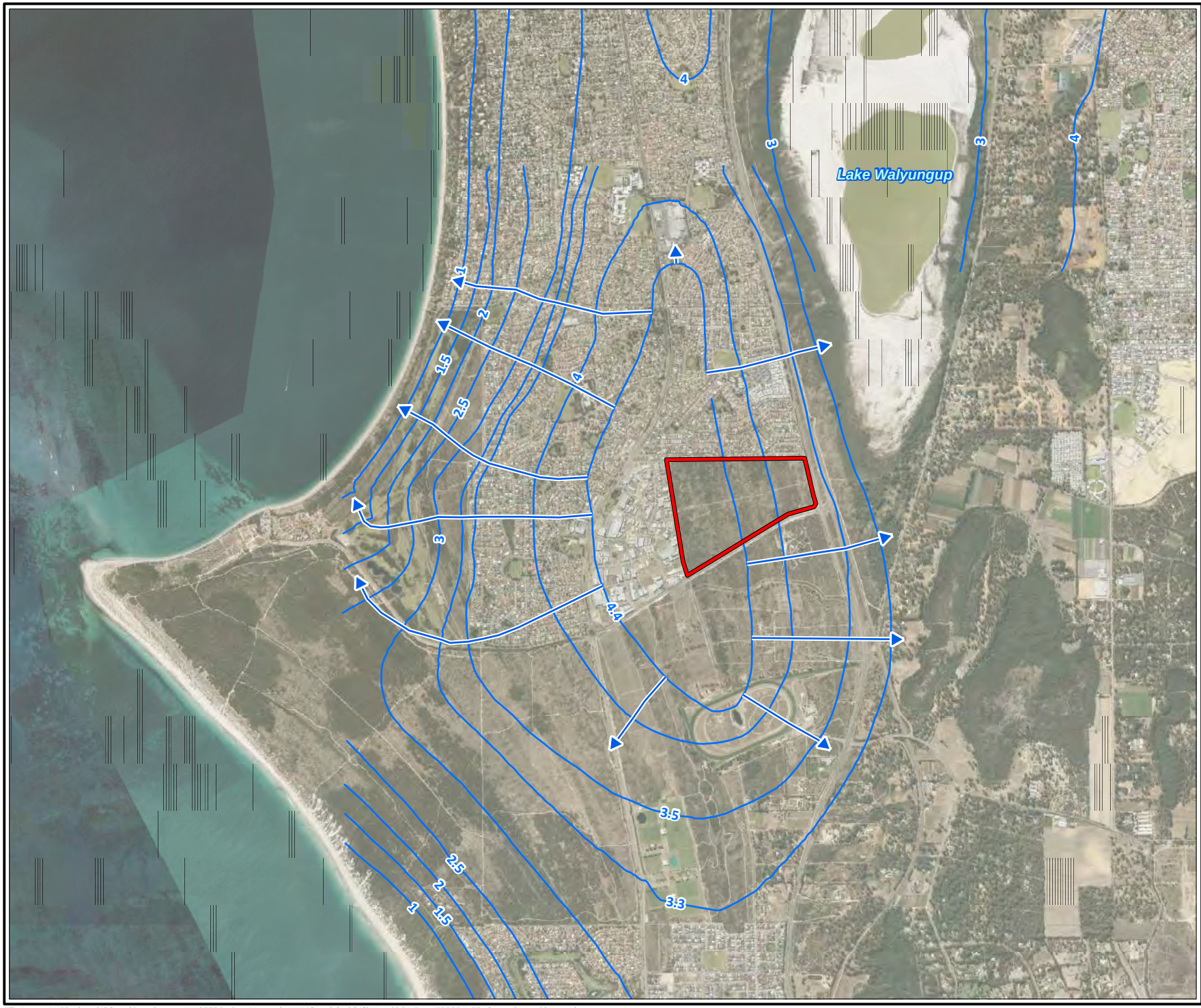
The site is located within the Warnbro groundwater subarea where approximately 77% of the groundwater in the superficial aquifer is allocated at the time of writing (DWER 2020b).

3.4.2 Pre-development monitoring

Pre-development groundwater monitoring was undertaken at the site over an 18-month period between October 2009 and April 2011 (JDA 2011). Eight shallow monitoring bores were installed at the site at depths between 4.5 m and 8.0 m. All bores were cased with 50 mm PVC and slotted over an interval of 3 m below the water table. A copy of the pre-development groundwater monitoring report (including all data recorded) is provided in Appendix C. To check for potential changes over time, further groundwater monitoring was undertaken between July and November 2022 by JBS&G. A subset of the bores was monitored, including redrilling of a former bore. Averaged over all bores, there was a difference of 0.075m in height, including those above and below the former maximum levels recorded. As 2022 was generally an above average rainfall year with high groundwater readings, the levels are considered suitable in confirming the previous AAMGL. The results from the 2022 monitoring can be seen in Appendix F, with the comparison in Table 3.

Table 3: Comparison of Groundwater Peak Levels

Bore	Max 2009-2011 sampling mAHD	Max 2022 sampling mAHD	Difference
1	3.47		
2	3.9	3.993	0.093
New PK2		3.883	
3	4.25	4.404	0.154
4	3.29	3.27	-0.02
5	3.62	3.489	-0.131
6	3.74		
7	2.64	2.919	0.279
8	2.88		
Average difference			**0.075**



Legend

- Project area
- Groundwater contours in mAHD
- Groundwater flow direction

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Client: Development WA

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Scale 1:40,000 at A4

0 500 1,000
metres

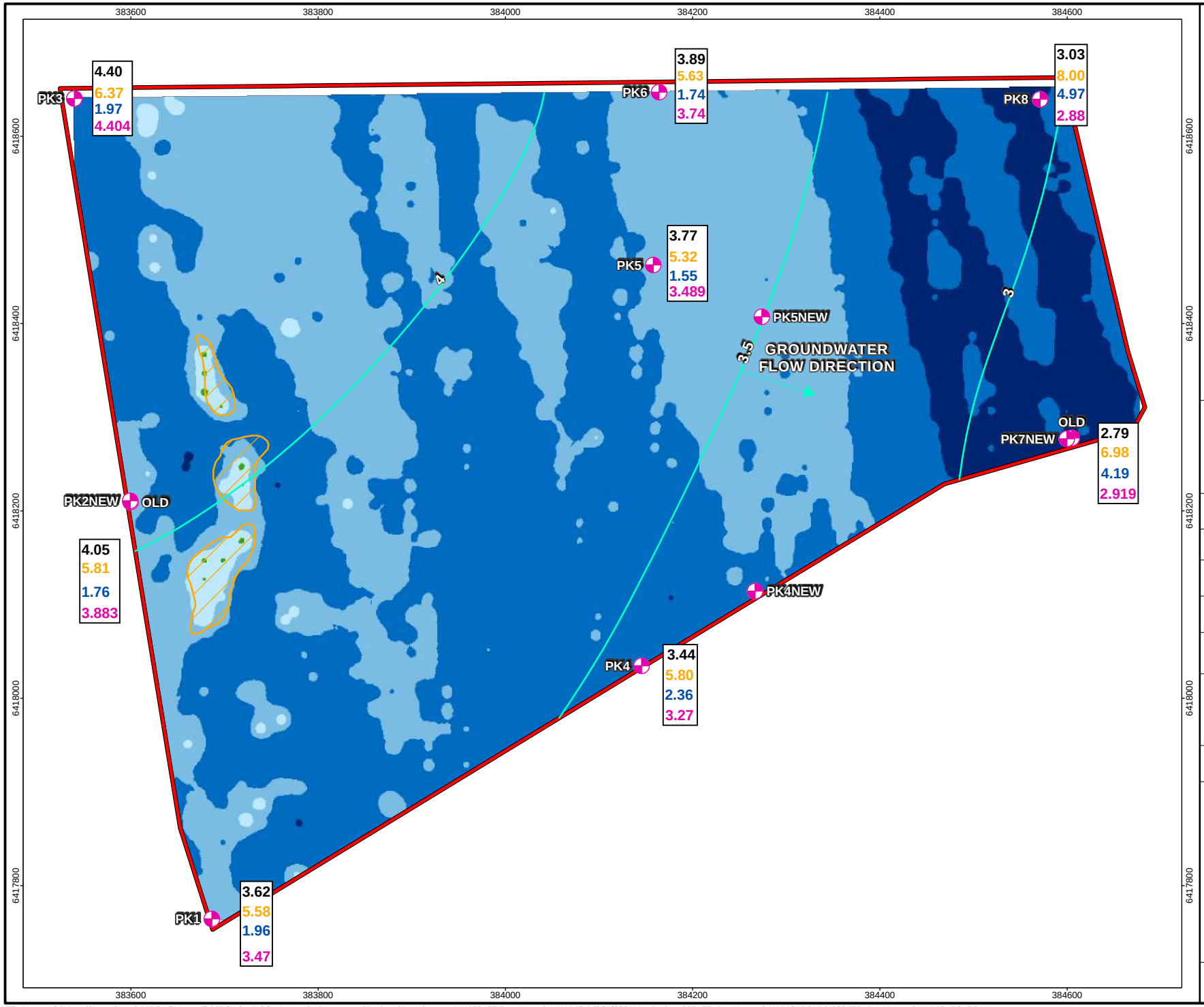
Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

REGIONAL GROUNDWATER PLAN

FIGURE 7

File Name: W:\Projects\1)Open\DevelopmentWA\57354 Port Kennedy LWMS revision\GIS\Maps\R01 Rev A\57354_07_GroundwaterPlan.mxd
Image Reference: SLIP Public Services Locate 2019 - 2020.



Legend

- Project area
- Wetland known to experience seasonal inundation

Depth to groundwater (m)

- Above GL
- 0 - 1
- 1 - 2
- 2 - 5
- > 5
- AAMGL (mAHD)
- JDA Bores

AAMGL (mAHD)
Natural surface level
Depth to AAMGL below natural surface
Recent monitoring MAX depth (mAHD)

JBS&G

Job No: 65475

Client: Development WA

Version: A	Date: 14/11/2023
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Scale 1:5,500 at A4

0 100 200
metres

Coord. Sys. GDA2020 MGA Zone 50

Port Kennedy Enterprise Park
Lot 4, Lot 17, Port Kennedy Drive
Port Kennedy, WA

LOCAL GROUNDWATER PLAN

FIGURE 8

File Name: C:\Users\ianandagoda\JBS&G Australia\JBS&G - DCS - Internal - Documents\Projects\DevelopmentWA\65475 Port Kenndey LWMS P2\GIS\02_MapProjects\65475_PortKennedyLWMS_P2_R01\65475_PortKennedyLWMS_P2_R01.aprx
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Groundwater Levels

Average annual maximum groundwater levels (AAMGL) calculated by JDA ranged from 2.79 mAHD (southeast corner of the site) to 4.4 mAHD (northwest corner of the site) (**Figure 8**, Appendix C). There was a rise of approximately 0.12m in the SE corner as part of the 2022 monitoring. Depth to AAMGL below natural surface varied from 1.55 to 4.97 m for the locations in which bores are located (**Figure 8**).

It is also noted that there are areas where groundwater is relatively close to the surface. This is related to the interdunal low areas, where the ground dips significantly below the surrounding area. These areas are concentrated on the western portion and can be seen in **Figure 8**. These areas are concentrated within the western half.

Maximum groundwater level (MGL) was calculated using the JDA monitoring data and DWER monitoring bore WIN ID 3012 (Ref 61410049) using data from 1990 to 2019.

Bores located on the eastern end of the site consistently displayed the greatest depths to water whilst the western end had lower depths to water. Depth to water over the whole site is estimated to range from above the surface in winter in depressions in the western part of the site, to 9 m below ground level at topographic highs in the south-eastern corner of the site.

Summer minimum groundwater levels ranged from 1.72 m AHD (southeast corner of the site) to 2.93 m AHD (northwest corner of the site). Observed seasonal groundwater variations were in the range of 0.3 m to 0.62 m across the site, which is typical of the Swan Coastal Plan (JDA 2011).

Extra pre-development level monitoring will be undertaken as required to inform exact groundwater levels in key locations such as infiltration basins. This information will be included in the UWMP and relevant civil engineering plans.

Groundwater Flows

Local groundwater flow in the superficial aquifer was recorded as flowing in an easterly to south easterly direction across the site, away from the Conservation Area (**Figure 8**). This flow direction is consistent with the Perth Groundwater Atlas (DEC 2004) which shows groundwater in the vicinity of the site flowing in an easterly direction.

Water Quality

Water quality monitoring results are summarised in **Table 4** with all data presented in Appendix C.

Monitoring data for pH ranged from 6.61 (PK4, January 2010) to 8.32 (PK1, July 2010) with a mean across all bores of 7.43 (**Table 4**). This indicates that groundwater is generally neutral to alkaline with all bores within the site showing values above 6.6. Mean values within the Australian and New Zealand Environment and Conservation Council and Agriculture Resource Management Council of Australia and New Zealand (ANZECC) guidelines range of 6.5–8.0 for slightly disturbed ecosystems in South Western Australia (ANZECC 2000).

Groundwater at the site is fresh with a mean electrical conductivity (EC) level of 0.61 mS/cm (**Table 4**) mean EC level is within the expected range of 0.3-1.5 mS/cm for slightly disturbed ecosystems in south-west Australia (ANZECC 2000). EC levels were generally consistent in all bores over the monitoring period ranging from 0.27 mS/cm (PK1, October 2010) to 0.85 mS/cm (PK5, July 2010).

Total nitrogen (TN) levels varied from 0.93 mg/L to 22 mg/L throughout the monitoring period (**Table 4**). Mean TN levels were between 2.78 mg/L (PK7) and 10.72 mg/L (PK1) which exceeds the Swan Canning Water Quality Improvement Plan's (SCWQIP) long-term and short-term target for TN (1 mg/L and 2 mg/L respectively) (Swan River Trust 2009).

Table 4: Summary of pre-development groundwater quality monitoring (JDA 2011)

Parameter	Mean	Range	ANZECC (2000)	SCWQIP (2009)	ADWG
pH	7.43	6.61–8.32	6.5 – 8.0	-	-
EC (mS/cm)	0.61	0.27-0.85	0.3-1.5	-	-
Tot N (mg/L)	6.31	0.93–22.00	1.2	long term = 1.0 short term = 2.0	

Total phosphorus (TP) results at all bores were below the SCWQIP long-term and short-term target for TP (0.1 mg/L and 0.2 mg/L respectively) on all sampling rounds except one (April 2010) where all monitored bores displayed 0.33 mg/L.

3.5 Surface Water

Standing water has been observed in three of the wetlands over the winter period (**Figure 10**). These bodies of water are considered to be ephemeral expressions of groundwater levels. These wetlands are all located in the Conservation Area.

Lake Walyungup is permanent and is located to the east of the site. The lake is recharged mainly through groundwater flow in the superficial aquifer. A DoW surface water monitoring site is located at Lake Walyungup. Water levels in Lake Walyungup have slowly declined since monitoring began in 1927 and levels were below the datum in May 2011 (DoW 2011a).

Surface water is not expected to flow off the site in the 1% AEP event due to the high permeability of the local sands. For the same reason, water is considered unlikely to enter the wetlands on site via surface runoff in events up to the 10% AEP event.

3.6 Vegetation, Flora and Wetlands

An Environment Assessment and Justification Report (Strategen 2011b) was prepared for the Site in 2011 as part of the initial assessment. In 2020, PGV Environmental prepared and Environmental Assessment Report (EAR) (PGV, 2020) for the Site.

The following section provides a summary of the vegetation, flora, and wetland aspects of this report.

3.6.1 Vegetation

The predominant vegetation community in the Proposal area is the Quindalup Vegetation Complex as described by Heddle et al. (1980) of which there is approximately 47% remaining in the Swan Coastal Plain (EPA 2006).

A Level 2 flora and vegetation spring survey of the study lots was conducted by RPS BBG in 2006 to confirm the presence or absence of conservation listed species, define the vegetation units present, define wetland areas, map vegetation condition and locate any Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC). The study included a PATN analysis by EA Griffen & Associates.

The survey found two dominant vegetation communities occurring at the site:

1. Dune System – Open low heath to closed tall shrubland of *Acacia rostellifera* and *Melaleuca systena*.
2. Wetlands, Damplands and Depressions in Dune Swales – Low, open forest of *Melaleuca raphiophylla*, closed sedgelands of *Baumea juncea, B. articulata, Lepidosperma longitudinale* and *Ficinia nodosa*, with areas of open *Xanthorrhoea preissii* scrub.

Vegetation community 1 mapped by RPS BBG (2006b) correspond to FCT 29b *Acacia* shrublands on taller dunes, which is currently listed as a Priority 3 Priority Ecological Community (PEC) by the DBCA (**Figure 9**).

Vegetation type 2 included several areas identified as the Threatened Ecological Community *Sedgelands in Holocene Dune Swales* (FCT 19) (See Section below).

Threatened Ecological Communities

The Threatened Ecological Community (TEC) SCP 19 'Sedgelands in Holocene dune swales of the southern Swan Coastal Plain' is known to occur on the site. The TEC is listed as Endangered under the EPBC Act and Critically Endangered at the State level.

Two sub-types of SCP 19 are recognised at State level although the TEC listing is for the overall SCP type (DEC 2011). SCP 19a includes 'sedgelands in Holocene dune swales' while SCP 19b includes 'woodlands over sedgelands in Holocene dune swales'. SCP 19b is generally associated with the older occurrences of the community.

Six occurrences of TEC 19 are mapped on the site by DBCA. Five of the six occurrences are the sub-type 19a while one contains trees and is mapped as sub-type 19b. The three northern most TEC 19 areas were recognised by DBCA as being degraded due to firebreaks and weed impacts.

According to the wetland/TEC assessment undertaken by PGV Environmental (2016) the TEC mapping on the site is reasonably accurate, with some minor modifications (Figure 8). PGV Environmental (2016) mapped one additional occurrence of TEC 19a (Wetland B) on the site and assessed the vegetation in wetland 19 as not beingTEC19.

In total, PGV Environmental consider there are 8 occurrences of TEC19 in the development lot and 14 in the proposed conservation lot.

The vegetation types of the dryland vegetation on the site were analysed by RPS-BBG (2006) to be representative of SCP 29b ''Acacia shrublands on taller dunes, southern Swan Coastal Plain" which is recognised as a Priority 3 Ecological Community at State level. PGV Environmental concurs with the identification of 29b for the dryland vegetation.

Vegetation Condition

The vegetation condition was assessed by PGV Environmental in September 2014 during a survey of weeds and in October 2016 during the spring flora survey.

PGV Environmental considered that the rating of Very Good for most of the western half of the site was a bit high and rated it as Good to Very Good with small areas of Degraded to Completely Degraded adjacent to the tracks and around the perimeter. The eastern half was considered to be Good with some areas Good to Degraded. The main weed species on the site were:

- *Avena fatua* (Wild Oats);
- *Bromus diandrus* (Great Brome);
- *Euphorbia terracina* (Geraldton Carnation Weed);
- *Lolium perenne* (Annual Ryegrass); and
- *Trachyandra divaricata* (Onion Weed).

3.6.2 Flora

A search of the EPBC Act Protected Matters Search Tool and the Naturemap database was conducted by PGV Environmental and identified eight species of significant flora that may potentially occur within 5km of the site.

Strategen (2012) conducted a DPaW Declared Rare Flora and Priority Flora database search with a 10km radius around the site for which they found three records of *Jacksonia sericea* (P4) and one record of *Acacia benthamii* (P2) occurring within 10km of the site.

A level 2 flora and vegetation survey of the site was undertaken in 2006 (RPS-BBG, 2006). A total of 119 species were recorded from the site in the 2006 RPS survey. The total included 117 naturally occurring species and two planted ornamental species. Of the 119 species, 61 were native and 58 were introduced. The percentage of introduced species (49%) is relatively high and reflects the low quality of vegetation particularly on the eastern half of the site as well as along the tracks and edges of the site next to developed areas and roads. The 2016 spring survey by PGV Environmental recorded 101 species, including 55 native and 46 introduced species. The percentage of introduced species (46%) was similar to that recorded by RPS in 2006.

PGV Environmental recorded 13 additional species not recorded in 2006 including six native and seven introduced species.

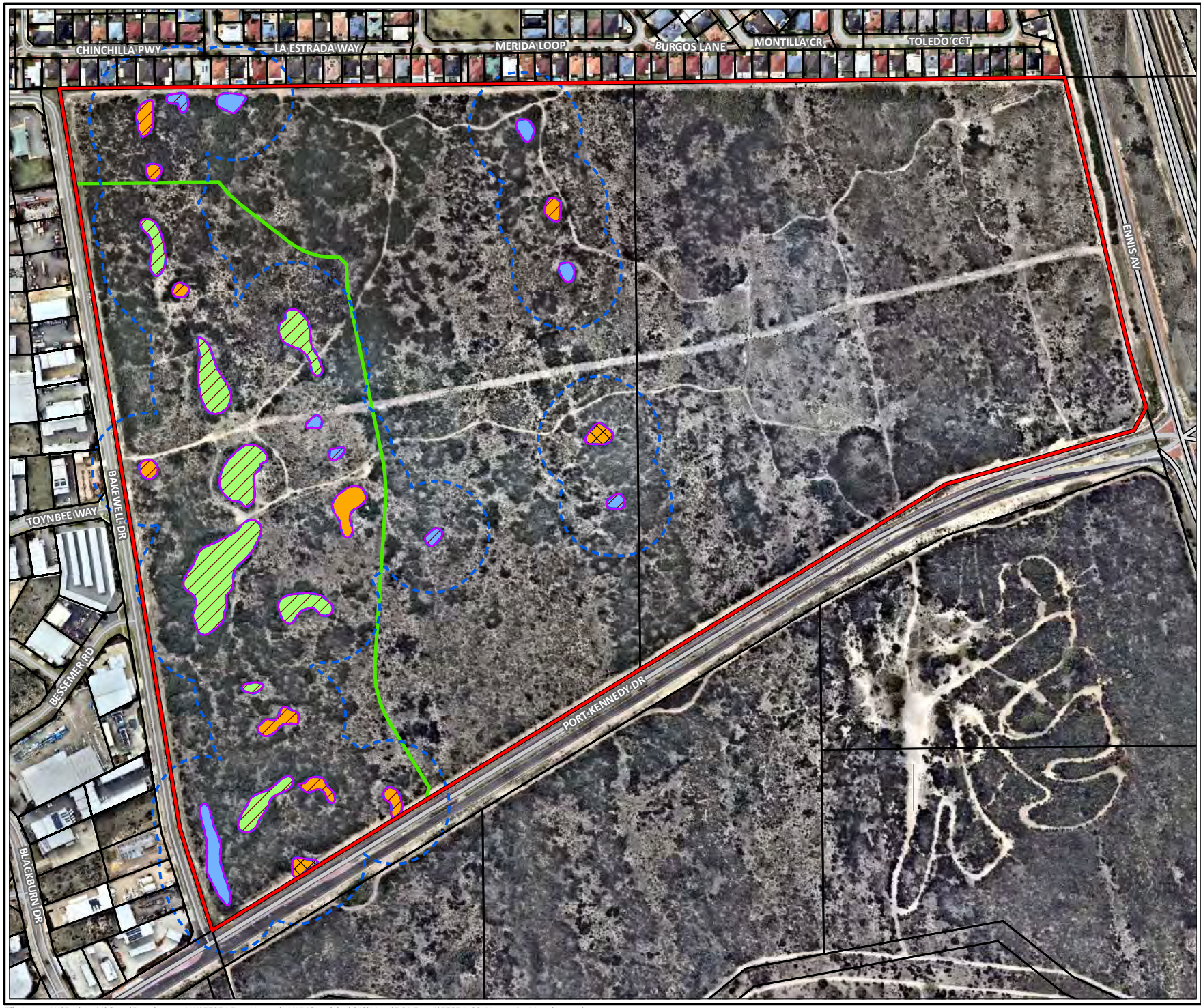
The total number of species recorded on the site between the two surveys is 132 (Lots 1 and 2), comprising 63 native and 69 introduced (46%).

Conservation Significant Flora

No Threatened (Declared Rare) or Priority Flora were recorded in the RPS-BBG survey in 2006 or the PGV Environmental survey in 2016.

Introduced Flora

The RPS BBG survey identified 54 introduced flora species, including several with a high rating as environmental weeds and several garden species.



Legend

- Project area
- Cadastral boundary
- Proposed conservation area boundary
- PVG wetland mapping
- 50m wide buffer from PGV wetlands

TECs

- TEC19a
- TEC19b

Environmental value

- H
- M
- L

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Job No: 57354

Client: Development WA

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Scale 1:5,500 at A4

0 100 200
metres

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Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

VEGETATION MAPPING

FIGURE 9

File Name: W:\Projects\1)Open\DevelopmentWA\57354 Port Kennedy LWMS revision\GIS\Maps\R01 Rev A\57354_09_VegetationMapping.mxd
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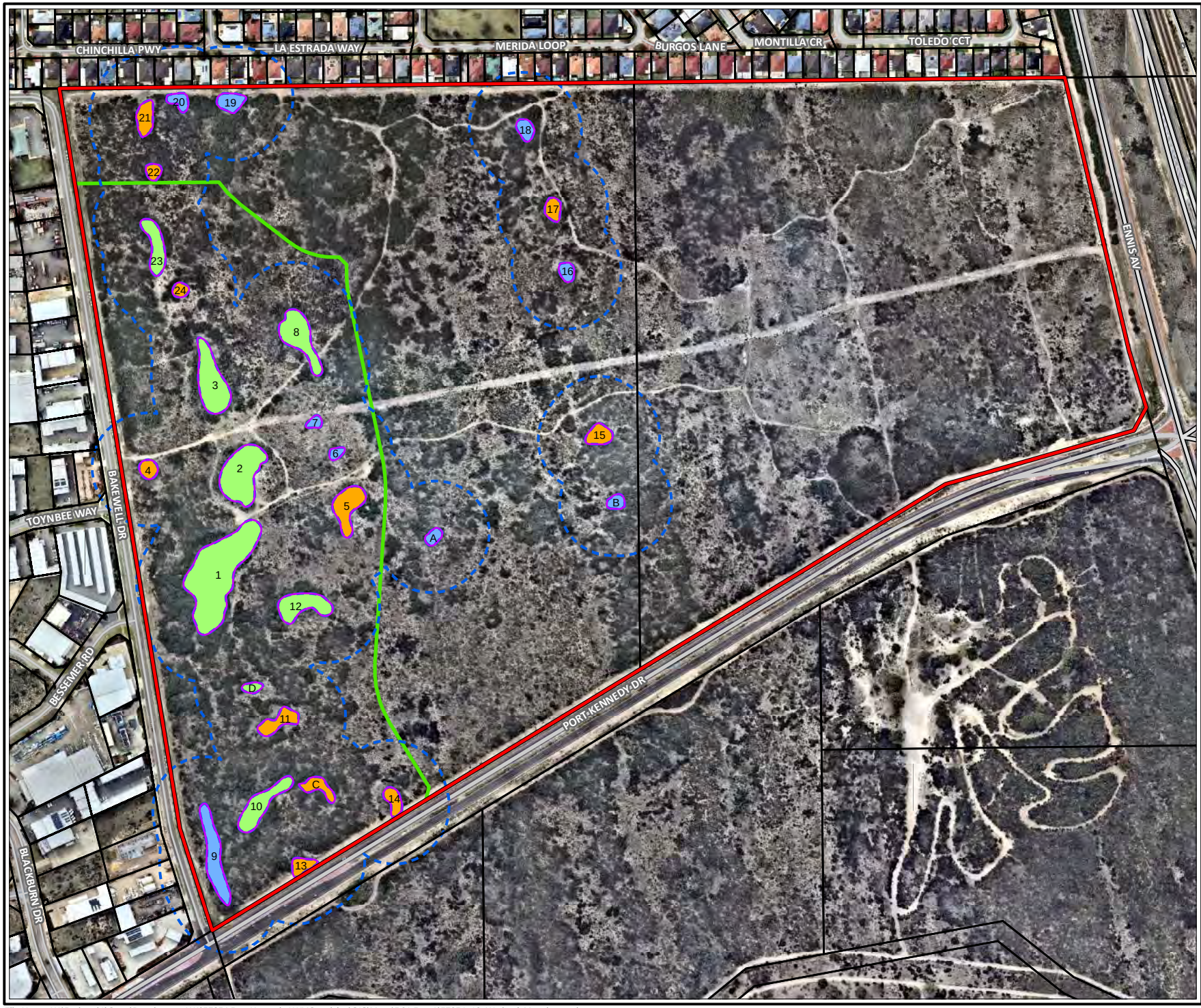

Legend

- Cadastral boundary
- Project area
- Proposed conservation area boundary
- PVG wetland mapping
- 50m wide buffer from PGV wetlands

Environmental value

- H
- M
- L

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Job No: 57354	
Client: Development WA	
Version: A	Date 8/06/2021
Drawn By: jcrute	Checked By: CT
Scale 1:5,500 at A4	

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

WETLANDS MAPPING

FIGURE 10

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3.6.3 Wetlands

The EAR (PGV 2020) reports that the site contains four wetlands as mapped by the *Geomorphic Wetlands of the Swan Coastal Plain* Database (National Map, 2020). These are described in **Table 5** and shown in **Figure 10**.

Table 5: Geomorphic Wetlands

Wetland Classification	Wetland Type	UFI Number	Wetland Name
Conservation	Dampland	6259	Point Becher Wetland
Conservation	Dampland	6473	Point Becher Wetland
Conservation	Dampland	6474	Point Becher Wetland
Resource Enhancement	Dampland	14638	Point Becher Wetland

Several studies have shown that the mapped wetlands do not align with the location of wetlands on the ground. PGV Environmental (2016) undertook a wetland vegetation assessment and a wetland boundary assessment (2017) to resolve the differences in the two previous wetland studies and to assess the vegetation within the proposed conservation area. Eleven wetlands (wetlands 14, 15, 16, 17,18, 19, 20, 21, 22, A and B) were mapped on the site (Plates 4-14). The wetland mapping did not match the mapping in the Geomorphic Wetlands of the Swan Coastal Plain Database but aligned closely with the TEC 19 boundaries provided by DBCA (V. English).

The environmental value of each wetland was assessed by PGV Environmental according to its size, condition, and vegetation types (**Table 6**). Seven of the eleven wetlands were rated as having a Low value due to the small size, poor condition, and low diversity of vegetation types. Several of the Low rated wetlands were considered transitional wetlands/drylands. The remaining four wetlands were rated as having a Medium environmental value.

The wetlands on the site are not part of the Becher Point Wetlands site which is listed as a Ramsar site (Wetlands of International Importance). However, the wetlands in the Conservation Area to the west of the development site are proposed to be managed by DBCA and added to the Rockingham Regional Lakes. As such they may be added to the Becher Point Wetlands Ramsar listing and managed accordingly.

3.6.4 Conservation Area

DevelopmentWA is committed to retaining and rehabilitating a 17.9 ha Conservation Area at the westernmost extent of the site. This area contains the majority of the TEC occurrences and the wetland on the site. The Conservation Area will be fenced and rehabilitated with the aims of:

- improving vegetation health and condition
- retaining fauna habitat
- preventing ingress of introduced flora and fauna species.

3.6.5 Additional Survey Work

Given the age of the previous field surveys by RPS BBG, we recommend an updated flora and vegetation assessment to the standards of the current EPA guidelines, be undertaken for any areas impacted by works.

Broad detail of the management of the Conservation Area can be found in Section 1.4. DevelopmentWA will prepare a Conservation Area Management Plan (CAMP) to accompany the Subdivision Application.

Table 6: PGV Environmental Evaluation of Wetlands

Wetland Number	TEC19	Vegetation Description	Vegetation Condition	Environmental Value	Comments
14	19a	*Ficinia nodosa* Sedgeland mixed with *Bromus diandrus,* Oats, *Acacia saligna, Hakea prostrata.*	Good - Degraded	M	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
15	19b	*Melaleuca rhaphiophylla* Low Forest over weeds, some *Ficinia nodosa.*	Degraded	M	Good stand of Paperbark (*Melaleuca rhaphiophylla*) trees with degraded understorey.
16	No	*Xanthorrhoea preissii, Acacia saligna, Lepidosperma longitudinale,* some *Baumea juncea, Ficinia nodosa*.	Good	L	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
17	19a	Central area of *Lepidosperma longitudinale, Ficinia nodosa, Gahnia trifida* Sedgeland and *Adriana quadripartita* shrubs surrounded by *Acacia saligna, Xanthorrhoea preissii* Shrubland.	Good	M	Very small wetland, good surrounding vegetation.
18	No	*Xanthorrhoea preissii/Acacia rostellifera* Shrubland with few *Ficinia nodosa, Lepidosperma longitudinale* sedges.	Good - Degraded	L	Small marginal wetland in poor condition, very low wetland diversity.
19	No	Dense *Acacia saligna* Tall Shrubland over *Bromus diandrus* dense grassland. Some *Lepidosperma longitudinale* sedges.	Degraded	L	Poor quality marginal wetland.
20	19a	*Acacia rostellifera/ A. saligna* Shrubland over *Melaleuca systena, Bromus diandrus, Euphorbia terracina,* Oats. Very small amount of *Ficinia nodosa, Baumea juncea, Gahnia trifida, Lepidosperma longitudinale*.	Degraded	L	Poor quality marginal wetland.
21	19a	*Ficinia nodosa/Baumea juncea* Sedgeland with *Bromus diandrus* and Oats weeds. Surrounded by *Acacia rostellifera.*	Good - Degraded	M	Moderate size wetland in average condition, low wetland diversity.
22	19a	*Ficinia nodosa, Centella asiatica, Baumea juncea* surrounded by *Hakea prostrata, Acacia rostellifera, Acacia saligna.*	Good	L	Small wetland in average condition, low wetland diversity.
A	19a	*Ficinia nodosa* Sedgeland mixed with weeds *Bromus diandrus*, Oats.	Good - Degraded	L	Poor condition wetland with low diversity.
B	19a	Some *Ficinia nodosa* sedges among *Xanthorrhoea preissii/Acacia rostellifera* Shrubland.	Good	L	Very small wetland in average condition and low wetland diversity.

3.7 Fauna

An Environment Assessment Report (EAR) (PGV 2020) has been prepared for the site and is presented in Appendix D. The following section provides a brief summary of the fauna aspects of this report.

A Level 1 fauna survey was undertaken by Bamford Consulting Ecologists (Bamford) in June 2011 to identify the fauna values of the Proposal. A total of 34 fauna species were recorded during the site inspection from the survey area including 25 bird species, two mammal species, two introduced mammal species, four reptile species and one frog species (Bamford 2011).

One species of conservation significance was recorded by Bamford (2011) within the Proposal area, Quenda (*Isoodon obesulus fusciventer)* listed as Priority 5 fauna by DBCA. The Quenda was recorded within or on the margins of wetlands on the western side of the Proposal area (**Figure 11**). Quenda tend to favour sedgeland habitats (Bamford 2011).

The Graceful Sunmoth, listed as Vulnerable under the WC Act and Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) at the time of the 2011 survey was also recorded within the Proposal area. However, this species was delisted from the EPBC Act in 2013. The species is now listed as a Priority 4 species under the State *Biodiversity Conservation Act 2016* (BC Act) and is no longer listed under the EPBC Act.

Legend

- Project area
- Cadastral boundary
- Proposed conservation area boundary
- Quenda Wetland Habitat

Lomandra Maritima Density

- None Recorded
- 1-5%
- 11-25%
- 6-10%
- GSM recorded locations (Bamford 2012)
- GSM recorded locations (Emerge Associates 2011)

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metres

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Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

FAUNA HABITAT MAPPING

FIGURE 11

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Image Reference: www.nearmap.com© - Imagery Date: 26. April 2021.

3.8 Matters to be addressed at Subdivision Stage

A Conservation Area Management Plan (CAMP) to outline the management of the Conservation Area will be prepared at the subdivision stage. A key objective of the CAMP will be to confirm the vesting and future management responsibilities for the Conservation Area.

Matters to be addressed at the subsequent subdivision (UWMP) stage are:

- ASS investigations shall be undertaken prior to any dewatering works being undertaken near the western boundary of the site at the subsequent subdivision stage.
- investigation of dumped material prior to subdivision to determine if any formal investigation (e.g., a PSI) is required on the site).
- removal of dumped waste as part of management on the site prior to the final subdivision of the site into lots.

4. Water Conservation Strategy

4.1 Water Conservation

4.1.1 Lot Scale Measure

Water conservation in developments will be managed at both a development and lot scale. Water use at a lot scale depends on the type of industry established. While warehouses and retail showrooms may not require large volumes of potable water, some industries, such as commercial laundries, require large volumes of water. DevelopmentWA is proposing to utilise a mixture of design guidelines and incentives to ensure that the measures chosen to manage water use at a lot scale are flexible, to meet the needs of different types of business. These design guidelines and considerations have been based on DevelopmentWA design guidelines for the Element Precinct (Light Industry Precinct) in the East Rockingham Industrial Park (DevelopmentWA undated).

Water conservation measures will be incorporated into the site design guidelines, which will include measures to require:

- water efficient tap fixtures and showers to be installed within the buildings
- the use of low water use irrigation systems within the lot, such as trickle irrigation systems, with a programmable controller/timer system
- support of rainwater tanks connected to a suitable, seasonally independent water use, such as toilet flushing.

Consideration will be given to the following items at the subdivision stage:

- provision of waterwise and low fertiliser use landscaping packages, including advice on minimising fertiliser and water use in landscaping
- rebates or provision of infrastructure for rainwater tanks such as tanks and pumps
- complimentary access to a nominated water conservation consultancy to assist with design and commissioning of rainwater and/or greywater recycling systems, up to a certain value.

These measures will assist industries present on the site to reduce their water use, while providing a high level of amenity and meets the design guidelines' objective to minimise the use of potable water where drinking water quality is not essential.

Industries that use more than 20,000 kL/year are required to submit a Water Efficiency Management Plan (WEMP) to the Water Corporation. It is considered unlikely that industries in the Industrial Park would require such large volumes of water.

Maintaining summer water levels in the wetlands is considered important for their long-term survival.

4.1.2 Development Scale Measures

At a development scale, the development is not proposing to include any irrigated POS, although limited irrigation may be required for establishment of swales and bioretention gardens. Irrigation during establishment is anticipated to be provided through the use of water tankers. The POS provided will consist of 17.9 ha Conservation Area as described in Section 1.4 and some small areas with drainage function (**Figure 12**). The drainage area has been allocated in the north-west corner of the site to manage road drainage from areas adjacent to the POS. The lack of irrigated POS significantly reduces the use of water at a development scale. Additional detail regarding the rehabilitation and management of the Conservation Area will be provided as part of the Conservation Area Management Plan (CAMP).

4.2 Servicing

4.2.1 Potable Water Supply

The site is within the Water Corporation water supply scheme area but is not yet serviced. The Water Corporation will allow lots to be serviced with water from the reticulated scheme via a connection to the existing Water Corporation service.

The proposed servicing includes a new DN200 loop main extending from the existing 200mmm water main at the intersection of Blackburn Drive/ Port Kennedy Drive, through the estate and back to the 200mm main at the intersection Bakewell Drive / Paxton Way. All other water mains are DN150. Approval in principle has been provided by the Water Corporation for the layout. Detail is provided in (Appendix E) (Porter Consulting Engineers 2021).

As part of detailed design, consideration is to be undertaken in relation to potential clashes between the potable water alignment and the proposed drainage network. Final design will need approval by the Water Corporation.

4.2.2 Wastewater

Water Corporation will require a sewer to be extended from the existing in Bessemer Road and then advanced in an easterly direction throughout the subdivision. A concept sewer layout has been prepared and is presented in (Appendix E). The gravity sewer crosses under the Conservation Category Wetland (CCW) via trenchless techniques, before it branches out to service the estate. The subdivision sewers will be 225mm diameter and developed on a frontage basis.

The north western corner of the site is serviced via a separate sewer. This reduces fill requirements and allow the seamless tie in with the existing Bakewell Drive. Approval in principle has been provided by the Water Corporation for the layout. Detail is provided in (Appendix E).

As part of detailed design, consideration is to be undertaken in relation to potential clashes between the sewer alignment and the proposed drainage network. Final design will need approval by the Water Corporation.

4.3 Matters to be Addressed at Subdivision Stage

Matters to be addressed at the subdivision (UWMP) stage are:

- further details regarding water conservation measures to be incorporated into the site design guidelines and any incentive packages to be offered by DevelopmentWA
- further details regarding provision of information regarding reducing water and fertiliser use
- Detailed checking of any servicing clashes with the drainage infrastructures.

5. Stormwater Management Strategy

One of the aims of stormwater management on the site is to maintain pre-development flows off the site. As there is currently no flow off the site for events up to a 1% AEP rainfall event, no flow off the site will occur post-development. Water will therefore be infiltrated within the development. Stormwater in events up to the 1% AEP event will be retained within the lots, drainage reserves, POS and the road reserves. There may also potentially be some discharge to the Conservation area in events above the 10% AEP, subject to detailed design and agreement from relevant parties including the City of Rockingham and Department of Biodiversity and Conservation and Attractions (DBCA). The advantages of this on-site infiltration concept are:

- maintaining the current surface water hydrology of the wetlands and TECs, where water does not enter these areas via surface runoff
- a modular approach that allows flexibility, should the road layout need to be modified to address demand for a particular size of industrial lot.

Different management approaches have been investigated to manage the road stormwater runoff. **Figure 13** shows the locations of each of these likely approaches. The options include:

- at source disposal at low point via bioretention gardens and infiltration systems in road reserves adjacent to lots)
- at source disposal via linear open planted swale
- at source disposal via below ground linear infiltration system
- at source disposal to open air basin for larger events (where other management systems are impractical or flow can be directed to dedicated drainage reserve and edges of the POS).

With these structures, it is anticipated that only minimal piped drainage will be required on the site (**Figure 13**). As the development is currently at the Structure Planning stage, combinations or alternative options may be used in each catchment. To assist with future detailed design, stormwater modelling has been undertaken for both vegetated linear swales and underground infiltration systems for each catchment that doesn't have a designated open basin. All open basins have also been modelled.

Ratios for bioretention gardens to capture and infiltrate the first 15mm of rainfall, as well as infiltration chamber sizing for larger events have also been determined based on different road lengths.

The analysis of these different options provides direction in determining the most suitable option for each area as part of detailed design. While the above systems have all been analysed and included as options, it is noted that the City's has a hierarchical preference for stormwater treatment in industrial areas. This hierarchy is as follows:

1. Linear swales on one side of the road, (with potential offsetting centreline to maximise verge space)
2. Pit and pipe system discharge to a linear swale
3. Pit and pipe system discharge to a linear swale with underground storage.

Option 2 and 3 also assumes the use of bioretention areas/treatment trains prior to pit capture.

At detailed design, this hierarchy is to be followed, in consultation with the City, to determine the optimal option for each drainage location.

These best management practices (BMPs) are considered to provide simple, easy to maintain structures for stormwater management on the site.

The drainage system of Port Kennedy Drive will not be altered. No stormwater is to be discharged from the development area to any land reserved as Primary Regional Road under the Metropolitan Region Scheme. This will be outlined in detail as part of the UWMP.

Further detail of the drainage management is detailed in Appendix E.

Legend

- Project area
- Conservation category wetland
- At source disposal within street
- Roadside disposal with possible discharge to conservation lot
- At source disposal leading to open aired basin for larger events
- Basin area and flood storage areas
- Lot layout boundary
- Cadastral boundary
- Lot layout
- Proposed kerb
- Proposed drainage
- Maximum groundwater level
- 50m environmental buffer
- Basin top
- Basin toe
- Footpath
- 6.9 Finished lot level
- Highway
- Major road
- Minor road

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Job No: 65475

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Version: A | Date: 13-Aug-2024

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0 50 100
metres

Coord. Sys. GDA2020 MGA Zone 50

Port Kennedy Enterprise Park
Lot 4, Lot 17, Port Kennedy Drive
Port Kennedy, WA

CONCEPT DRAINAGE DISPOSAL PLAN WITH CATCHMENTS

FIGURE 12

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Coord. Sys. GDA2020 MGA Zone 50

Port Kennedy Enterprise Park
Lot 4, Lot 17, Port Kennedy Drive
Port Kennedy, WA

CONCEPT DRAINAGE PLAN

FIGURE 13

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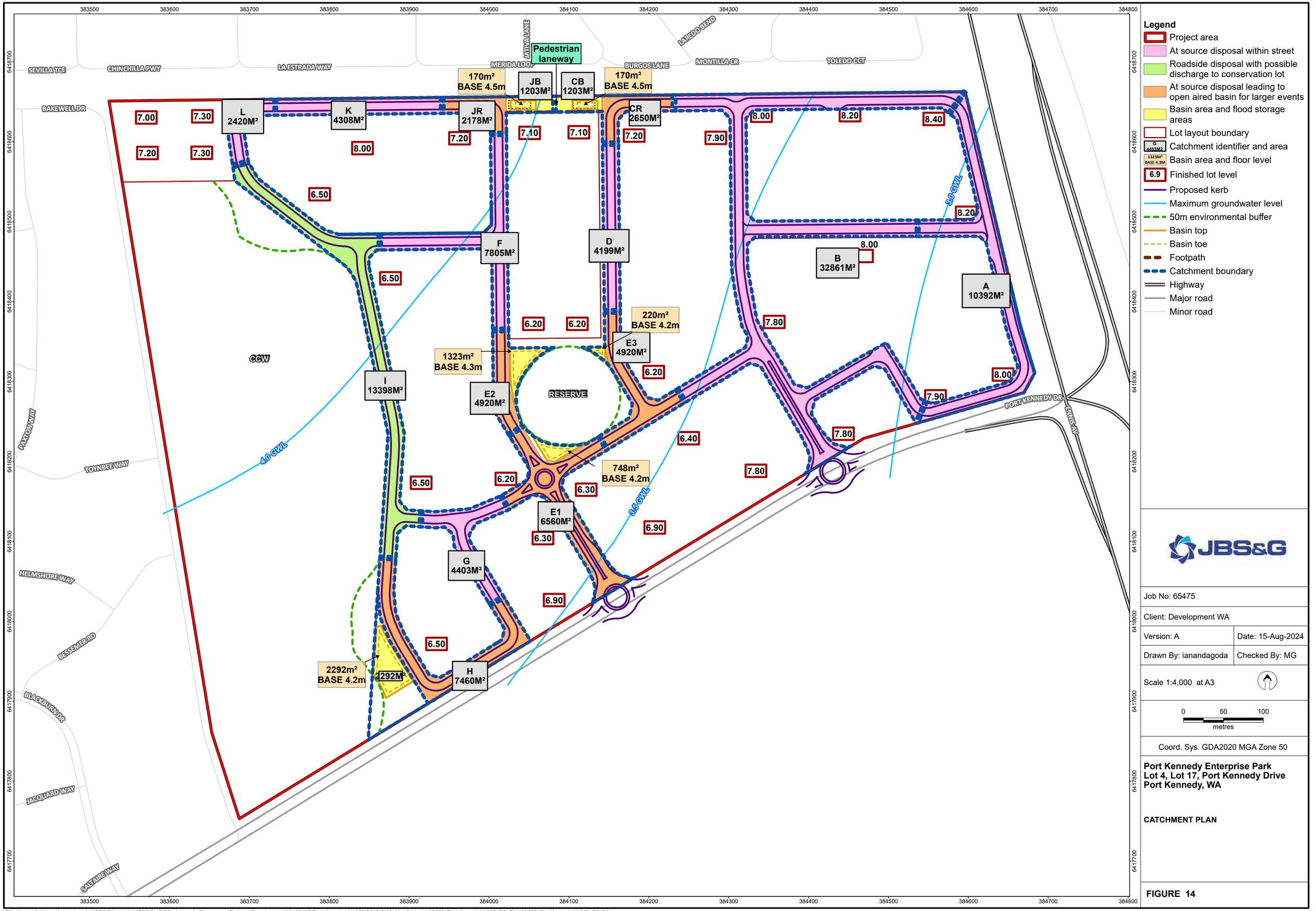

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5.1 Minor storm event drainage system - 15mm and 10% AEP event

A minor storm event is considered to be an event up to and including the 10% AEP storm. The aim of the design for management of the minor storm events is to treat and infiltrate the first 15mm with infiltration of the entire 10% AEP stormwater. Treatment is through the use of vegetated areas prior to infiltration (biofiltration). In the 10% AEP event, the aim is to infiltrate stormwater without water covering the road pavement. As the design and infiltration systems for the minor storm events on the site are very similar, these are discussed together.

To provide flexibility in the final design, a range of drainage infiltration options have been modelled. Wherever possible, the treatment for the 63% AEP will be via vegetated systems such as bioretention gardens, vegetated swales and basins. These will treat the first 15mm of rainfall collected. In larger events, up to and including the 10% AEP, stormwater runoff will also make use of these structures plus other infiltration devices. In line with the City's guidelines (Planning Procedure No. 18), all soakwells are to have a minimum separation of 0.3m between the base of the soakwell and the AAMGL. All swales and basins are to have a minimum separation between their base and the AAMGL of 0.5m.

The following sections provide more information on these various options for stormwater management as well as the assumptions used within the drainage modelling.

5.1.1 Drainage Modelling

Drainage modelling has been undertaken for the subject land to determine concept level sizing of a range of stormwater management structures.

A spreadsheet analysis was undertaken to provide general guidance on infiltration sizing for different lengths of road.

More detailed modelling using DRAINS software was used to determine the sizing of vegetated swales, underground infiltration systems and vegetated basins for the sub catchments within the subject land. The model included the following assumptions and parameters:

- Horton/ ILSAX drainage modelling method was used.
- ARR 2019 methodology and rainfall figures was used.
- To reflect the sandy soils and high measured infiltration rates, a soil factor of 1 was applied.
- Catchments were defined by Porters Engineering and represent likely high points for roads. There may be some modification as part of detailed design. The catchments and areas can be seen in **Figure 14**.
- All developed lots were assumed to infiltrate the entire 1% AEP within their boundaries as per City requirements.
- Roads were assumed to be 70% directly connected impervious, e.g. road and driveways, with a further 10% indirectly connected impervious, e.g. footpaths (total 80% impervious). The remaining 20% was assumed to be pervious.
- Impervious areas had an assumed retardance coefficient of 0.01 for connected areas and 0.013 for disconnected impervious areas.
- Pervious surfaces were assumed to have a retardance coefficient of 0.1.
- Infiltration structures were assumed to have a permeability of 5m/day, which is conservative, given testing of 15m/day and a recommended infiltration rate of 8.64m/day.
- Swales were assumed to have a 1m wide base, be 0.4m deep to the gutter and 1:6 sides.
- Infiltration systems were assumed to be 1m wide and 0.6m high, with vertical sides. An assumed 0.3m rise to the gutter level was also modelled.

- Basin areas around the central POS wetland (Catchment E), were modelled based on the indicative top areas provided by Porter Consulting. Sides were assumed to be 1:6. All bases were at least 0.3m above the AAMGL. Depths varied, depending on the location.
- The large south-west basin (Catchment H) was modelled as 0.5m deep, to maintain groundwater separation. It has 1:6 sides.
- The northern basins for Catchments C and J are modelled as 1m deep, with events above the 10% AEP able to flood the laneway area (laneway adjacent to northern boundary). These basins take water from both the relevant road and laneway area. The Laneway was modelled as being 65% impervious to reflect the wet basins and the likely footpath. The Location can be seen in Figures 12 – 14.
- The final storms modelled were the 5min,10min, 15min, 20min, 25min, 30min, 1 hr, 2hr, 3hr, 4.5hr, 6 hr, and 9hr. Longer events were not modelled as the peak events off any localised or combined areas were generally less than 1 hour and predominately 30min or less. These events were modelled for the 10% AEP and 1%AEP.

5.1.2 Bioretention Gardens

Due to the undulating topography, isolated vegetated bioretention gardens and infiltration areas will be placed at the low points of the roads or terminal basin locations. Roads in the development will generally be kerbed, with kerb openings used to direct water into the bioretention gardens via a bubble up pit to prevent erosion (**Figure 15**).

The first 15mm of rainfall will runoff into the infiltration area of the bioretention garden which will then infiltrate through the base of the bioretention garden (**Figure 16**). The bioretention garden will be vegetated with native species to strip nutrients and particulates. Soil underneath and around the bioretention garden will be selected to have an elevated phosphorus retention index, such as Spearwood Sand. For this size event, the water levels will not be high enough to enter the soak well system associated with the bioretention garden, where these may be used (**Figure 16**).

The required volume of the infiltration area will be dependent upon the catchment area of the road reserve. As the road reserves will generally be 20m wide, the length of the road reserve for each catchment is the main variable to determine runoff volume for the critical event. **Table 7** shows the required infiltration area for a range of catchment road lengths based on the current layout. These volumes are adequate to provide storage for a 63% AEP event, based on a critical event duration of one hour (approximately 15mm). The final requirements will be determined as part of detailed design and presented in the UWMP.

Table 7: System sizing table

Road length (20m wide road reserve)	Equivalent Impervious Area (c=0.8)	Infiltration zone dimensions to hold and dispose the first 15mm (63% AEP, 1 hour event)	Number of chambers with soakage base to manage the 10% AEP (including the infiltration zone)	Depth of flooding (above gutter level at the low) for the 1% AEP	Dry road width during 1% AEP flood (centre of the road assuming 3% crown)
50m	800m^2	6m x 3.2m x 0.35m	3 x Ø1.8m x 1.2m	0mm*	10m
100m	1,600m^2	12m x 3.2m x 0.35m	5 x Ø1.8m x 1.2m	81mm	4.6m
150m	2,400m^2	18m x 3.2m x 0.35m	8 x Ø1.8m x 1.2m	47mm	6.8m
200m	3,200m^2	24m x 3.2m x 0.35m	10 x Ø1.8m x 1.2m	81mm	4.6m
250m	4,000m^2	29m x 3.2m x 0.35m	13 x Ø1.8m x 1.2m	89mm	4.0m
300m	4,800m^2	35m x 3.2m x 0.35m	16 x Ø1.8m x 1.2m	70mm	5.3m

* all stormwater contained within infiltration area

Bioretention gardens will have a minimum 0.5 m separation from the base of the vegetated infiltration area to the groundwater level (**Figure 16**). Bollards will be placed around the infiltration area of bioretention gardens to avoid cars parking in these areas.

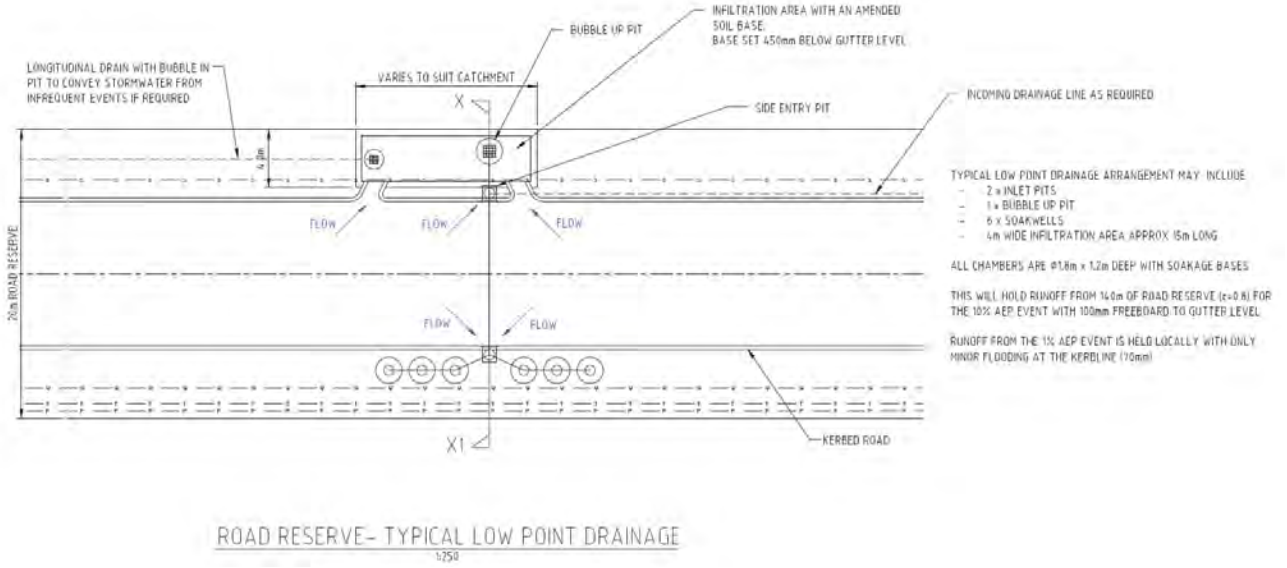


Figure 15 Cross section of road reserve showing typical bioretention garden concept in plan view

In the 10% AEP event, the water will overtop the grate on top of the soak well within the bioretention area and flow via the distribution pipe into the interconnected soak wells which will be located in the road reserve on the other site of the road (**Figure 15**). The number of soak wells will again be dependent upon the length of the road reserve catchment. **Table 7** provides guidance on the number of soak wells required to detain the 10% AEP event for a range of road reserve lengths.

In a 1% AEP event, the water will flood the road. **Table 7** indicates the depth of flooding and the unflooded road width for this size event.

Indicative locations of bioretention gardens are shown in **Figure 13**.

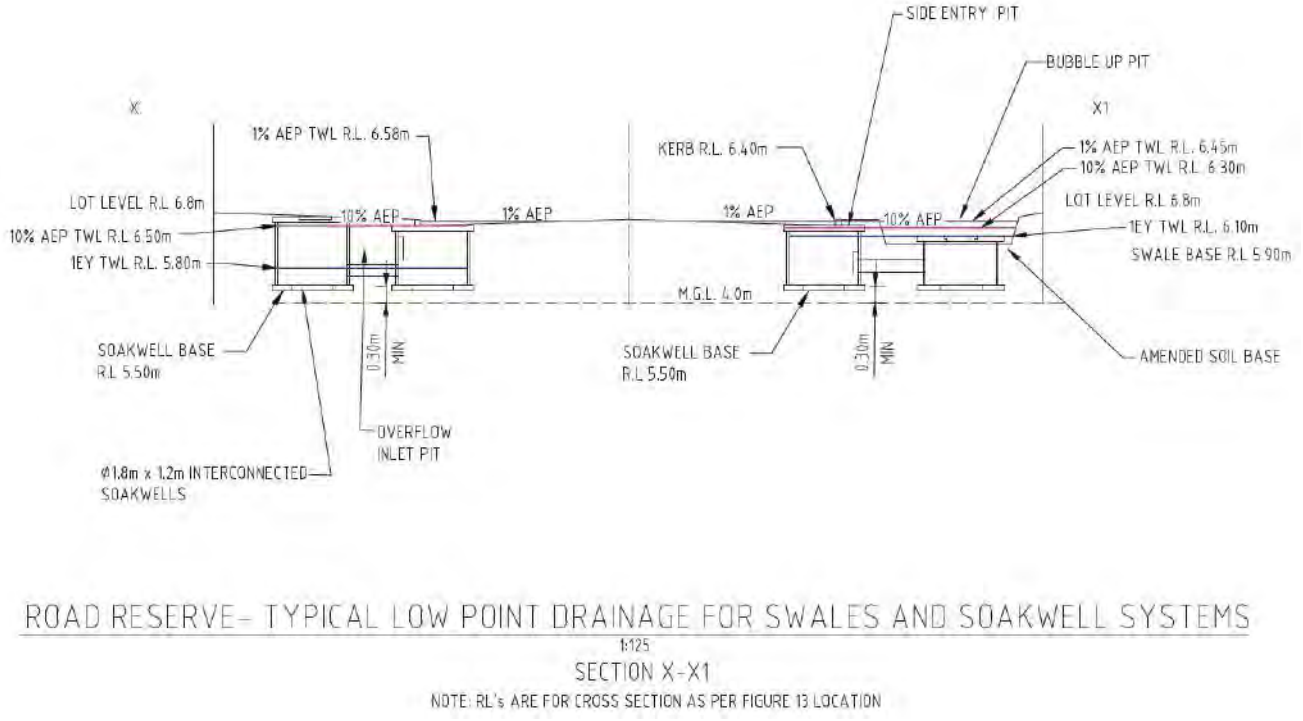


Figure 16 Cross section of road reserve showing bioretention rain garden

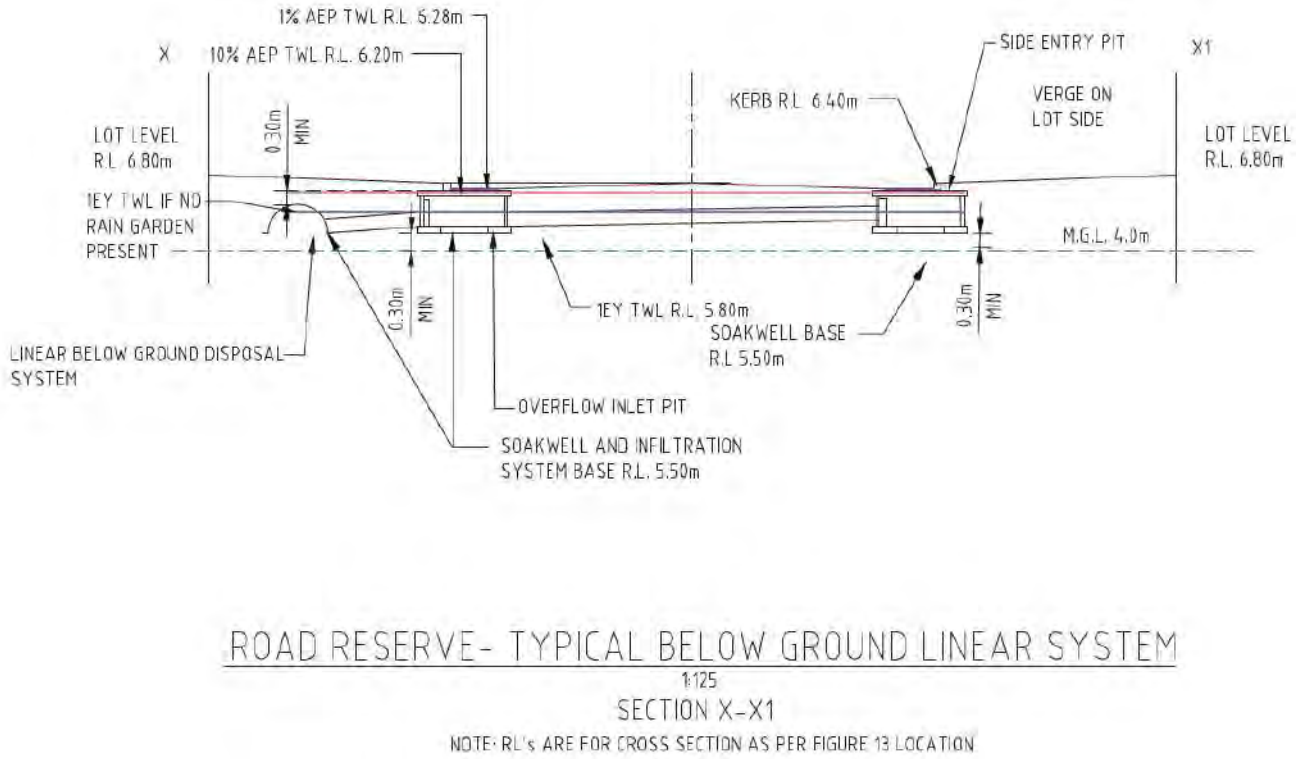


Figure 17 Cross section of typical below ground linear infiltration system

5.1.3 Swales

Swales with local native vegetation suited to sporadic inundation are likely to be utilised in areas adjacent to the Conservation Area to minimise the impact of drainage infrastructure on the Conservation Area. They may also be used in as other catchments where they are determined to be the most suitable option at detailed design. The swales will be designed to retain the 1% AEP event within the road reserve unless agreement is reached as part of detailed design to allow some higher flows through to the conservation area in a controlled manner. Soil underneath the swales will be selected to have an elevated phosphorus retention index (>10), such as Spearwood Sand.

The swales may also have a buried, infiltration drain filled with limestone or other rock sized material to maximise infiltration rates and ensure that the swale drains quickly (**Figure 18**). Where used, the infiltration drain will be wrapped with geofabric to prevent sand and silt entering the infiltration drain. A high-level inlet will prevent the first 15mm from entering the infiltration drain associated with the swale ensuring that water is infiltrated through the biofilter. The use of these systems will be determined in consultation with the City at detailed design and subject to the best overall option for the location and City maintenance regimes.

Vegetation planted within the swales will be chosen to have root systems compatible with the infiltration system. This includes sedges, rushes, and small shrubs. The final design, including the potential requirement for an infiltration trench will be determined as part of the detailed design in consultation with the City of Rockingham. The design will consider the necessary maintenance regime for the City. Should the infiltration trench be included, the inclusion of geofabric around the structure will also be determined in consultation with the City.

The sides of the swale will be battered at a grade of 1 in 6 for safety. It has been proposed to make the road edge adjacent to the swales flush kerbed with bollards to prevent vehicle entry to the road reserve.

Alternatively, they may be kerbed with designated rocked chutes. This detail will be confirmed with the City of Rockingham at the design stage.

Indicative locations for swales within relevant catchments can be seen in **Figure 13. Figure 16** also shows the modelled depths of water in the 1EY, 10% AEP and 1% AEP.

Table 8 provides a breakdown of swale sizes for each non basin catchment, to assist with determining the area required, should swales be used in each catchment (which is to be determined at detailed design).

It also contains the 10% AEP and 1% AEP depths and volumes, as well as the emptying time for the 10% AEP.

Table 8: Swale sizing table

Catchment	Catchment Area (m^2)	Swale Base area (m^2)	Swale Top area (m^2)	Volume to gutter invert (m^3)	10% AEP			1% AEP			Emptying times (hr) *	Comments
					Volume (m^3)	Depth (m)	Emptying times (hr) *	Volume (m^3)	Depth (m)	Outflow (m^3/s)		
A	10392	110	724	152	126.9	0.38	2	265.9	0.54	0	3	0.4m deep swale, 1m base
B	32861	320	1884	410	410.8	0.4	2.2	875.2	0.58	0	3.1	0.4m deep swale, 1m base
D	4199	41	266	55	51.6	0.39	2	108.1	0.55	0	3	0.4m deep swale, 1m base
F	7805	75.5	466	97	97.4	0.4	2.2	199	0.56	0	3	0.4m deep swale, 1m base
G	4403	43	277	57	54.2	0.39	2	114	0.55	0	3	0.4m deep swale, 1m base
I	13398	130	776	163	167.2	0.4	2.2	334.3	0.53	0	3.1	0.4m deep swale, 1m base
K	4308	42	271	56	53	0.39	2	111.3	0.55	0	3	0.4m deep swale, 1m base
L	2420	24	167	34	29.1	0.24	1.5	60.3	0.52	0	2	0.4m deep swale, 1m base

Note:

- *1EY level generally a maximum of 0.3m deep when no bioretention garden present.*
- *Levels above the 0.4m swale depth represent back flooding onto the road gutter*
- ** Emptying time is conservatively from conclusion of peak storm event.*

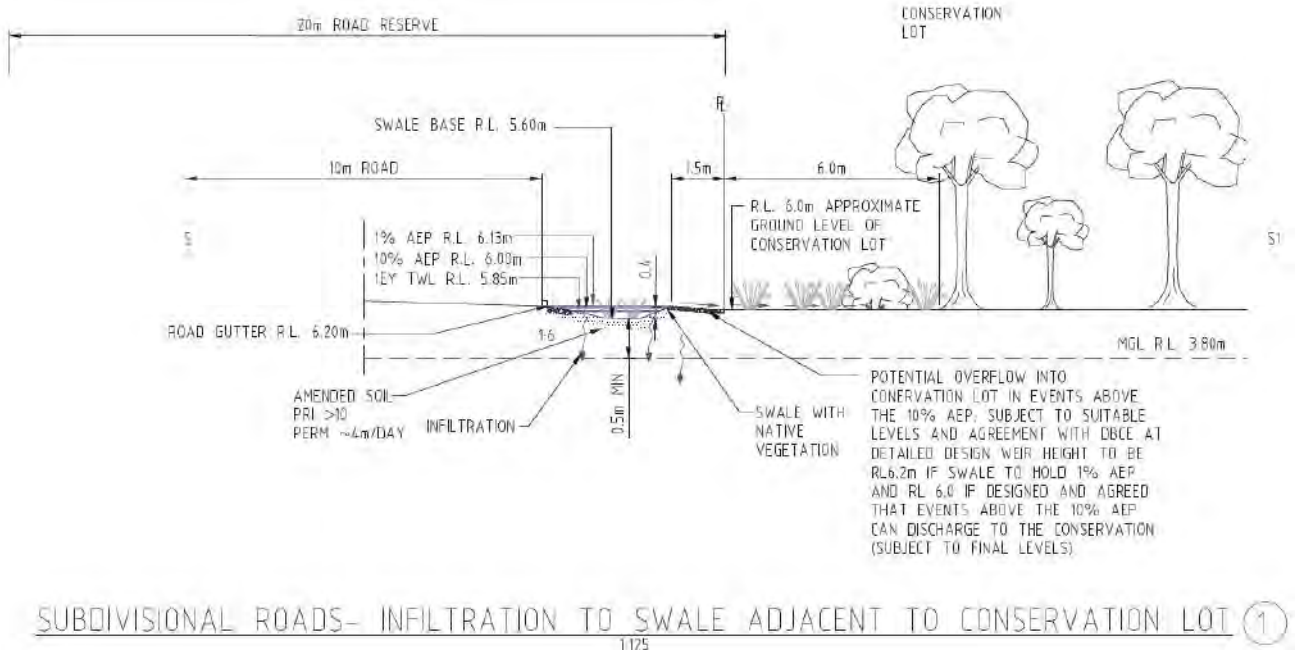


Figure 18 Cross section of road reserve showing swale and potential overflow to Conservation Lot

Swales have been designed with a minimum 0.3 m separation from the base of the vegetated infiltration area to the groundwater level.

The swales and bioretention gardens in the roads adjacent to the Conservation Area will be required to be managed to ensure the understorey and surface fuels remain in a low threat, minimal fuel condition in accordance with Clause 2.2.3.2 (f) of AS 3959 and Schedule 1 *Guidelines for Planning in Bushfire Prone Areas* (WAPC 2017). This will limit the surface fuel load allowed to occur in this area to less than 6 millimetres in thickness and maintained at 2 tonnes per hectare or vegetation that can be slashed prior to summer to reduce fire risk. Trees are allowed in the low fuel zone, provided the density is not adequate to constitute a fire risk. This will require lower branches removed to height of 2 m above surface vegetation, canopy cover less than 15% and tree canopy at least 5 m apart.

The use of swales for drainage management meets the objective of maintaining 63% AEP event volume and peak flow rates maintained at or below pre-development conditions for the 10% AEP, as there is no outflow from any system.

5.1.4 Underground infiltration systems

Where it may not be possible to utilise swales, underground infiltration systems may be used. To assist with determining where these may be the most suitable option at detailed design, all non-basin catchments have been analysed to determine the appropriate sizing for these systems. The modelling has assumed that the infiltration systems are 0.6m deep with straight sides. It is also assumed that there is 0.3m of rise from the top of the system to the gutter level. The sizing can be seen in **Table 9.** The sizing assumes all stormwater is contained within the infiltration system with no standing water on the road surface in the 10% AEP or 1% AEP to be conservative. As part of detailed design, these will be refined to suit the subcatchment feeding them, with the potential for some storage in the road in the 1% AEP. To be conservative, no upstream soakage in bioretention gardens is assumed.

The 1EY is generally 0.3m deep within the infiltration systems if there is no bioretention garden before the infiltration system. A cross section with 1EY, 10% AEP and 1% AEP levels is shown in **Figure 17.** Indicative locations within the 'at source disposal catchments' are shown in **Figure 13**.

Table 9: Underground infiltration system sizing

Catchment	Area (m^2)	Base area (m^2)	Top area (m^2)	Volume to gutter invert (m^3)	10% AEP			1% AEP			Emptying time (hr)*	Comments
					Volume (m^3)	Depth (m)	Emptying time (hr) *	Volume (m^3)	Depth (m)	Outflow (m^3/s)		
A	10392	240	240	144	151.7	0.7	3.5	246.5	0.78	0	4	0.6m deep infiltration with 0.3m cover to gutter
B	32861	400	400	480	479	0.6	3	734.7	0.78	0	3.5	0.6m deep infiltration with 0.3m cover to gutter
D	4199	100	100	60	61.2	0.7	3.5	98.3	0.73	0	4	0.6m deep infiltration with 0.3m cover to gutter
F	7805	180	180	148	113.8	0.7	3.5	183.5	0.76	0	4	0.6m deep infiltration with 0.3m cover to gutter
G	4403	100	100	60	63.6	0.7	3.5	101.6	0.74	0	4	0.6m deep infiltration with 0.3m cover to gutter
I	13398	320	320	192	195.8	0.7	3.5	323.3	0.8	0	4	0.6m deep infiltration with 0.3m cover to gutter
K	4308	90	90	116	61.2	0.7	3.5	96.7	0.74	0	4	0.6m deep infiltration with 0.3m cover to gutter
L	2420	40	40	95	31.3	0.7	3.5	49.4	0.72	0	4	0.6m deep infiltration with 0.3m cover to gutter

Note:

- *1EY level generally a maximum of 0.3m deep when no bioretention garden present.*
- *Heights of 0.6 – 0.9 means water level is between main storage cavity and gutter level (eg within the inlet soakwell/pipe)*
- **Emptying time is conservatively from conclusion of peak storm event.*

5.1.5 Vegetated basins

Where suitable space is available, vegetated basins within designated reserves have been used to manage stormwater for all events up to and including the 1% AEP. They have been designed so that they completely contain the 10% AEP within the designed basin. In the 1% AEP, water may flood out into the land surrounding the basin within the reserve area, with the maximum depth of water in the basin, including surrounding standing water to be less than 1.2m deep. The indicative vegetated basin locations can be seen in **Figure 13**. The top and toe of the indicative vegetated basin areas can also be seen as orange lines.

Figures 19 – 21 show indicative cross sections of 3 basins which highlights the potential for use of the surrounding reserve to store events above the 1% AEP (Figure 19 and 21) or full detention in the basin (Figure 20). Their location can be seen in Figure 13.

For Catchment E, at detailed design, balance pipes may be used to allow water to flow between the different basins, depending on the exact catchment area that will feed each basin. The most suitable configuration to protect the wetland, keep all drainage infrastructure outside of the wetland buffer and allow for other passive uses will be determined in consultation with the City at detailed design. The current modelling highlights that there is suitable space available to achieve these outcomes within the available reserve area outside of the 50m buffer.

Any flooding of adjoining roads next to the basin has been designed to be less than 0.15m above the gutter, noting that it is likely that water will be completely contained within the reserve area due to the available space.

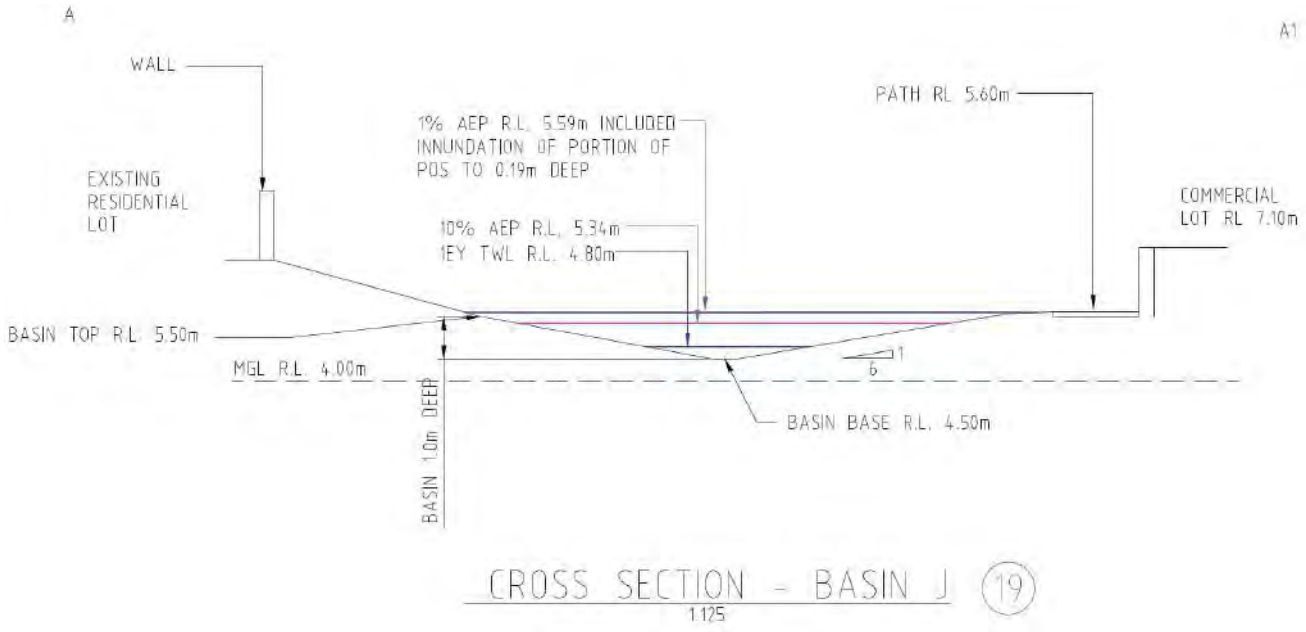
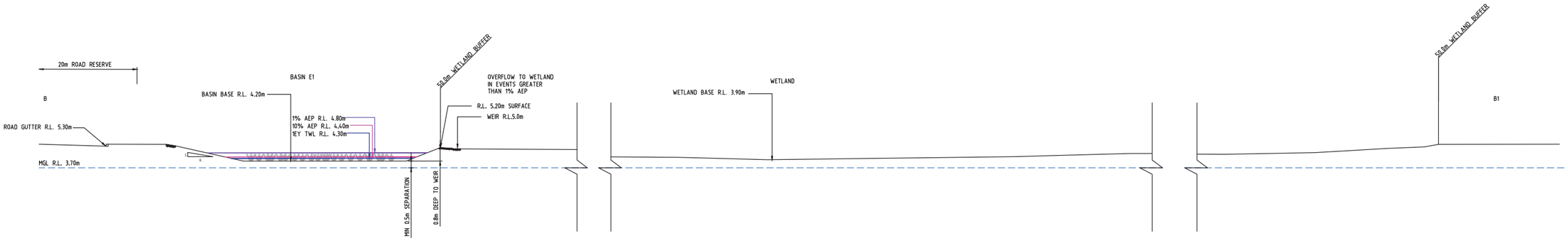


Figure 19 Basin J cross section



CROSS SECTION - BASIN E2 (20)
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Figure 20 Basin E2 and wetland cross section

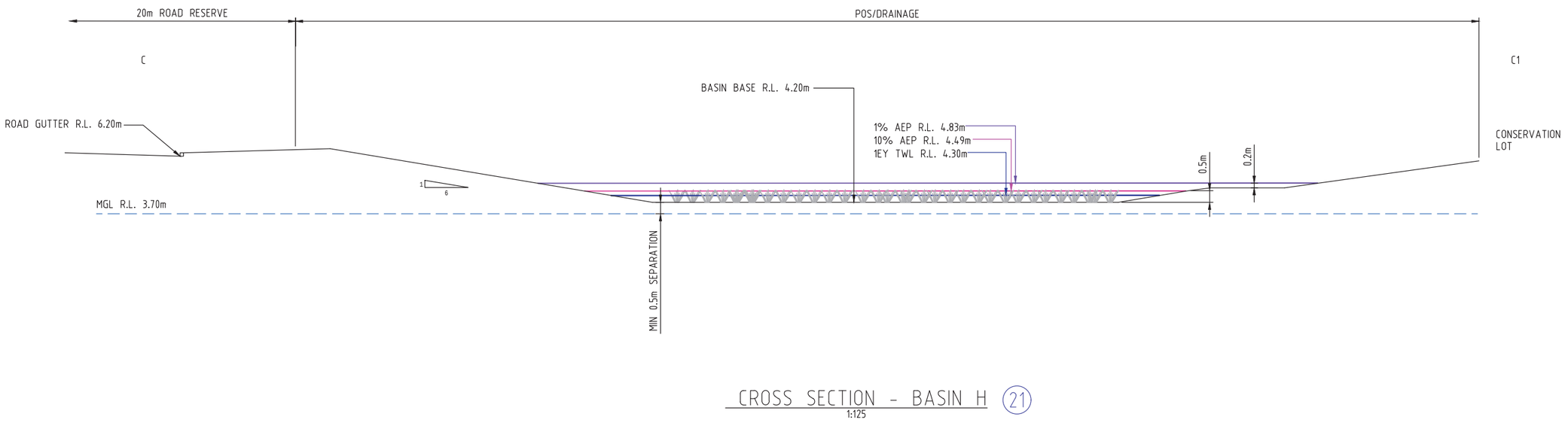


Figure 21 **Basin H cross section**

Table 10: Basin Sizing

Catchment	Catchment Area (m^2)	Basin Base area (m^2)	Basin Base (RL)	AAMGL (RL)	Basin Top area (m^2)	Volume to gutter invert (m^3)	Volume (m^3)	10% AEP				1% AEP						Comments
								Depth (m)	Top water level (RL)	Emptying times (hr)*	Top water area (m^2)	Volume (m^3)	Depth (m)	Top water level (RL)	Top Water area (m^2)	Outflow (m^3/s)	Emptying time (hr)*	
C	2650	1	4.5	4	169	61	45	0.9	5.4	5	139	95.1	1.12	5.62	203	0	6	1m deep basin. Up to 0.2m of flooding in laneway reserve.
Cb	1203																	Cb feeds into C basin
E1	6560	603	4.2	3.7	742	387	71	0.21	4.4	1	409	170.4	0.6	4.8	300	0	2	0.78m deep basin
E2	4920	8	4.2	3.7	224	91	28	0.93	5.13	5	200	108.4	1.07	5.27	250	0.081	6	1m deep basin to weir. Flows in 1% AEP to adjoining wetland.
E3	4920	570	4.3	3.8	690	340	77.4	0.06	4.36	0.5	580	81.9	0.13	4.43	677	0	1	1m deep basin to weir. Basin size may be reduced as part of detailed design or connected to other basins via balance pipe.
H	7460	250	4.2	3.7	496	183	92	0.29	4.49	1.5	384	200.8	0.53	4.83	520		3	0.5m deep basin. With extra 0.2m of detention in surrounding POS
J	2178	2	4.5	4	166	74	37.2	0.84	5.34	4	121	83.5	1.09	5.59	205	0	5	1m deep basin. Up to 0.2m of flooding in laneway reserve.
Jb	1203																	Jb feeds into J basin

*Notes: * Emptying time is conservatively from conclusion of peak storm event.*

5.2 Major event drainage system - 1% AEP event

The 1% AEP event will generally be retained within the bioretention gardens, swales, infiltration systems and basins with potentially some minor flooding of adjoining roads to less than 0.2m.

Finished floor levels on lots will be designed to maintain a 0.3 m clearance from the relevant 1% AEP event flood level, to prevent flooding. Final levels of all roads and therefore flood levels lots and finished floor levels are to be determined at detailed design and set out in the UWMP. This meets the design guideline for flood management by managing events up to the 1% AEP event within the development area to match pre-development flows. Detained stormwater will fully infiltrate within 96 hours of the rainfall event, in line with the design criteria for disease vector and nuisance insect management. The indicative flooding extent within the road reserves for the 1% AEP event is shown in **Table 7** (e.g. difference between the infrastructure depth and 1% AEP depth). Underground infiltration systems (**Table 9**) are designed to hold the entire 1% AEP, however, this may be refined at detailed design stage. As all flows are infiltrated on site, there are no post development flows off the site in the 1% AEP.

The current drainage concepts has been designed so that there is no need for stormwater runoff to enter the Conservation Area in events up to the 1% AEP event, to minimise impacts on wetlands and Threatened Ecological Communities. The flow paths within the Conservation Lot are to be vegetated with the plants to include a high portion of groundcover and low multi stemmed plants such as dryland sedges to assist with protecting the ground surface from sporadic occurrences of flowing water. The species choice and mix of plants is to be in accordance with the approved Conservation Area Management Plan.

Due to using plants to manage the flow into the Conservation Lot, the maintenance will be primarily of a plant management nature. Maintenance is also to review any potential erosion, with rectification should it occur. Should there be a need to sheet the flow over any trails within the Conservation Lot, the relevant portion of the pathway is to be protected with a suitable surface such as crushed stabilised stones.

Potential locations for discharge can be seen in **Figure 13**. A cross section of an indicative flow path can be seen in **Figure 18**.

It is noted that generally the Conservation area is slightly higher than the preliminary design level of the adjoining road, limiting the opportunity for flows to it. Any possible discharge options will be undertaken in negotiation with the relevant authorities, primarily DBCA and the City. It is noted that DBCA and DWER have provided support for flows above the 10% AEP being directed to the Conservation Lot, should final levels allow for it. The final agreement will be detailed in both the UWMP and the Conservation Lot Management Plan.

5.3 Lot scale stormwater management

Lots will be required to manage all stormwater on the lot up to the 1% AEP event. This will be required through the design guidelines for the site. Stormwater management on the lots will be required to consider requirements for management of clean roof water, runoff from clean areas such as car parks and access roads, and management of dirty water from areas such as vehicle maintenance areas.

5.3.1 Roof Water

DevelopmentWA will support the use of rainwater tanks to collect a portion of roof water on the lots for connection to a non-seasonally dependent water use such as toilet flushing to maximise the use of rainwater (Section 4.1.1). This will reduce the volume of roof water requiring management on the site. It is anticipated that surplus roof water will be infiltrated on site through the use of suitably sized soak wells or other infiltration structures.

5.3.2 Car parks and access roads

Stormwater from car parks and access roads will also be infiltrated on site. A range of infiltration options is available in this scenario, depending on the area available for infiltration. Management methods suggested for car parks/access roads include:

- networks of interconnected soak wells situated at low points (in line with standard practice)
- swales with soak wells to provide additional volume (**Figure 19**)
- swales without soak wells.
- permeable paving where there is minimal risk of spills/contamination

Excess roof water may also be infiltrated through these structures.

Swales may be vegetated or grassed and would be particularly suitable for lots where setbacks are required to residential areas or for fire management purposes. Swales will be of a maximum 200 mm depth and will be battered at a maximum grade of 1 in 6 for safety purposes (**Figure 19**).

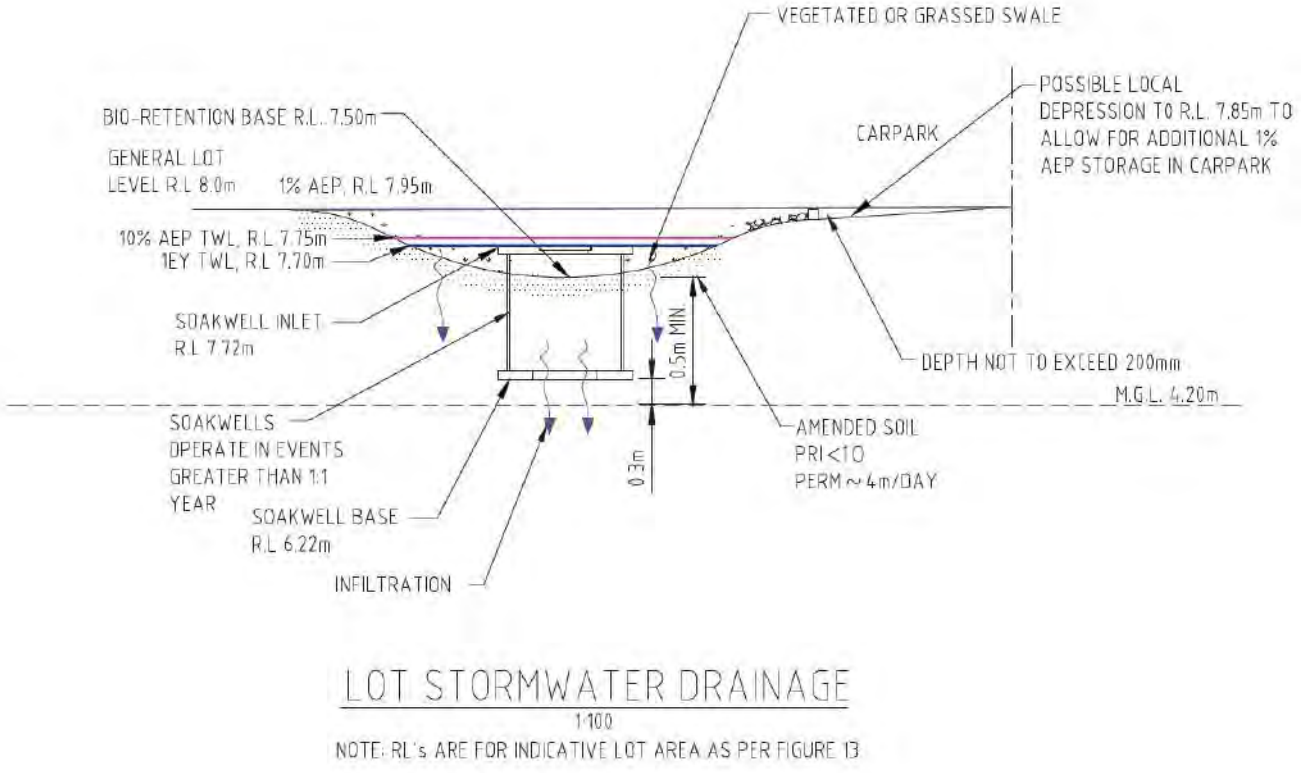


Figure 22 Combined swale and soak well system for lot drainage

5.3.3 Facilities requiring special attention

Some industrial practices produce high loads of litter, sediment, hydrocarbons and other contaminants that can impact water quality. Examples of land uses and operations that may produce high loads of these contaminants include:

- vehicle maintenance
- washdown of equipment and/or vehicles
- scrapyards

- chemical storage.

Additional structural and non-structural BMPs may be required for these facilities to manage water quality and minimise pollution of stormwater and groundwater. Depending on the facility, these BMPs may include:

- potentially polluting activities and chemical storage occurring under cover, in suitably bunded areas
- use of separators and/or gross pollutant traps to remove oil and sediment from stormwater prior to infiltration
- use of allocated washdown areas with bunding and dirty water sent to sewer
- staff training and procedures to manage potentially contaminating activities, such as equipment washdown and chemical handling
- development of a Waste Management Plans to ensure that solid and liquid wastes are minimised and stored correctly to reduce the risk of stormwater contamination
- provision and use of appropriate spill response kits.

Structural BMPs for industrial lots are usually managed through the Development Application process, when owners are required to submit plans for buildings and facilities to the City of Rockingham for approval. DevelopmentWA will provide advice to buyers regarding appropriate structural and non-structural stormwater management measures as part of the design guidelines for the site.

Any landscaping packages provided for the site will be designed to be waterwise and minimise fertiliser use (Section 4.1.1).

5.3.4 Guidelines for lot purchasers

Lot purchases are to be provided with guidance documents as to their requirements for on lot storm water management. These will reflect the strategies outlined above in Section 5.3. The exact specifications are to be included in the UWMP.

The design guidelines will include but not be limited to:

- separation of clean roof runoff from ground surface water treatment pathways where possible
- encouragement of landscaped vegetated systems that form part of the lot landscaping requirements
- management of fertiliser use
- formula for determining suitable storage volumes to facilitate infiltration of the entire 1% AEP
- typical diagrams of treatment and soakage structures that can be used
- options for suitable permeable paving
- best management practices for storage and use of polluting chemicals
- use of washdown facilities
- options for staff training in stormwater best management practices and use of potentially polluting substances
- management of sediment generated on site
- management of any spills as well as general waste and rubbish

Information related to the current relevant City guidelines for Lot stormwater will also be provided.

5.4 Water Quality Management

At the development scale, stormwater quality will be managed through use of vegetated bioretention gardens and swales for infiltration and amended soils. There are no plans for landscaping that requires fertilisers in the Conservation Area. These measures, and the use of appropriate swales and water pollution control BMPs at a lot level complies with the design principles of maintaining or improve groundwater and surface water quality and minimising the discharge of pollutants to shallow groundwater.

5.5 Matters to be Addressed at Subdivision Stage

Matters to be addressed at the subsequent subdivision (UWMP) stage are:

- further details regarding water conservation measures to be incorporated into the site's design guidelines and any incentive packages to be offered by DevelopmentWA
- further details regarding provision of information regarding reducing water and fertiliser use
- provision of a landscaping plan for the road reserves
- development of the detailed design of the stormwater management system, including sizing and location of structures at both the estate and lot scale
- development of appropriate guidance to assist buyers in managing water quality at a lot scale.

6. Groundwater Management Strategy

6.1 Groundwater Level Management

Groundwater levels on the site are not anticipated to change as a result of the development. Any increase in recharge on the site caused by the development is anticipated to be offset by the drying climate being experienced in South-Western Australia. Control of groundwater by subsoil drainage is not proposed on the site, and the MGL for the site will be used as the Design Groundwater Level (DGL) from which fill levels for lots shall be calculated.

Groundwater levels are not considered to be a constraint to development on the site. A minimum 1.5 m separation will be allowed between finished lot levels and the DGL to allow for infiltration of stormwater. Additional fill may be required in the eastern part of the site to allow for gravity flow of sewage to the connection to the Water Corporation sewer in Bakewell Drive. Fill will be acquired from cut from other areas of the site where possible. Where additional fill is required, clean fill with appropriate characteristics will be used. It is not anticipated that large volumes of fill will be required.

6.2 Groundwater Quality Management

Management of groundwater quality will occur through management of the water infiltrated in the development, and hence the quality of water reaching local wetlands. Although the Conservation Area is up-gradient of the site, pollutants entering groundwater on the site may move down-gradient towards Lake Walyungup.

The BMPs proposed as part of the stormwater design will assist in reducing the level of nutrients reaching the groundwater, namely:

- vegetated swales and bioretention gardens to strip nutrients
- amended soils (PRI> 10) under all swales and infiltrating drains.

The use of fertiliser within the development is expected to be minimal as there will be no fertilised POS and a large portion of the lots will be roofed or covered in hardstand.

Management of potential pollutants such as chemicals and hydrocarbons at a lot scale is also important in industrial developments. As outlined in Section 5.3.3, structural BMPs such as washdown areas and oily water separators may be required on some sites, as well as appropriate procedures and training processes for workers. DevelopmentWA will provide guidance to buyers regarding appropriate structural and non-structural stormwater management measures as part of the design guidelines for the site.

6.3 Post-groundwater monitoring

Groundwater monitoring is to be undertaken post development to determine if there are any significant changes due to the development. Indicative locations for post development monitoring bores are shown in **Figure 20**. They are generally located as close as possible to the pre-development monitoring locations and where possible will use the same bores. The preference will be to place post development monitoring bores within the road reserves or other reserve areas, rather than lots. The final post development monitoring bore locations are to distributed across the subject land. The post development monitoring program, including the parameters to be monitored, the trigger values and the locations, should be refined further in the detailed design stage and outlined in the UWMP.

The monitoring is to be undertaken quarterly for 2 years from the Practical Completion of each stage, by the developer. The monitoring will include levels, so monitoring runs should be timed to collect likely minimum and maximum levels e.g. April and September. Quality parameters are to include the same suite as the pre-development monitoring as well as specific analytes that may arise from the actual land uses/industries that begin operating on the site.

The results are to be compiled into an Annual Report and provided to the City and DWER for review. Furthermore, interim reports are to be provided to the City and DWER within 15 working days of any significant issues being identified. This may include but not be limited to levels rising by more than 0.2m above the maximum recorded or quality vary more than 10% above the pre-development records.

Further information on monitoring can also be found in **Table 11** and **Table 12.**

The full monitoring program is to be detailed in the UWMP.

6.4 Matters to be Addressed at Subdivision Stage

Matters to be addressed at the subsequent subdivision (UWMP) stage are:

- determination of final post development bore locations, taking into account ongoing access, relationship to stormwater management structures and ecologically sensitive locations
- determination of the water quality parameters to be monitored and schedule of monitoring, using Table 11 and 12 as a guide.

7. Water Dependent Ecosystem Management

Stormwater management and groundwater management as outlined above in Section 5 And 6, will assist with protecting the critical wetland systems within the subject land and the downgradient system of Lake Walyungup.

Furthermore, the critical wetlands are to be retained in 2 reserve areas. These can be seen in Figure 4. The Conservation reserve is to be appropriately fenced to restrict vehicle access. This will include fencing between the adjoining drainage reserve and the conservation area. Pedestrian access will be controlled through appropriate access points and pathways, with these to be determined as part of the detailed design at subdivision.

Weed control and potential revegetation works within and surrounding the wetland systems will also be outlined as part of the detailed design and reported in the Conservation Area Management Plan or other appropriate document. There is no direct surface drainage being sent to the wetlands within the conservation area.

The wetland retained within the central POS will be protected via a 50m vegetated buffer. Weed control and revegetation works will be determined at detailed design and included in the landscaping and restoration plans for this POS area. All drainage basins are located outside of the 50m buffer. They will be vegetated with locally native vegetation suited to stormwater basins and as such will act as ephemeral wetlands (e.g. drain quickly after rainfall). This will provide new habitat for fauna that already utilise the natural ephemeral wetland systems within the subject land. The drainage reserve adjoining the conservation area will also be vegetated in a similar manner, providing a vegetated link between the two areas.

The other vegetated stormwater treatment systems located throughout the development will also provide similar ephemeral wetland habitat.

The planting of all stormwater infrastructure is to consider bushfire management and setbacks as part of the detailed design.

Full details of the vegetated stormwater systems will be outlined in the UWMP's. The developer will be responsible to relevant management actions in the Conservation Reserve until handover to the Department of Biodiversity, Conservation and Attractions (DBCA). After this point, DBCA will manage any relevant stormwater flows into the reserve area. The exact requirements will be outlined in the proposed Conservation Area Management Plan and summarized in the UWMP.

8. The Next Stage - subdivision and urban water management plan

As outlined in Section 1, the westernmost 18 ha will be ceded as a Conservation Reserve. The remainder of the subdivision will then be subdivided into individual lots to be utilised for light industrial development. The LWMS has been prepared to support the proposed subdivision. Detailed design information regarding road layout will not be available until the subdivision, as lot sizing will depend on the demand for different types of industrial lots at the time.

Matters to be addressed at the subdivision stage include:

- preparation of a Conservation Area Management Plan (CAMP) to outline the rehabilitation and management of the Conservation Area
- ASS investigations shall be undertaken prior to any dewatering works being undertaken near the western boundary of the site
- investigation of dumped material prior to subdivision to determine if any formal investigation (e.g. a PSI) is required on the site
- removal dumped waste as part of management on the site prior to the final subdivision of the site into lots
- further details regarding water conservation measures to be incorporated into the site's design guidelines and any incentive packages to be offered by DevelopmentWA
- further details regarding provision of information regarding reducing water use
- provision of a landscaping plan for the road reserves
- development of the detailed design of the stormwater management system, including the type, sizing and location of structures at the estate scale. Includes detailing of all outlet structures, subsoil systems (if any) and other related stormwater infrastructure
- finalisation of earthworks plans including final fill levels, changes from natural levels and appropriate separation to groundwater
- development of appropriate guidance to assist buyers in managing water quality at a lot scale
- review groundwater levels over winter and spring and check against previous levels and determine specific levels under key infiltration locations.

9. Monitoring

9.1 Post- development monitoring

Post-development monitoring will be undertaken in line with the *Water Monitoring Guidelines for Better Urban Water Management Strategies and Plans* (DoW 2012). Post-development monitoring will occur from the completion of first subdivision stages until two years following the completion of construction.

- Any change in the water quality parameters during this period will be investigated. The monitoring is to: Review against baseline results from the pre-development period
- methods to determine whether the development's design criteria are being met
- contingency plans and management responses should variation occur between pre and post-development monitoring results
- how systems are generally performing

An initial monitoring program is outlined in **Table 11**. Groundwater monitoring Trigger values related to action being required are outlined in **Table 12**. These are related to the current predevelopment groundwater monitoring values.

A detailed Post-development Monitoring Plan will be included as part of the first UWMP:

Monitoring reports will be provided to the City of Rockingham and DWER on an annual basis.

Table 11: Monitoring Requirements

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsible Authority
FURTHER PRE - DEVELOPMENT						
Water monitoring	Groundwater levels	To check groundwater levels to determine if levels have varied from earlier monitoring.	Levels vary by more than 0.2m on average from currently determined AAMGL.	Update levels in UWMP and use new levels as part of detailed design.	Monthly for 1 further winter/spring, prior to detailed design.	Developer
CONSTRUCTION PHASE & POST-DEVELOPMENT						
Water monitoring	Groundwater levels	To check groundwater levels to determine if levels have varied from earlier monitoring.	Levels vary by more than 0.2m on average from currently determined AAMGL.	Update levels in future UWMP and use new levels as part of future detailed design for later stages.	Monthly winter/spring.	Developer
	Groundwater quality	To review groundwater quality to determine if quality has changed significantly post development.	The quality of any parameter varies negatively by more than 10% more than the worst pre-development reading or a 10% increase from upgradient to down gradient values. (See **Table 12**)	Determine reason for deterioration and rectify.	Quarterly	Developer
Drainage Management Systems (includes traditional	Structural Design	Systems are constructed to engineer detailed design specifications.	System constructed differs to design specifications.	Remedial work to rectify system to meet design specifications.	Ongoing during construction and for 12 months defect period.	Developer

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsible Authority
and WSUD systems)	Structural Effectiveness (inlets, traps, and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to Local Government
Drainage Management Systems (includes traditional and WSUD systems) **(Continued)**	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Event based (mobilisation of sediments) and a minimum of every 3 months.	Developer until handover to Local Government
	Sediment Build Up	Inspection for sediment accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to Shire standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed.	Event based (mobilisation of sediments) and a minimum of every 3 months.	Developer until handover to Local Government
	Compaction	Inspection of filter media for compaction.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to Local Government

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsible Authority
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Every 3 months	Developer until handover to Local Government
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Every 3 months	Developer until handover to Local Government
Drainage Management Systems (includes traditional and WSUD systems) **(Continued)**	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, (e.g. alter landscaping maintenance practices, community education). Remove litter.	Every 3 months	Developer until handover to Local Government
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Every 3 months	Developer until handover to Local Government
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks and is thick.	Notify Pollution Watch of the spill and clean up requirements.	Every 3 months	Developer until handover to Local Government
	Filter Media	Check that media is draining as designed.	Infiltration rate is outside of the design specifications.	Replacement of top layer or all of the filter media	Every 3 months	Developer until handover to

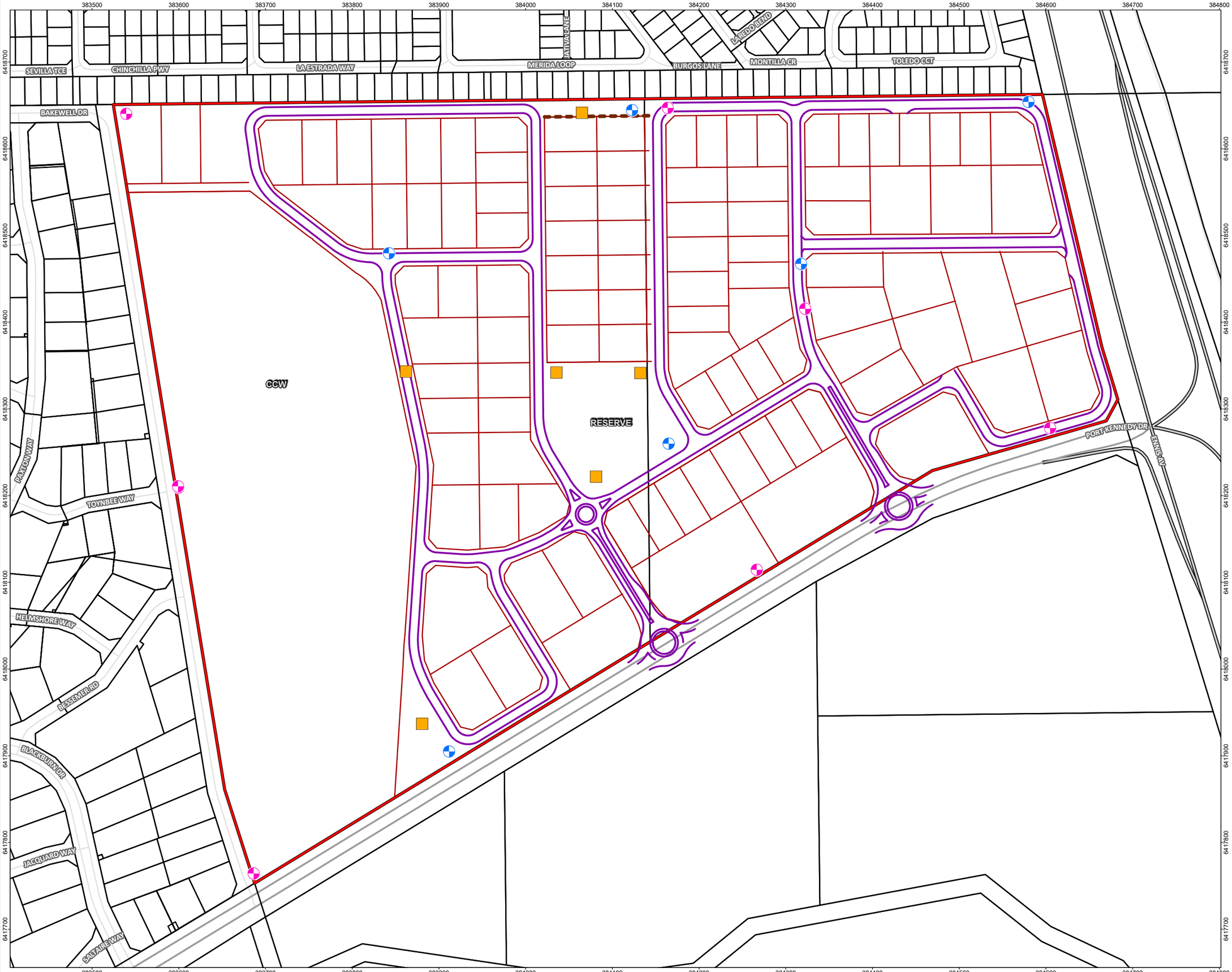
Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsible Authority
				(depending on issue).		Local Government
	Infiltration system	Check that geofabric is in working order.	Geofabric is deteriorating to the point that sand or roots have the ability to move through it.	Replace geofabric.	Every 3 months	Developer until handover to Local Government

Table 12: Trigger Values for Post Development Groundwater Monitoring

Parameter	Location	Predevelopment Critical Value	Trigger Value
pH - Alkalinity	PK1	8.32	8.82
	PK2	7.50	8.00
	PK3	7.89	8.39
	PK4	7.53	8.03
	PK5	7.58	8.08
	PK6	7.33	7.83
	PK7	7.97	8.47
	PK8	7.68	8.18
pH- Acidity	PK1	7.14	6.64
	PK2	7.15	6.65
	PK3	7.17	6.67
	PK4	6.61	6.11
	PK5	7.14	6.64
	PK6	6.92	6.42
	PK7	7.19	6.69
	PK8	7.12	6.62
EC (mS/cm)	PK1	2.30	2.53
	PK2		
	PK3	1.50	1.65
	PK4		
	PK5	1.50	1.65
	PK6		
	PK7	1.70	1.87
	PK8	1.80	1.98
NH_4_N (mg/L)	PK1	2.30	2.53
	PK2	-	-
	PK3	1.50	1.65
	PK4	-	-
	PK5	1.50	1.65
	PK6	-	-
	PK7	1.70	1.87
	PK8	1.80	1.98
Total N (mg/L)	PK1	22.00	24.20
	PK2	-	-
	PK3	5.50	6.05
	PK4	-	-
	PK5	7.50	8.25
	PK6	-	-
	PK7	6.50	7.15

Parameter	Location	Predevelopment Critical Value	Trigger Value
	PK8	9.90	10.89
TKN (mg/L)	PK1	6.00	6.60
	PK2	-	-
	PK3	3.50	3.85
	PK4	-	-
	PK5	5.50	6.05
	PK6	-	-
	PK7	4.70	5.17
	PK8	6.10	6.71
Total P (mg/L)	PK1	0.33	0.36
	PK2	-	-
	PK3	0.33	0.36
	PK4	-	-
	PK5	0.33	0.36
	PK6	-	-
	PK7	0.33	0.36
	PK8	0.33	0.36
PO_4_P (mg/L)	PK1	0.009	0.01
	PK2	-	-
	PK3	0.02	0.02
	PK4	-	-
	PK5	0.03	0.03
	PK6	-	-
	PK7	0.02	0.02
	PK8	0.02	0.02

1. pH trigger is a change of 0.5
2. For all other parameters, trigger value is 10% above highest predevelopment value.
3. If bore location changes post development, then trigger values may need to be reassessed, taking into account the highest values of nearby bores and gradients within the direction of groundwater flow.



Legend

- Project area
- Lot layout boundary
- Cadastral boundary
- Retain existing bore. If developed over shift to nearest road reserve
- Post development bores
- Stormwater basin monitoring points
- Lot layout
- Proposed kerb
- Footpath
- Highway
- Major road
- Minor road

* Post development bores and Stormwater basin monitoring points are an indicative location.

JBS&G

Job No: 65475

Client: Development WA

Version: A	Date: 14-Aug-2024
Drawn By: ianandagoda	Checked By: MG

Scale 1:4,000 at A3

0 50 100
metres

Coord. Sys. GDA2020 MGA Zone 50

Port Kennedy Enterprise Park
Lot 4, Lot 17, Port Kennedy Drive
Port Kennedy, WA

GROUNDWATER MONITORING LOCATIONS

FIGURE 23

File Name: C:\Users\ianandagoda\JBS&G Australia\JBS&G - DCS - Internal - Documents\Projects\DevelopmentWA\65475 Port Kenndey LWMS P2\GIS\02_MapProjects\65475_PortKennedyLWMS_P2_R01\65475_PortKennedyLWMS_P2_R01.aprx
Image Reference: www.nearmap.com© - Imagery 30 August 2023.

10. Implementation

Developer commitments and the roles of the developer, the City of Rockingham and DBCA are discussed in **Table 13**. No outside funding is being sought for this development.

Table 13: Roles and responsibilities

Role	Responsibility	Requirement and Period
Post-development monitoring	Developer	Post-development monitoring for two years following completion of construction
Preparation of UWMP	Developer	At subdivision stage
Preparation of full detailed stormwater plans in consultation with relevant authorities	Developer	At subdivision stage
Maintenance of POS and structural drainage controls	Developer	Two years following construction
	CoR	After handover from developer
Non-structural controls: public awareness of Water Sensitive Urban Design	Developer	Provide sustainability information packs, including information regarding non-structural control issues such as fertiliser application, native gardens and waste management at settlement
Development of design guidelines	Developer with advice from CoR	Develop design guidelines and incentive packages that address water efficiency, on lot drainage and water quality management issues
Enforcement of design guidelines	CoR	Enforce design guidelines developed above through building applications process
Water efficiency	Developer	Construction of waterwise POS, including retention of native vegetation and low water use landscaping
Conservation Reserve – initial works	Developer	Installation of suitable structures to manage stormwater flow into reserve and wetland restoration. Management for 2 years.
Conservation Reserve – ongoing management	DBCA (or as agreed with DBCA as part of detailed design)	Ongoing management of stormwater flows and wetlands as outlined in the Conservation Lot Management Plan.

10.1 Review

The UWMP process may be used to review the assumptions of this LWMS. It will also refine the drainage design to match the final layout, the requirements of relevant authorities and current best practice. This will be undertaken through consultation, which has begun, with preliminary meetings undertaken with the City of Rockingham on acceptable design. Any changes to the current design concepts will be discussed with DWER and the City of Rockingham as part of preparation of the UWMP. The UWMP will reflect the design changes.

11. Conclusions

The site contains a number of ephemeral wetlands and a Threatened Ecological Community. As such, water management is important to maintain hydrological regimes and ensure that water quality is managed on the site.

Design guidelines and incentives will be used to assist in minimising potable water use and fertiliser use at a lot level. Irrigated POS is not planned for this development.

The site will be developed in a water sensitive manner, using a modular drainage approach that manages events up to the 1% AEP event generally within the road reserve through a series of rain gardens and swales. This approach minimises the need for POS for drainage purposes and infiltrates water as high in the site as possible, in line with the principles of water sensitive urban design.

Stormwater will be retained on lots in events up to the 1% AEP event. Design guidelines will support the use of rainwater tanks to collect a portion of roof water on the lots. These rainwater tanks will be connected to a non-seasonally dependent water use such as toilet flushing to maximise the use of rainwater. Overflow from the roof water systems and water from cleaner areas such as car parks and access roads will be infiltrated through on-lot swales or soak wells or a mixture of both.

- Groundwater levels are not considered to be a constraint to development on the site. A minimum 1.5 m separation will be allowed between finished lot levels and the DGL to allow for infiltration of stormwater. Additional fill may be required in the eastern part of the site to allow for gravity flow of sewage to the connection to the Water Corporation sewer in Bakewell Drive. Management of potential pollutants such as chemicals and hydrocarbons at a lot scale is also important in industrial developments.
- Structural BMPs such as washdown areas and oily water separators may be required on some lots, as well as appropriate procedures and training processes for workers. DevelopmentWA will provide guidance to buyers regarding appropriate structural and non-structural stormwater management measures as part of the design guidelines for the site.

It is considered that through these measures, water can be managed on this site to meet the requirements of the DWER and the City of Rockingham.

A summary of the design elements is outlined in **Table 14**.

Table 14: Design elements and requirements for best management practices and critical control points

Category	Principles	Objectives	Development design elements and requirements
Water use	Consider all potential water sources in water supply planning. Integration of water and land use planning. Sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	Minimise the use of potable water where drinking water quality is not essential.	Water conservation measures will be incorporated into site design guidelines to require: • water efficient tap fixtures and showers to be installed • the use of low water use irrigation systems within the lot, with a programmable controller/timer system • support of rainwater tanks connected to a suitable seasonally independent water use, such as toilet flushing. Consideration will be given to the following items at the subdivision stage:

			• provision of waterwise and low fertiliser use landscaping packages • rebates or provision of infrastructure for rainwater tanks such as tanks and pumps • complimentary access to a nominated water conservation consultancy to assist with design and commissioning of rainwater and/or greywater recycling systems. Irrigated Public Open Space is not proposed due to the nature of the development.
Groundwater levels and surface water flows	To retain natural drainage systems and protect ecosystem health. To protect from flooding and water logging. To implement economically viable stormwater systems. Post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	For ecological protection, 63% AEP event volume and peak flow rates maintained at or below pre-development conditions. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles. For flood management, manage up to the 1% AEP event within the development area to pre-development flows.	There will be no flow off the site in events up to the 1% AEP event, as is currently the case. Stormwater will not enter wetlands in events up to the 1% AEP event. A modular drainage approach will be used that manages events up to the 1% AEP event within the road reserve through a series of bioretention gardens and swales.
Groundwater and surface water quality	To maintain or improve groundwater and surface water quality. Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater. Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge of pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	Implement current known best management practice as detailed in the DoW Stormwater Management Manual for Western Australia (DoW 2004 – 2007) and the Decision Process for Stormwater Management in Western Australia (DWER 2017), with an emphasis on a treatment train approach including nutrient input source control, use of bioretention systems, and maintaining 1% AEP event post development discharge volumes and peak flow rates at pre-development levels.	Best Management Practices (BMPs) have been implemented through the development to minimise pollution, including rain gardens and vegetated swales within the road reserve. Structural BMPs such as washdown areas and oily water separators may be required on some sites, as well as appropriate procedures and training processes for workers. DevelopmentWA will provide guidance to buyers regarding appropriate structural and non-structural stormwater management measures as part of the design guidelines for the site. Direction provided to the City on how to maintain road and POS systems and enforce lot management systems to water quality is maintained.
Disease vector and nuisance insect management	To reduce the health risk from mosquitoes, retention and detention treatments should be designed to	Permanent water bodies are discouraged, but where accepted by DoW, must be designed to maximise	Detained stormwater will be fully infiltrated within 96 hours. Permanent waterbodies are not proposed.

	ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	predation of mosquito larvae by native fauna to the satisfaction of the local government on advice of Departments of Water and Health.	

12. Limitations

Scope of services

This report ("the report") has been prepared by JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. JBS&G has also not attempted to determine whether any material matter has been omitted from the data. JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to JBS&G. The making of any assumption does not imply that JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Appendix A BUWM LWMS Checklist

Checklist for integrated water cycle management assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide a brief description of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals.

LWMS item	Deliverable	Included?	Location in text
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMPs and critical control points	✓	Executive Summary
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		✓	Sections1
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	✓ ✓	Section 2, Figures 2 and 3
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	✓	Section 2.2, Figure 4
Design criteria			
Agreed design objectives and source of objective		✓	Section 2
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		✓	Section 3
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	✓	Section 3, Figure 5
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	✓	Section 3.3 Figure 6
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	✓	Section 3.6 and 4.7, Figures 7 - 11
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	✓	Section 3.5
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	✓	Section 4.4, Figure 7,8
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		✓	Section 4.1

LWMS item	Deliverable	Included?	Location in text
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		✓	Section 4
Wastewater management		✓	Section 4.2
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	✓ n/a	Section 5.2
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	10yr event Plan	n/a	Section 5.1,
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	n/a n/a	Section 5.1,
Groundwater management strategy			
Post development groundwater levels, fill requirements(including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	✓	Section 7, Figure 18,
Actions to address acid sulfate soils or contamination		✓	Sections 3.3 and 3.8
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		✓	Section 7
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		✓	Section 8
Implementation			
Developer commitments		✓	Section 9
Roles, responsibilities, funding for implementation		✓	Section 9
Review		✓	Section 9

Appendix B Preliminary geotechnical investigation (Douglas Partners 2011)

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Preliminary Geotechnical Investigation

Proposed Industrial and Commercial Development
Port Kennedy Business Park
Port Kennedy, WA

Prepared for
Porter Consulting Engineers

Project 76219
July 2011

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

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Document status and review

Revision	Prepared by	Reviewed by	Date issued
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Distribution of copies

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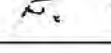
The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		15/7/2011
Reviewer		15/7/2011

NCS INTERNATIONAL CERTIFIED QUALITY MANAGEMENT SYSTEM

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Report on Preliminary Geotechnical Investigation
Proposed Industrial and Commercial Development
Port Kennedy Business Park, Port Kennedy

1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken for a proposed industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA. The investigation was commissioned in an email, dated 27 May 2010, by David Porter of Porter Consulting Engineers, and was undertaken in accordance with Douglas Partners' proposal dated 19 April 2011.

The aim of the investigation was to assess the sub-surface soil and groundwater conditions across the site and thus:

- Provide a description of the soil, rock and groundwater conditions beneath the site.
- Determine the suitability of the site for the proposed development.
- Provide an appropriate classification of the site in accordance with the requirements of AS 2870-2011, and the earthworks requirements to achieve a 'Class A' classification.
- Provide recommendations on site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development.
- Suggest appropriate foundation system(s), including the assessment of allowable bearing pressures and likely settlements.
- Provide suitable parameters, including California Bearing Ratio (CBR) for the design of new pavements, based on field observations and limited laboratory testing.
- Provide permeability values for the soils encountered at the site based on observations made in the field and laboratory testing.

The investigation included the excavation of 26 test pits and laboratory testing on selected samples.

2. Site Description

The site comprises an area of approximately 67 ha, and is identified as Lots 4 and 17 Port Kennedy Drive in Port Kennedy, WA. It is bounded by Port Kennedy Drive to the south, Ennis Avenue to the east, Bakewell Drive to the west and a residential subdivision to the north.

At the time of the investigation, the site was generally covered with dense shrubs, medium length grasses and several small to medium sized trees and bushes. Several sand tracks transect the site. The ground surface, where exposed across the site, was sandy. A few stockpiles of filling approximately up to 1.0 m high, possibly associated with the construction of adjacent existing roads, were noted along the Bakewell Drive and Ennis Avenue.

The site topography was undulating owing to the presence of numerous sand dunes up to approximately 4.0 m high across the site. The surface levels generally vary from RL 5 in the level areas across the site to RL 10 in the eastern end of the site. At the western part of the site, the surface level reduces up to RL 3.7.

The Rockingham 1:50 000 Geology sheet indicates that shallow sub surface conditions beneath the site consist of calcareous sand of the Safety Bay Sand unit.

3. Field Work Methods

Field work was carried out on 1 June 2011 and 12 July 2011, and comprised the excavation of 26 test pits, drilling of four boreholes and Perth sand penetrometer (PSP) testing adjacent to each test locations.

It should be noted that dense vegetation and a requirement to undertake testing from existing tracks to minimise the impact of the investigation on vegetation, precluded access to some parts of the site. Boreholes (BH27 to BH30) were drilled to a depth of 2.0 m using a 110 mm diameter hand auger in these areas.

The test pits (TP1 to TP26) were excavated to a maximum depth of 2.6 m, using a 5 tonne Komatsu excavator equipped with a 600 mm wide toothed bucket.

Test pits and boreholes were logged in general accordance with test procedure AS 1726–1993 by a suitably experienced geotechnical engineer from Douglas Partners. Representative soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out in accordance with AS 1289.6.3.3 to assess the density of the shallow soils.

Test locations were determined using a GPS and are shown on Drawing 1. Surface elevations at each test location were interpolated from a survey provided by Porter Consulting Engineers and are quoted in metres above Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix A, together with notes defining descriptive terms and classification methods.

Ground conditions encountered generally comprised topsoil overlying sand. The intersected subsurface profile can be summarised as:

- **Filling** - loose, light yellow, uncontrolled sand filling was encountered at BH28 to a depth of 0.2 m;

- **Topsoil** - brown silty sandy topsoil generally to depths of between 0.05 m and 0.15 m observed at all test locations;
- **Sand** – generally medium dense, brown and light yellow-brown, sand was encountered at all test locations underlying topsoil to the terminated depth (2.6 m) of investigation. Extremely low strength lithified sand layers were encountered at TP6, TP8, TP9, TP19, TP22 and TP26.
- **Organic sand** – loose, dark grey, organic sand with some low plasticity fines was encountered at BH27 from a depth of 1.1 m to 1.5 m.

4.2 Groundwater

Free groundwater was observed at TP2 at a depth of 2.5 m (RL 3.0 AHD) below existing surface level on 1 June 2011. The test pits were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels.

The Perth Groundwater Atlas (2004) indicates that the groundwater level was approximately 1.7 m (RL 2 AHD) below the lowest part of the site, in May 2003.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of the particle size distribution on six samples.

Detailed test report sheets are given in Appendix B and the results are summarised in Table 1.

Table 1: Results of Laboratory Testing

Pit	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	Material
TP3	0.3	2	0.17	0.27	Sand – light brown with trace silt
TP6	0.8	2	0.16	0.27	Sand – light grey with trace silt
TP9	0.5	1	0.16	0.26	Sand – light yellow-brown with trace silt
TP13	0.5	1	0.16	0.27	Sand – light yellow-brown with trace silt
TP15	1.4	1	0.17	0.30	Sand – light yellow-brown with trace silt
TP23	0.6	1	0.17	0.29	Sand – light yellow-brown with trace silt

Where:

-The % fines is the amount of particles smaller than 75 µm.

-A d_{10} of 0.21 mm means that 10% of the sample particles are finer than 0.21 mm.

-A d_{60} of 0.50 mm means that 60% of the sample particles are finer than 0.50 mm.

6. Proposed Development

It is understood that the proposed development comprises the subdivision of the site into industrial allotments and associated access roads. The concept plan provided by the client indicates that a proposed public open space (POS) occupies the western part of the site (shown on Drawing 1 in Appendix A).

7. Comments

7.1 Site Classification

The shallow ground conditions beneath the site comprise generally medium dense sand. Based on the results of the investigation, a site classification 'Class A' in accordance with AS 2870-2011 should be suitable for this site provided site preparation is carried out as detailed in Section 7.2.

As detailed in Section 4.2, organic sand was encountered at BH27, which was located within the proposed public open space area. Organic soils are considered unsuitable for the support of structures. If similar soil is encountered within the proposed allotment areas during detailed investigation, then the above mention site classification would be affected.

7.2 Site Works, Preparation and Compaction

Prior to excavation for foundations and/or placement of fill, all deleterious material, including vegetation and topsoil, should be stripped from the proposed allotments and road reserve areas, and either removed from site or stockpiled for possible re-use for landscaping purposes only.

As detailed in the above section, organic sand is unsuitable for the support of structures. If such soil is encountered within the proposed allotments during detailed investigation, then it should be excavated and removed from the site or stockpiled for re-use as landscaping only.

Following removal of unsuitable material and prior to any filling, it is recommended that the exposed subgrade beneath the building envelopes and pavement areas be proof rolled using a medium to heavy (minimum of 12 tonne) vibrating smooth drum roller. Any areas that show signs of excessive deformation during compaction should be continually compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural filling compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Care should be taken not to operate heavy plant and vibrating roller immediately adjacent to existing buildings and services.

Naturally occurring sand excavated from the site should be suitable for re-use as structural fill, provided it is free from organic material and particles greater than 150 mm in size. Imported filling, if required, should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that naturally occurring sand at this site and imported sand filling be placed in loose lift thickness of not more than 300 mm, within 2% of its optimum moisture content

with each layer compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Compaction control of the sand at the site could be carried out using a PSP in accordance with test method AS 1289.6.3.3.

All proposed building envelopes and pavement areas should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 1.0 m and 0.75 m below foundation level of the proposed buildings and proposed pavement subgrade respectively. Compaction control of the sand at the site could be carried out using a Perth sand penetrometer (PSP), as suggested above.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.3 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for 'Class A' conditions, provided that site preparation is carried out as detailed in Section 7.2.

AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. For buildings not covered by AS 2870-2011, a presumptive allowable bearing pressure of 200 kPa is suggested for foundation design of strip and pad footings founded at a minimum depth of 0.5 m in at least medium dense sand. This should ensure that total and differential settlements will be less than 5 mm.

7.4 Pavement Design Parameters

Based on field observations it is recommended that a subgrade CBR of 12% be used for the design of flexible pavements on sand subgrade encountered at this site, provided that such subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction, as determined by AS 1289.5.2.1.

7.5 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand, therefore it is considered that stormwater disposal using soakwells and sumps should be feasible at this site.

A permeability value was derived using grading results of soil samples and the Hazen's formula, which applies for sand in a loose state. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of the Derived Permeability Values

Pit	Depth (m)	Derived Permeability (m/s)	Material
TP3	0.3	2.9×10^{-4}	Sand – light brown with trace silt
TP6	0.8	2.6×10^{-4}	Sand – light grey with trace silt
TP9	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP13	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP15	1.4	2.9×10^{-4}	Sand – light yellow-brown with trace silt
TP23	0.6	2.9×10^{-4}	Sand – light yellow-brown with trace silt

Results of the analyses indicate permeability values ranging between 2.6×10^{-4} m/s and 2.9×10^{-4} m/s for the sand encountered at this site. Given that the density of the sand at the site is likely to be increased during earthworks operations, a design permeability value of 1×10^{-4} m/s is suggested. It is emphasised that a lower permeability value than that indicated may be appropriate for a long-term design value which takes into account long term bio-build up and/or siltation of the infiltration surface.

8. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
3. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
4. Australian Standard AS 2870-2011, Residential Slabs and Footings
5. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.

9. Limitations

Douglas Partners (DP) has prepared this report for an industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA in accordance with DP's proposal dated 19 April 2011 and acceptance received from Mr David Porter of Porter Consulting Engineers on 27 May 2011. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Porter Consulting Engineers for this project only and for the purposes described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and

also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings
Results of Field Work

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

Douglas Partners

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

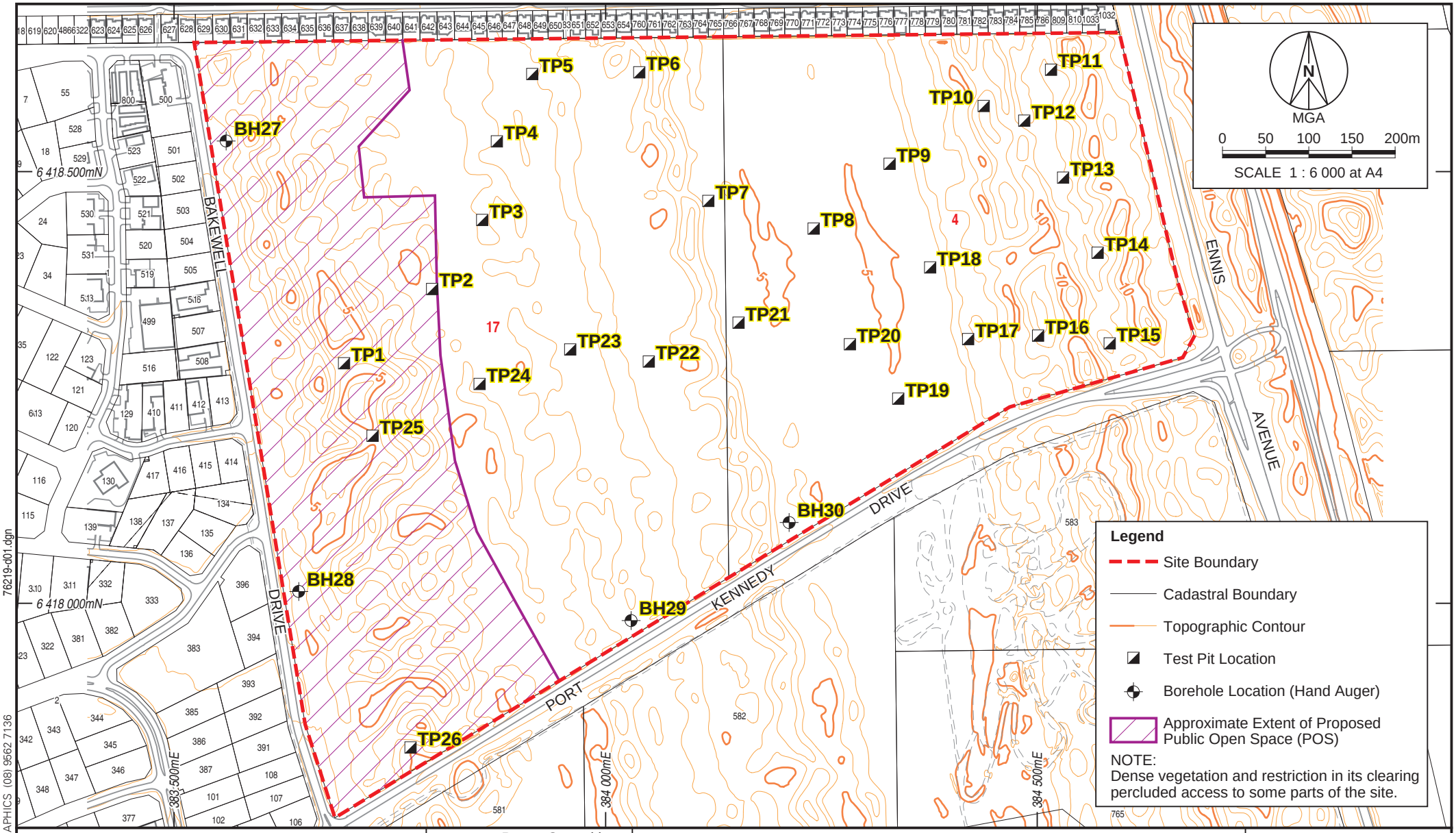
Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.



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PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Porter Consulting Engineers
OFFICE:	Perth
DATE:	13 Jul 2011

Location of Tests
Port Kennedy Business Park
Port Kennedy, WA

PROJECT No.:	76219
DRAWING No.:	1
REVISION:	A

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 383697
NORTHING: 6418278
DIP/AZIMUTH: 90°/--

PIT No: TP01
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
6		TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
	0.1	SAND - medium dense, light brown, fine to medium grained sand with some silt, moist.							
		- becoming medium dense from 0.45 m.		D	0.7				
5	1								1
4	2								2
	2.6	Pit discontinued at 2.6m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.5 AHD
EASTING: 383799
NORTHING: 6418364
DIP/AZIMUTH: 90°/--

PIT No: TP02
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.1	TOPSOIL - dark grey-brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - loose, brown, fine to coarse grained sand, with a trace of silt, moist.							
		- becoming light yellow-brown from 0.4 m.							
		- becoming medium dense from 0.45 m.							
	1			D	1.3				1
4									
	2								2
		- becoming wet from 2.3 m.						▼ 01-06-11	
3	2.6	Pit discontinued at 2.6m (Target depth)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: Free groundwater observed at 2.5 m

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 383857
NORTHING: 6418444
DIP/AZIMUTH: 90°/--

PIT No: TP03
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
6		TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
	0.15	SAND - medium dense, light brown, fine to medium grained grained sand, with a trace of silt, moist.		B	0.3				
		- with a trace of roots and rootlets to 0.9 m.							
5	1								1
4	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 383874
NORTHING: 6418535
DIP/AZIMUTH: 90°/--

PIT No: TP04
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
6		TOPSOIL - brown, silty sandy topsoil, with some rootlets and a trace of roots, moist.							
	0.1	SAND - medium dense, brown, fine to medium grained grained sand, with a trace of silt and roots, dry to moist.							
5	1	- becoming light yellow-brown with depth.		D	1.4				1
4	2 2.0	Pit discontinued at 2.0m (Collapse)							2

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.9 AHD
EASTING: 383915
NORTHING: 6418613
DIP/AZIMUTH: 90°/--

PIT No: TP05
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.05	TOPSOIL - brown, silty sandy topsoil, with a trace of rootlets, moist.							
		SAND - medium dense, brown, fine to medium grained grained sand, with a trace of silt, dry to moist.							
		- becoming light yellow-brown from 0.7 m.							
5	1			D	1.0				1
		- becoming moist from 1.9 m.							
4	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 384039
NORTHING: 6418615
DIP/AZIMUTH: 90°/--

PIT No: TP06
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
6		TOPSOIL - dark grey-brown, silty sandy topsoil, with some roots and rootlets, moist.							
	0.15	SAND - medium dense, brown, fine to medium grained grained sand, with some rootlets and extremely low strength lithified zones and a trace of silt, dry to moist.							
		- becoming light grey from 0.4 m. - loose between 0.45 m and 0.6 m.		D	0.8				
5	1	- becoming light yellow-brown from 1.1 m. - becoming moist from 1.2 m.							1
4	2	- becoming wet from 2.2 m.							2
	2.5	Pit discontinued at 2.5m (Target depth)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 384119
NORTHING: 6418466
DIP/AZIMUTH: 90°/--

PIT No: TP07
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
6		TOPSOIL - dark grey-brown, silty sandy topsoil with some rootlets, moist.							
	0.1	SAND - medium dense, light grey, fine to medium grained sand with a trace of silt and rootlets, dry to moist.							
5	1	- becoming light yellow-brown from 1.0 m.		D	1.5				
4	2	- becoming wet from 2.1 m.							
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.6 AHD
EASTING: 384241
NORTHING: 6418434
DIP/AZIMUTH: 90°/--

PIT No: TP08
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, light yellow-brown, fine to medium grained sand with some extremely low strength lithified zones and a trace of silt and rootlets, dry to moist.							
5		- becoming dense from 0.6 m.		D	0.7				
	1								1
4		- becoming moist from 1.9 m.							
	2								2
		- becoming wet from 2.3 m.							
	2.5	Pit discontinued at 2.5m (Target depth)							
3									

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.7 AHD
EASTING: 384329
NORTHING: 6418509
DIP/AZIMUTH: 90°/--

PIT No: TP09
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark brown, silty sandy topsoil, with some rootlets, moist							
	0.15	SAND - medium dense, light yellow-brown, fine to medium grained sand, with some extremely low strength lithified zones and a trace of silt and rootlets, dry to moist.		B	0.5				
5									
	1	- becoming moist from 1.2 m.							1
4		- becoming wet from 1.7 m.							
	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							
3									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7.2 AHD
EASTING: 384438
NORTHING: 6418576
DIP/AZIMUTH: 90°/--

PIT No: TP10
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
7	0.1	TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, light grey, fine to medium grained sand, with a trace of silt and rootlets, dry to moist.							
	1								1
6		- becoming light yellow-brown from 1.1 m.		D	1.4				
	2								2
5		- becoming wet from 2.2 m.							
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7 AHD
EASTING: 384516
NORTHING: 6418618
DIP/AZIMUTH: 90°/--

PIT No: TP11
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
7		TOPSOIL - grey-brown, silty sandy topsoil, with some rootlets, moist.							
	0.15	SAND - medium dense, brown, fine to medium grained sand, with a trace of silt, moist.							
		- becoming yellow-brown from 0.5 m.							
6	1			D	1.0				1
5	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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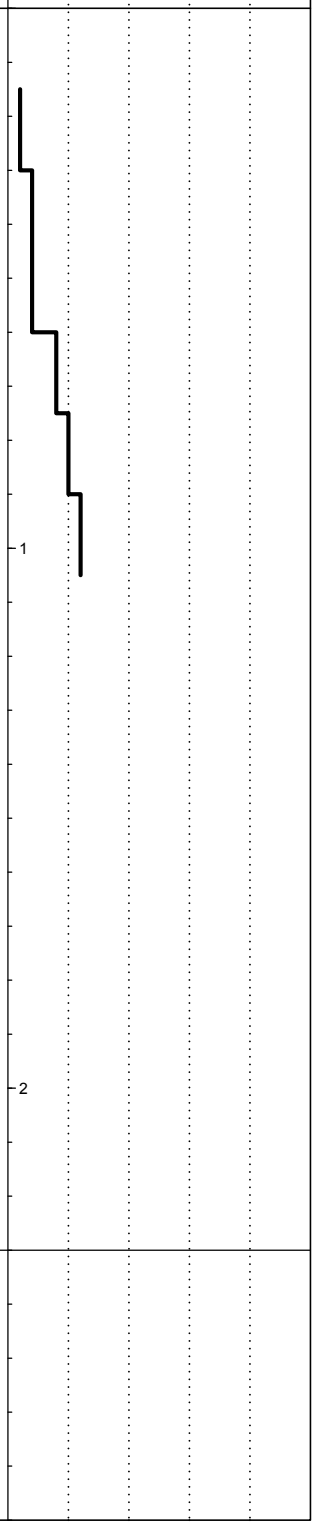
TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7.2 AHD
EASTING: 384485
NORTHING: 6418559
DIP/AZIMUTH: 90°/--

PIT No: TP12
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
7	0.1	TOPSOIL - brown, silty sandy topsoil, with a trace of rootlets, moist.							
		SAND - medium dense, brown, fine to medium grained sand, with a trace of silt, moist.							
		- becoming light yellow-brown from 0.7 m.		D	1.7				
6	2.3	Pit discontinued at 2.3m (Collapse)							



RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7.2 AHD
EASTING: 384530
NORTHING: 6418493
DIP/AZIMUTH: 90°/--

PIT No: TP13
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
7	0.15	TOPSOIL - dark brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, light brown, fine to medium grained sand, with a trace of silt and rootlets, moist.							
		- becoming light yellow-brown from 0.4 m.		D	0.5				
6	1								1
5	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6.9 AHD
EASTING: 384570
NORTHING: 6418406
DIP/AZIMUTH: 90°/--

PIT No: TP14
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
6	0.1	TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, brown, fine to medium grained sand, with a trace of silt and rootlets, moist.		B	0.3				
	1	- becoming light yellow-brown from 0.6 m.							1
5	2								2
	2.3	Pit discontinued at 2.3m (Collapse)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6.9 AHD
EASTING: 384584
NORTHING: 6418301
DIP/AZIMUTH: 90°/--

PIT No: TP15
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
6	0.05	TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, brown, fine to medium grained sand, with a trace of silt, dry to moist.							
	1	- becoming light yellow-brown from 0.4 m.							1
		- becoming moist from 1.2 m.		D	1.4				
5	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7.6 AHD
EASTING: 384501
NORTHING: 6418310
DIP/AZIMUTH: 90°/--

PIT No: TP16
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
7	0.1	TOPSOIL - dark brown, silty sandy topsoil with a trace of rootlets, dry to moist.							
		SAND - medium dense, brown, fine to medium grained sand, with a trace of silt and rootlets, dry to moist.							
		- becoming light yellow-brown from 0.6 m.		D	1.0				1
6	2								2
	2.2	Pit discontinued at 2.2m (Collapse)							
5									

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 7 AHD
EASTING: 384420
NORTHING: 6418306
DIP/AZIMUTH: 90°/--

PIT No: TP17
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
7		TOPSOIL - brown, silty sandy topsoil, with some rootlets, moist.							
	0.15	SAND - medium dense, light grey-brown, fine to medium grained sand, with some silt, dry to moist.							
		- becoming light yellow-brown from 0.9 m.		D	1.2				
6	1								1
5	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.7 AHD
EASTING: 384376
NORTHING: 6418389
DIP/AZIMUTH: 90°/--

PIT No: TP18
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey, silty sandy topsoil, with some rootlets, moist.							
		SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt and roots, dry to moist.		D	0.6				
		- becoming moist from 1.2 m.							
		- with some pockets of low strength limestone to 1.6 m.							
	2.6	Pit discontinued at 2.6m (Target depth)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.4 AHD
EASTING: 384339
NORTHING: 6418237
DIP/AZIMUTH: 90°/--

PIT No: TP19
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark grey, silty sandy topsoil, with a trace of roots and rootlets, dry to moist.							
		SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt and rootlets, dry to moist.		D	1.1				
		- with some extremely low strength lithified zones from 1.8 m.							
	2.6	Pit discontinued at 2.6m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.3 AHD
EASTING: 384283
NORTHING: 6418300
DIP/AZIMUTH: 90°/--

PIT No: TP20
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.15	TOPSOIL - dark brown, silty sandy topsoil, with a trace of rootlets, moist.							
		SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt and rootlets, moist.		D	1.3				
4	1								1
3	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.3 AHD
EASTING: 384154
NORTHING: 6418325
DIP/AZIMUTH: 90°/--

PIT No: TP21
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - dark brown, silty sandy topsoil, with some rootlets and a trace of roots, moist.							
5		SAND - medium dense, light grey, fine to medium grained sand, with a trace of silt and rootlets, moist.							
		- becoming light yellow-brown with depth.		D	0.7				
	1								1
4									
	2								2
3	2.3	Pit discontinued at 2.3m (Collapse)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.7 AHD
EASTING: 384050
NORTHING: 6418280
DIP/AZIMUTH: 90°/--

PIT No: TP22
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark grey, silty sandy topsoil, with a trace of roots and rootlets, moist.							
	0.15	SAND - medium dense, light grey, fine to medium grained sand, with some extremely low strength lithified zones and a trace of silt, dry to moist.							
		- becoming light yellow-brown with depth.		B	0.4				
	2.3	Pit discontinued at 2.3m (Collapse)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.9 AHD
EASTING: 383959
NORTHING: 6418294
DIP/AZIMUTH: 90°/--

PIT No: TP23
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - brown, silty sandy topsoil, with some rootlets, dry to moist.							
	0.1	SAND - medium dense, light grey, fine to medium grained sand, with a trace of silt roots and rootlets, dry to moist.							
		- becoming light yellow-brown with depth.		D	0.6				
5	1								1
4	2								2
	2.4	Pit discontinued at 2.4m (Collapse)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 6 AHD
EASTING: 383854
NORTHING: 6418254
DIP/AZIMUTH: 90°/--

PIT No: TP24
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
6		TOPSOIL - dark brown, silty sandy topsoil, with many roots and rootlets, moist.							
	0.15	SAND - loose, brown, fine to medium grained sand, with a trace of silt and rootlets, dry to moist.							
		- becoming medium dense from 0.45 m. - becoming light grey from 0.5 m.		D	0.5				
		- becoming light yellow-brown from 0.9 m.							
5	1								1
4	2								2
	2.3	Pit discontinued at 2.3m (Collapse)							

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.3 AHD
EASTING: 383730
NORTHING: 6418194
DIP/AZIMUTH: 90°/--

PIT No: TP25
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.1	TOPSOIL - dark grey-brown, sandy topsoil, with some silt and rootlets, moist.							
		SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt, moist.			0.5				
4	1								1
3	2								2
	2.5	Pit discontinued at 2.5m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)
LOGGED: BD
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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TEST PIT LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.6 AHD
EASTING: 383774
NORTHING: 6417833
DIP/AZIMUTH: 90°/--

PIT No: TP26
PROJECT No: 76219
DATE: 1/6/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark grey-brown, silty sandy topsoil, with many roots and rootlets, moist.							
	0.2	SAND - medium dense, light grey, fine to medium grained sand, with some extremely low strength lithified zones, roots, rootlets and a trace of silt, dry to moist.							
				D	1.0				
		- becoming light yellow-brown from 1.5 m.							
	2.3	Pit discontinued at 2.3m (Collapse)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 5 tonne Komatsu (600 mm toothed bucket)

LOGGED: BD

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH27
PROJECT No: 76219
DATE: 12/7/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.1	TOPSOIL - dark brown, silty sandy topsoil, moist.							
		SAND - loose to medium dense, brown, fine to medium grained sand, with a trace of silt, moist.		D	0.5				
4	1.1	ORGANIC SAND - loose, dark grey, fine to medium grained organic sand, with some low plasticity fines, moist.		D	1.2				
	1.5	SAND - medium dense, dark grey, fine to medium grained sand, moist.		D	1.7				
3	2.0	Bore discontinued at 2.0m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** SS **LOGGED:** SS **SURVEY DATUM:**
TYPE OF BORING: Hand Auger **CASING:**
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.2 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH28
PROJECT No: 76219
DATE: 12/7/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
5	0.2	FILLING (SAND) - loose, light yellow, find to medium grained sand filling, with some fine to medium gravel, moist.							
	0.3	TOPSOIL - dark grey, silty sandy topsoil, moist.							
	0.6	SAND - medium dense, brown, fine to medium grained sand, with a trace of silt, moist.							
4	1	SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt, moist.		D	1.2				1
	2.0	Bore discontinued at 2.0m (Target depth)							2
3									

RIG: 110 mm diameter hand auger. **DRILLER:** SS **LOGGED:** SS **SURVEY DATUM:**
TYPE OF BORING: Hand Auger **CASING:**
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.9 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH29
PROJECT No: 76219
DATE: 12/7/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - dark grey, silty sandy topsoil, moist.							
	0.15	SAND - loose, brown, fine to medium grained sand, with a trace of silt, moist.							
	0.4	SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt, moist.		D	0.7				
5	1								1
4	2	2.0 Bore discontinued at 2.0m(Target depth)							2

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** SS **LOGGED:** SS **SURVEY DATUM:**
TYPE OF BORING: Hand Auger **CASING:**
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Porter Consulting Engineers
PROJECT: Port Kennedy Business Park
LOCATION: Port Kennedy, WA

SURFACE LEVEL: 5.4 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH30
PROJECT No: 76219
DATE: 12/7/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
5	0.1	TOPSOIL - dark grey, silty sandy topsoil, moist.							
	0.3	SAND - loose, brown, fine to medium grained sand, with a trace of silt, moist.							
	1	SAND - medium dense, light yellow-brown, fine to medium grained sand, with a trace of silt, moist.		D	0.5				
4				D	1.2				
				D	1.7				
	2	2.0 Bore discontinued at 2.0m (Target depth)							
3									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger. **DRILLER:** SS **LOGGED:** SS **SURVEY DATUM:**
TYPE OF BORING: Hand Auger **CASING:**
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface level interpolated from the survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix B

Geotechnical Laboratory Testing

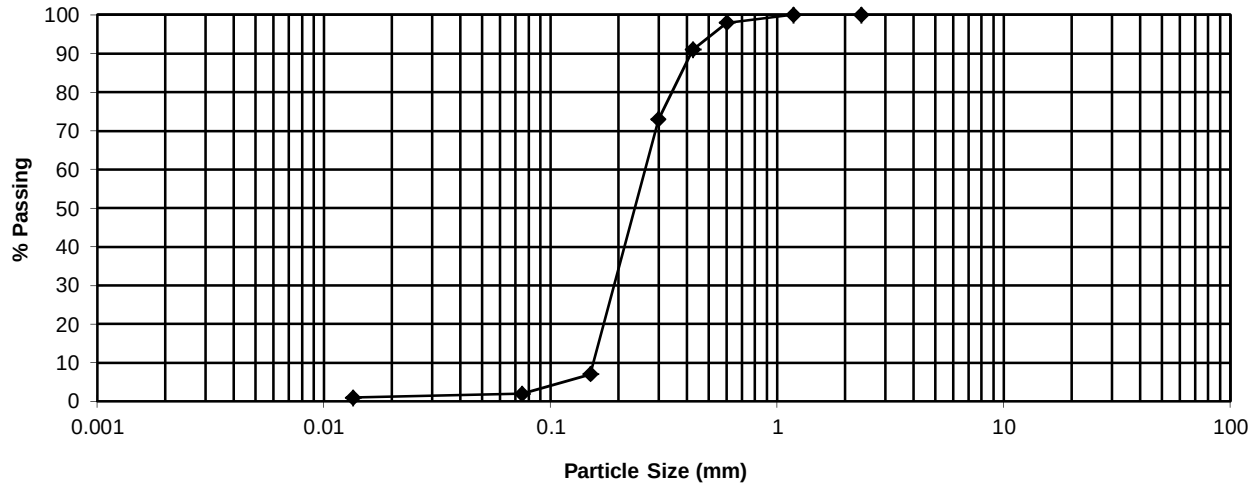
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1626**
Sample No:	**P11/1626**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 3**
Depth (m): **0.3**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	98
0.425	91
0.300	73
0.150	7
0.075	2
0.0135	1

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

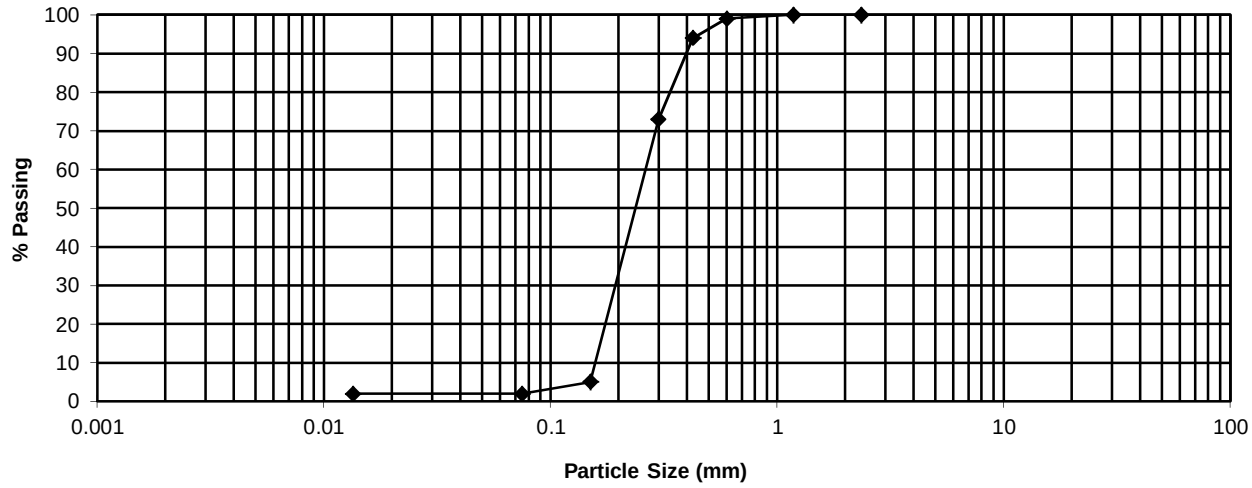
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1628**
Sample No:	**P11/1628**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 6**
Depth (m): **0.8**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	99
0.425	94
0.300	73
0.150	5
0.075	2
0.0135	2

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

Approved signature

Kevin M Jones

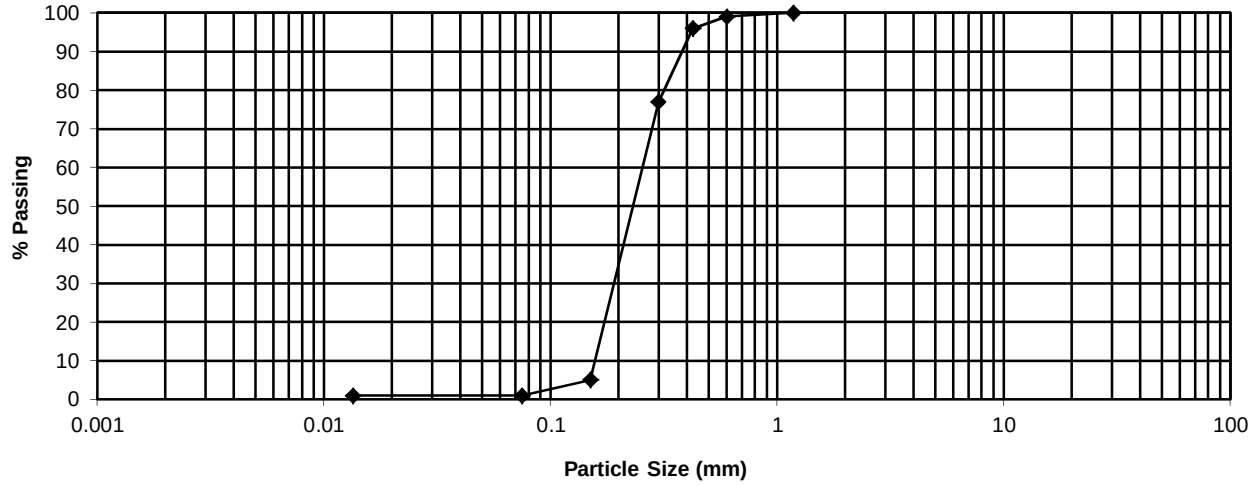
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1627**
Sample No:	**P11/1627**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 9**
Depth (m): **0.5**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	100
0.600	99
0.425	96
0.300	77
0.150	5
0.075	1
0.0135	1

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

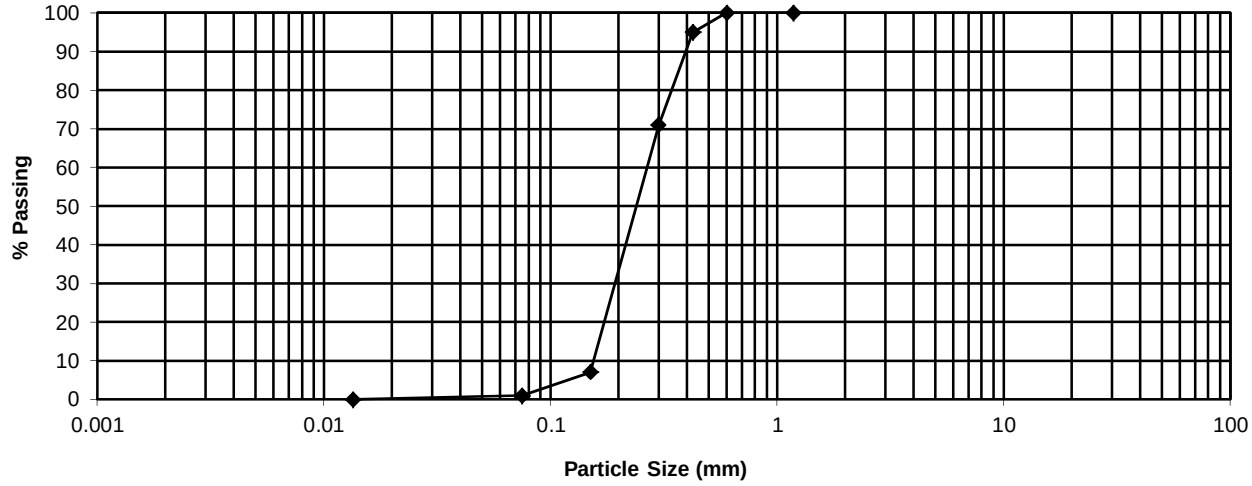
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1629**
Sample No:	**P11/1629**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 13**
Depth (m): **0.5**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	100
0.600	100
0.425	95
0.300	71
0.150	7
0.075	1
0.0135	0

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

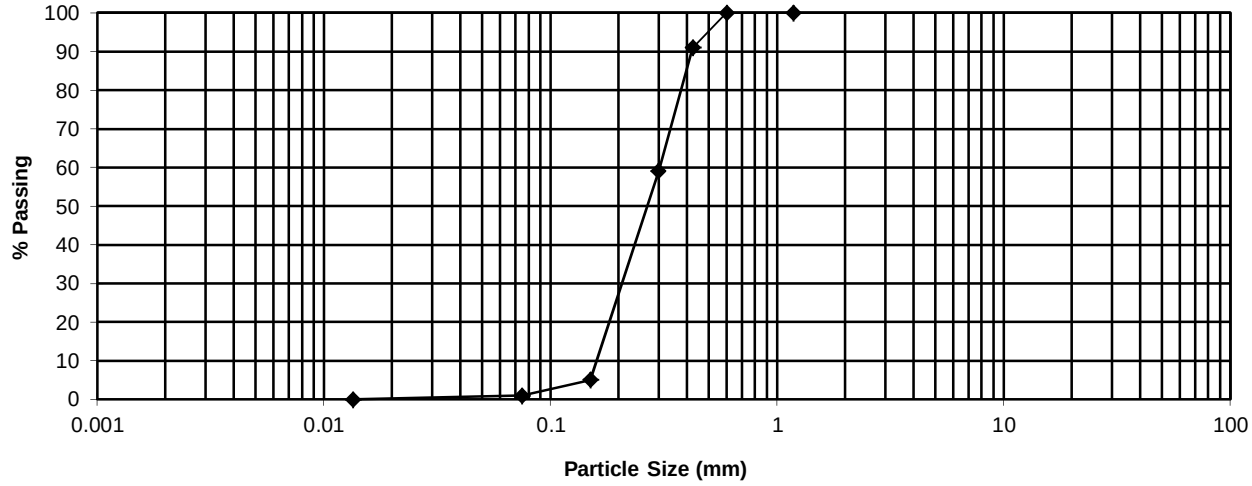
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1630**
Sample No:	**P11/1630**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 15**
Depth (m): **1.4**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	100
0.600	100
0.425	91
0.300	59
0.150	5
0.075	1
0.0135	0

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

Approved signature

Kevin M Jones

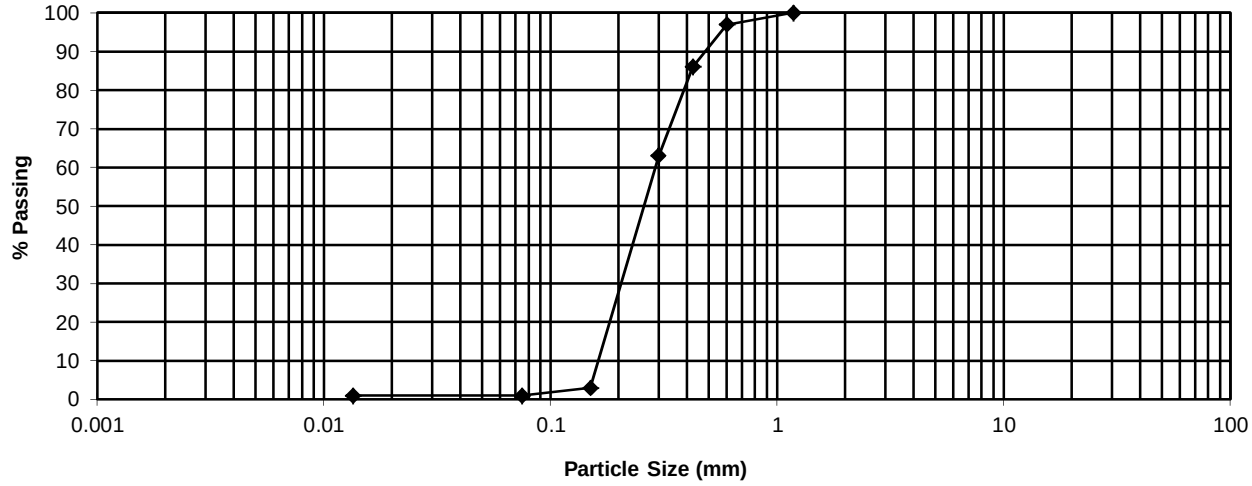
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P11/1631**
Sample No:	**P11/1631**
Issue Date:	**6 June 2011**

Client: **Porter Consulting Engineers**
Project: **Port Kennedy Business Park**
Location: **Port Kennedy WA**

Sample Location: **TP 23**
Depth (m): **0.6**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	100
0.600	97
0.425	86
0.300	63
0.150	3
0.075	1
0.0135	1

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

Approved signature

Kevin M Jones

Appendix C Pre- development annual groundwater monitoring report 2011-2012

Jim Davies & Associates Pty Ltd
ABN 24 067 295 569
Suite 1, 27 York Street, Subiaco
PO Box 117, Subiaco WA 6008
Ph: (08) 9388 2436
Fx: (08) 9381 9279
info@jdahydro.com.au
www.jdahydro.com.au

To :	Landcorp	**Date :**	4 May 2011
Attention :	Nicola Popenhagen	**Our Ref:**	J4511b
Email :	*NicolaPopenhagen@landcorp.com.au*	**Pages :**	19
cc :			

LOT 4 & 17 PORT KENNEDY DRIVE, PORT KENNEDY
Pre-Development Annual Monitoring Report 2010-2011

1 Introduction

This monitoring report has been prepared by JDA Consultant Hydrologists on behalf of Landcorp for Lot 4 &17 Port Kennedy Drive, Port Kennedy herein referred to as the Study Area (Figure 1).

JDA Consultant Hydrologists completed an investigation of the Average Annual Maximum Groundwater Level (AAMGL) for the Study Area in October 2009 (JDA 2009), which has been followed by an 18 month pre development hydrological monitoring program.

This report constitutes the first and final annual hydrological monitoring report for the Study Area. It presents a brief summary of groundwater data collected over the 18 month monitoring period from October 2009 to April 2011 with 16 months of predevelopment data.

2 Monitoring Program

On 28 September 2009 JDA installed eight shallow aquifer monitoring bores at the Study Area (PK1 – PK8). The bores were installed by 75mm push probe drill to depths between 4.5 m and 8.0 m. All bores were cased in 50 mm PVC pipe with end caps, and slotted 3m into the water table. Bore locations are shown in Figure 2 and details in Table 1.

Lithological logs recorded during the installation of the bores, indicate the general soil profile over the entire site consist of 0.5 m brown topsoil overlying white cream Safety Bay sands. Bore logs are included as Appendix A.

Department of Water (DoW) bores T430 OBS and T480 are the closest long term monitoring bores to the Study Area and were included in the monthly groundwater level monitoring program.

The following parameters were monitored over the 18 month period:

- Monthly monitoring of groundwater levels in the superficial aquifer of 8 JDA bores and the nearby DoW long term monitoring bore. Levels were measured using an electrical depth probe in metres below natural surface. Survey of the bores was used to convert measured levels to mAHD.
- Quarterly groundwater quality sampling of the JDA bores PK1, PK3, PK5, PK7 and PK8. Bores were analysed for nutrients (TN, NH_4, NOx, TKN, TP and PO_4); pH and EC were tested in situ. Samples were submitted to a NATA certified laboratory for analysis of the nutrients.

Table 1: JDA Groundwater Bore Details

Bore	Location (GDA 94)		Natural Surface (mAHD)	Top of Casing (mAHD)
	Easting	Northing		
PK1	383685	6417763	5.88	6.53
PK2	383599	6418208	5.81	6.42
PK3	383538	6418639	6.37	6.97
PK4	384144	6418033	5.80	6.41
PK5	384157	6418461	5.32	5.92
PK6	384163	6418645	5.63	6.23
PK7	384604	6418276	6.98	7.68
PK8	384570	6418638	8.00	8.64
T480	383643	6413859	-	8.62
T430 (OBS)	385714	6416781	-	7.18

3 Monitoring Data

3.1 Groundwater Levels

Recorded monthly groundwater levels are shown in Figure 3, with a summary of recorded annual maximum and minimum groundwater levels shown in Table2.

Winter maximum groundwater levels ranged from 2.64 mAHD (PK7) to 4.25 mAHD (PK3) across the Study Area. Depth to the maximum groundwater level below natural surface varied from 1.72 to 4.25 m across the Study Area. Summer minimum groundwater levels ranged from 1.72 mAHD (PK7) to 2.93mAHD (PK3) across the Study Area. Observed seasonal groundwater variations were in the range of 0.3m to 0.62 m across the site, which is typical of the Swan Coastal Plain.

The AAMGL investigation undertaken in October 2009 (figure 2) is consistent with the pre development groundwater monitoring program undertaken by JDA between 2009 and 2011.

Table 2: Groundwater Level Data

Bore	Natural Surface (mAHD)	Summer Feb 2010 minimum		Winter Oct 2009 maximum		Seasonal Groundwater Variation (m)
		mBNS	mAHD	mBNS	mAHD	
PK1	5.88	2.89	2.99	2.41	3.47	0.48
PK2	5.81	2.48	3.33	1.91	3.90	0.57
PK3	6.37	2.74	3.63	2.12	4.25	0.62
PK4	5.80	2.91	2.89	2.51	3.29	0.4
PK5	5.32	2.22	3.10	1.70	3.62	0.52
PK6	5.63	2.44	3.19	1.89	3.74	0.55
PK7	6.98	4.64	2.34	4.34	2.64	0.3
PK8	8.00	5.7	2.30	5.12	2.88	0.58

3.2 Groundwater Quality

All groundwater bores were monitored quarterly for nutrients. The monitoring results are shown in Table 3. Rubbish located close to many of the bores at the site may alter the groundwater quality of the samples obtained from the Study Area over time.

3.2.1 pH & Electrical Conductivity

pH and EC were recorded insitu at each of the 8 monitoring bores. pH ranged between a minimum of 6.61 at PK4 in January 2010 and a maximum of 8.32 at PK1 in July 2010. Mean pH is between 7.16 and 7.63 across all bores for the monitoring period.

pH results indicate groundwater is generally neutral with all bores within the Study Area showing pH values above 6.60, and mean values within the ANZECC guideline range of 6.5-8.0 pH units (ANZECC 2000).

Electrical conductivity (EC) was generally consistent at all bores over the monitoring period ranging from a minimum of 0.27 mS/cm (PK5, October 2010) to a maximum of 0.85 mS/cm (PK5, July 2010). Mean EC values were between 0.47 and 0.79 mS/cm. These mean EC values are within the expected range of 0.3-1.5 mS/cm for slightly disturbed ecosystems in south-west Australia (ANZECC 2000).

3.2.2 Nutrients

In general, all parameters for the sampled bores remained generally consistent for all monitoring events with the exception of Nitrogen Oxide (NOx) and Total Nitrogen (TN) parameters. Nutrient levels did not follow expected seasonal variation of elevated recordings during winter peaks and the initial flush of nutrients at the beginning of the monitoring period. The predevelopment monitoring levels for the nutrient parameters are shown in figure 4 and figure 5.

Ammonia (NH_4N) results were consistent and remained above 0.05mg/L, until October 2010 when all bore results decreased below 0.005mg/L, and remained low for the rest of the monitoring period. The mean values for NH_4H ranged between 0.28-0.44mg/L, above the ANZECC guideline value of 0.08mg/L (ANZECC 2000).

Bores PK3, PK5 and PK7 were consistent throughout the monitoring period for Nitrogen Oxide (NOx_N) with values below 5.3mg/L. PK1 and PK8 had much higher readings for NOxN ranging from 5.9-16mg/L with the exception of July 2010.

This was consistent with results for Total Nitrogen (TN), with PK1 and PK8 values above the mean for the monitoring period of 6.31mg/L, except in July 2010. July 2010 results were consistent for PK3, PK5 and PK7 bore results for both NOxN and TN.

Total Nitrogen (TN), TN varied from a minimum of 0.93 mg/L (PK1, July 2010 and PK3, April 2011) to a maximum of 22 mg/L (PK1 April 2010). Mean TN concentrations for individual bores ranged from 2.78 mg/L to 10.72 mg/L. These mean values exceed the ANZECC predevelopment value of 1.2 mg/L (ANZECC 2000).

Total Phosphorus (TP) varied from below the detectable limit (0.01 mg/L) to a maximum of 0.33 mg/L. Mean TP concentrations for individual bores ranged from 0.08 mg/L to 0.09 mg/L, which is above the ANZECC guideline value of 0.065mg/L (ANZECC 2000).

.

Table 3: Groundwater Water Quality Data: pH, EC, TDS & Nutrients

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
pH	PK1	7.14	7.57	8.32	7.39	7.66	7.68	7.63
	PK2	7.15	7.36	7.50				7.34
	PK3	7.17	7.59	7.89	7.38	7.87	7.80	7.62
	PK4	6.61	7.39	7.53				7.18
	PK5	7.14	7.43	7.58	7.24	7.62	7.52	7.42
	PK6	6.92	7.24	7.33				7.16
	PK7	7.19	7.76	7.59	7.57	7.97	7.64	7.62
	PK8	7.12	7.48	7.56	7.48	7.68	7.42	7.46
EC (mS/cm)	PK1	0.62	0.65	0.30	0.27	0.53	0.55	0.49
	PK2	0.62	0.62	0.52				0.59
	PK3	0.52	0.50	0.55	0.43	0.40	0.4	0.47
	PK4	0.62	0.68	0.64				0.65
	PK5	0.62	0.65	0.85	0.57	0.56	0.64	0.65
	PK6	0.82	0.77	0.78				0.79
	PK7	0.80	0.64	0.57	0.66	0.56	0.57	0.63
	PK8	0.66	0.63	0.61	0.56	0.60	0.65	0.62
NH_4_N (mg/L)	PK1	0.33	2.30	0.024	<0.005	<0.005	<0.005	0.44
	PK2							
	PK3	0.29	1.50	0.019	<0.005	<0.005	<0.005	0.30
	PK4							
	PK5	0.13	1.50	0.028	<0.005	<0.005	<0.005	0.28
	PK6							
	PK7	0.18	1.70	0.087	<0.005	<0.005	0.009	0.33
	PK8	0.22	1.80	0.050	<0.005	<0.005	<0.005	0.35
NOx_N (mg/L)	PK1	9.40	16.00	0.12	6.40	11.00	9.60	8.75
	PK2							
	PK3	2.20	4.30	0.52	5.30	2.60	0.56	2.58
	PK4							
	PK5	1.80	2.00	0.32	3.50	2.60	3.10	2.22
	PK6							
	PK7	0.84	1.80	0.25	1.30	1.50	1.80	1.25
	PK8	16.00	5.90	0.91	9.70	6.70	6.10	7.55

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
Tot N (mg/L)	PK1	10.00	22.00	0.93	6.70	6.70	18.00	10.72
	PK2							
	PK3	3.90	5.50	4.00	5.40	5.40	0.93	4.19
	PK4							
	PK5	3.20	7.50	3.90	3.50	3.50	3.70	4.22
	PK6							
	PK7	2.10	6.50	2.60	1.50	2.00	2.00	2.78
	PK8	17.00	8.80	7.00	9.90	7.40	7.70	9.63
TKN (mg/L)	PK1	0.60	6.00	0.81	0.25	0.19	8.80	2.78
	PK2							
	PK3	1.70	1.20	3.50	0.13	0.70	0.34	1.26
	PK4							
	PK5	1.40	5.50	3.60	0.04	0.98	0.68	2.03
	PK6							
	PK7	1.30	4.70	2.30	0.21	0.49	0.21	1.54
	PK8	1.50	2.90	6.10	0.15	0.69	1.60	2.16
Tot P (mg/L)	PK1	0.06	0.33	0.06	0.01	0.02	0.02	0.08
	PK2							
	PK3	0.06	0.33	0.05	0.02	0.02	0.03	0.09
	PK4							
	PK5	0.06	0.33	0.05	0.02	0.04	0.04	0.09
	PK6							
	PK7	0.06	0.33	0.05	0.01	0.01	0.02	0.08
	PK8	0.06	0.33	0.06	0.02	0.01	0.03	0.09
PO4_P (mg/L)	PK1	0.008	<0.005	<0.005	0.009	0.006	0.01	0.01
	PK2							
	PK3	0.012	<0.005	<0.005	0.02	0.01	0.02	0.01
	PK4							
	PK5	0.013	<0.005	0.006	0.02	0.01	0.03	0.01
	PK6							
	PK7	0.01	<0.005	<0.005	0.006	0.007	0.02	0.01
	PK8	0.01	<0.005	0.007	0.02	0.01	0.02	0.01

4 Conclusions

Analysis of depth to groundwater at each of the 8 bores indicates a separation for natural surface to groundwater of greater than 1.7m at all bores. Typical building design requires clearance of at least 1.2m for soakwells. Groundwater levels at the site do not appear to pose any constraints to this requirement.

The results obtained during the 18 month monitoring period at Port Kennedy are considerably higher than the Groundwater Quality ANZECC guideline values for Fresh and Marine Water Quality (2000a). This is common for predevelopment monitoring within the superficial aquifer on the Swan Coastal Plain. Results obtained for predevelopment monitoring should be considered as baseline and for the basis upon which water quality reduction targets are formed. Rubbish located close to many of the bores at the site may also have influenced the groundwater quality of the samples obtained from the Study Area over time.

These conclusions and recommendations are supported by results collected over the 18 month monitoring period, and should be considered as the baseline for which water quality reduction targets are formed.

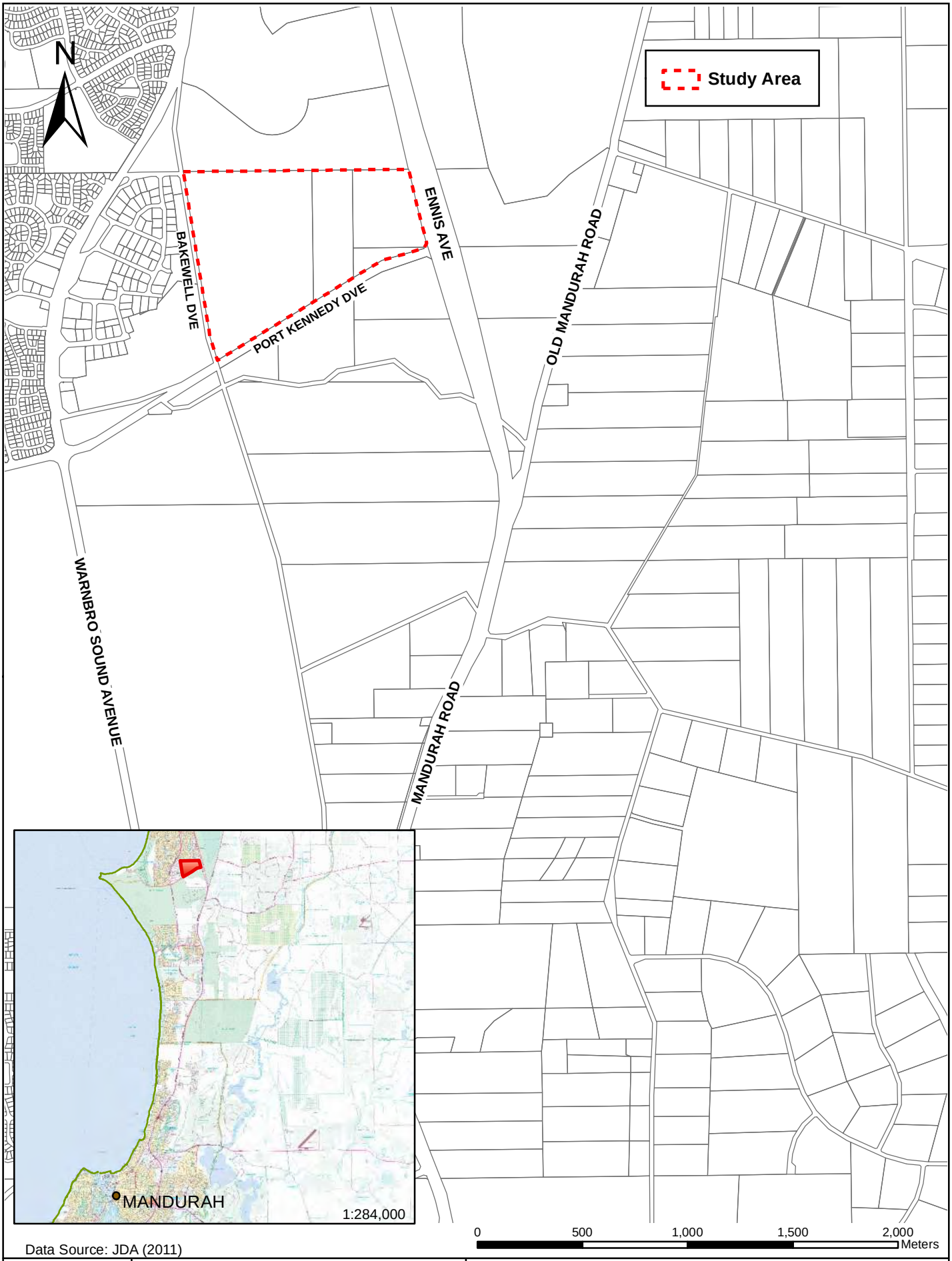
5 References

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, October 2000

JDA (2009) Lot 4 & 17 Port Kennedy Drive, Port Kennedy AAMGL Investigation, November 2009

Should you have any queries regarding the above report, please contact Matthew Yan or Kate Smith of this office.

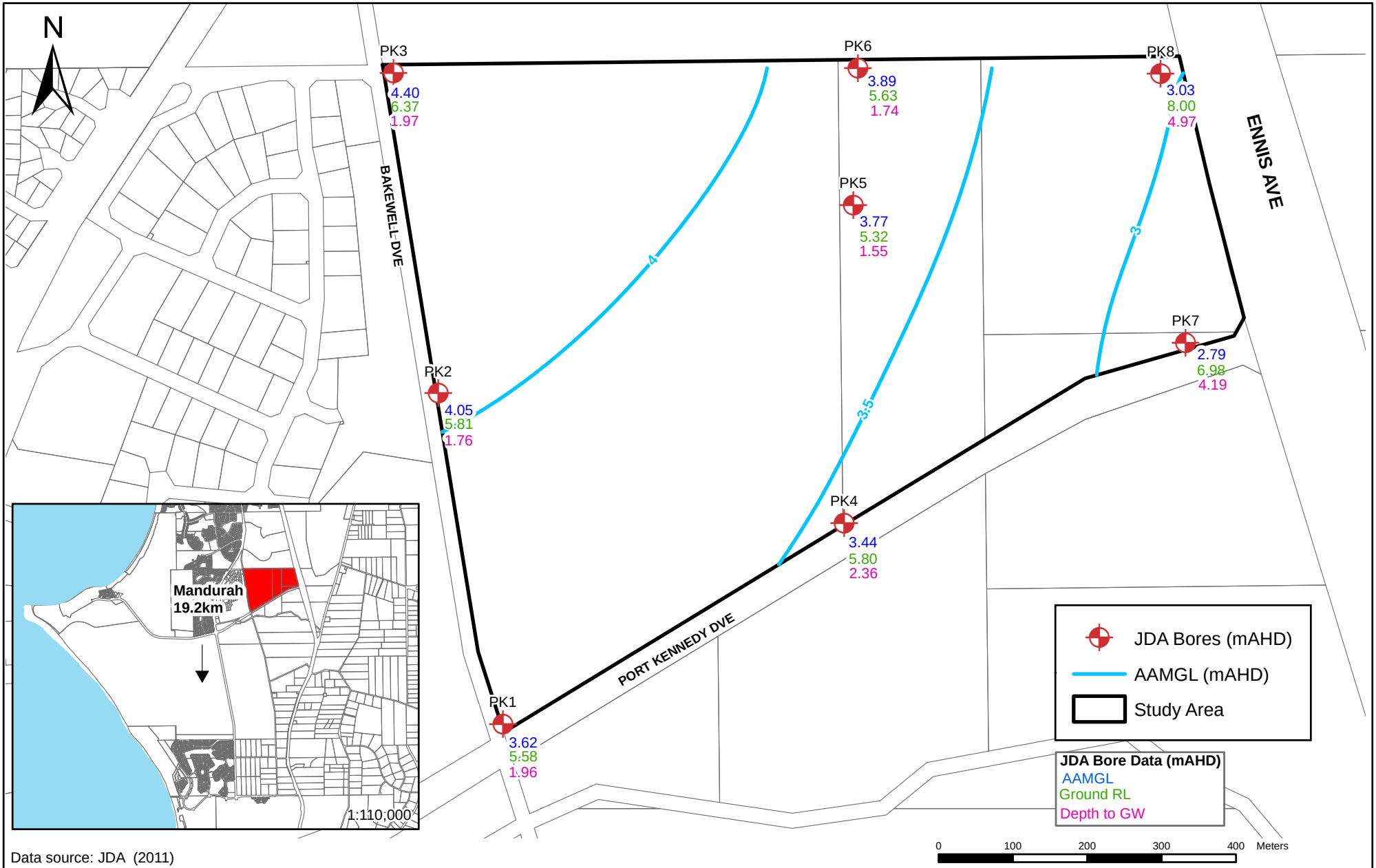
JDA CONSULTANT HYDROLOGISTS



Data Source: JDA (2011)

Job No. J4511
Scale 1:24,000

Landcorp
Lots 4 & 17 Port Kennedy Drive: Predevelopment Gorundwater Investigation
Figure 1: Location Plan



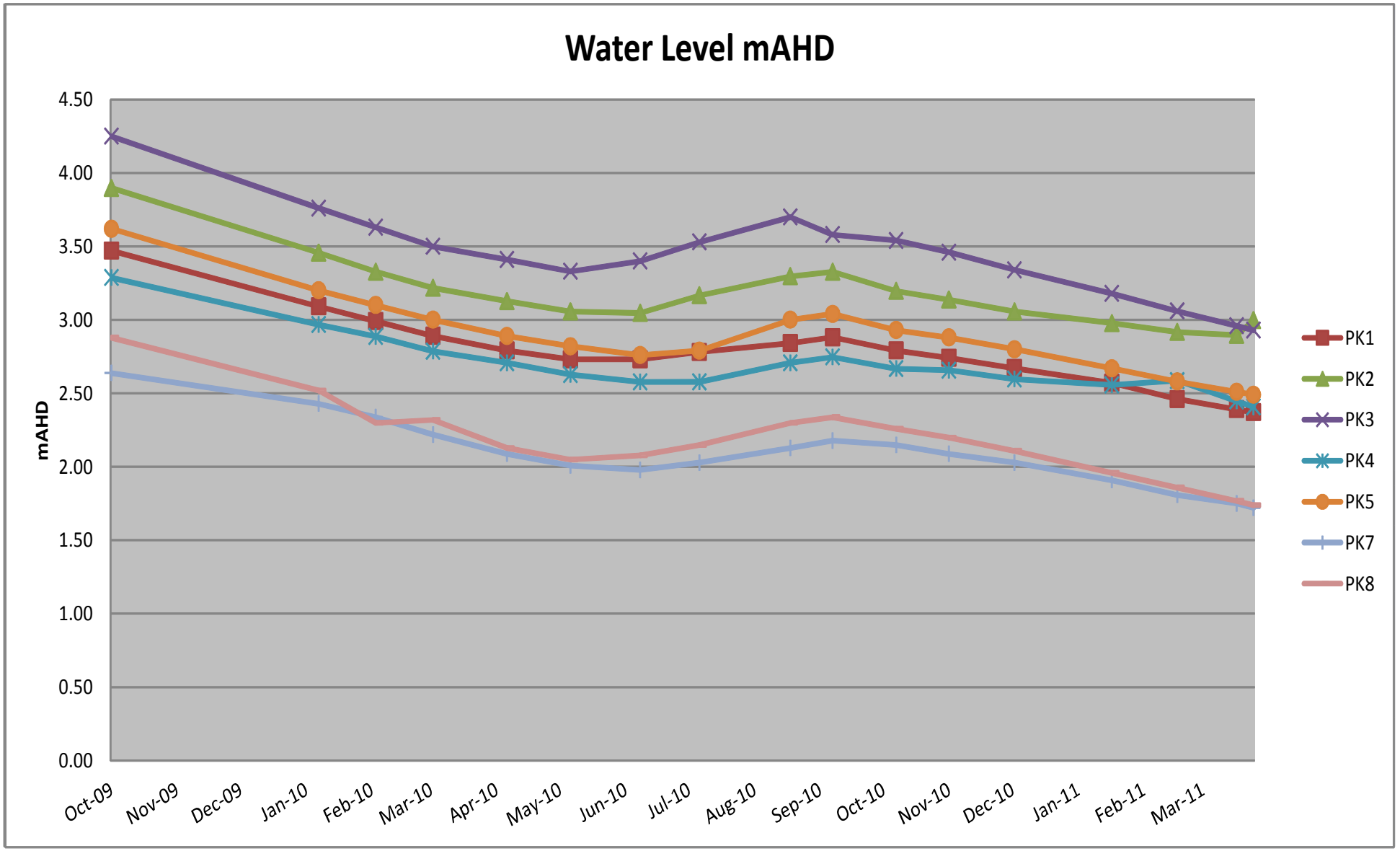
Data source: JDA (2011)

Job No. J4511
Scale:1:7,000

Landcorp

Lots 4 & 17 Port Kennedy Drive: PredevelopmentGroundwater Investigation

Figure 2: Groundwater Plan



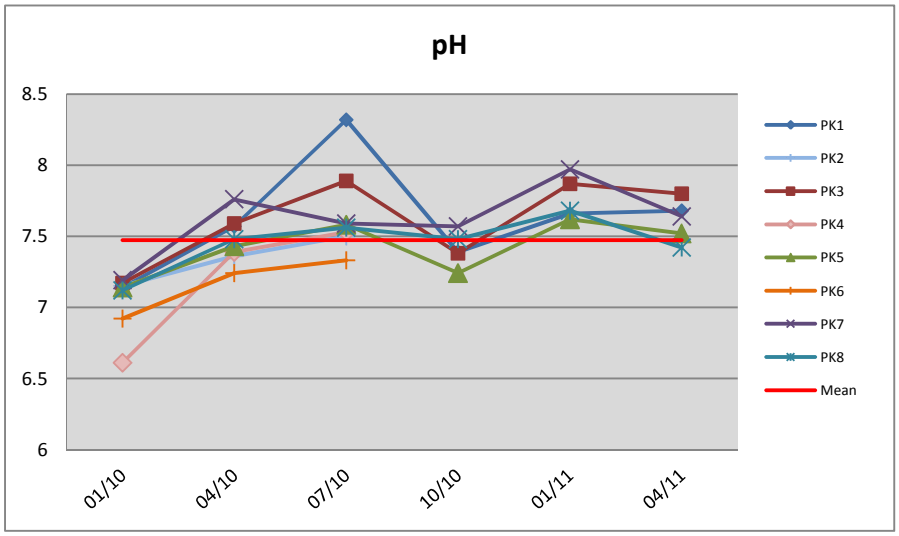
Data Source: JDA (2011)

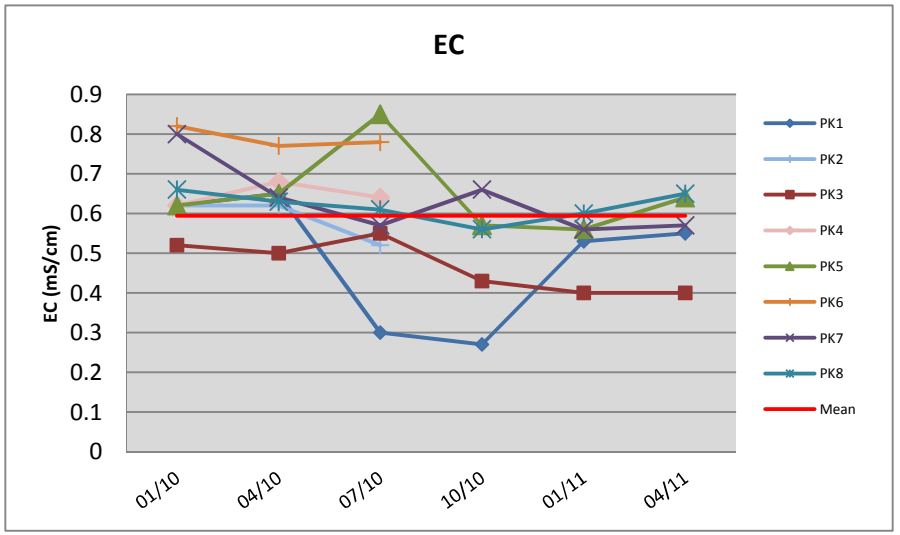
Job No. J4511

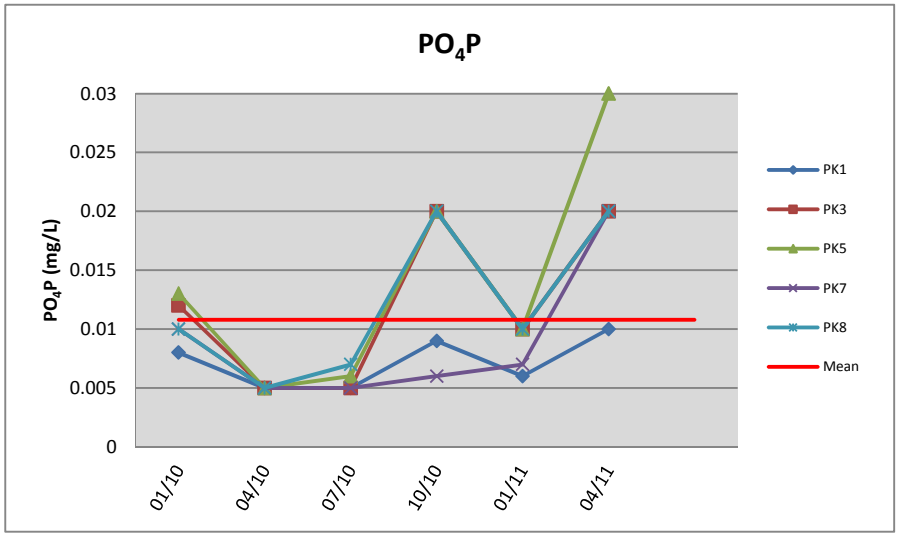
0 100 200 300 400 Meters

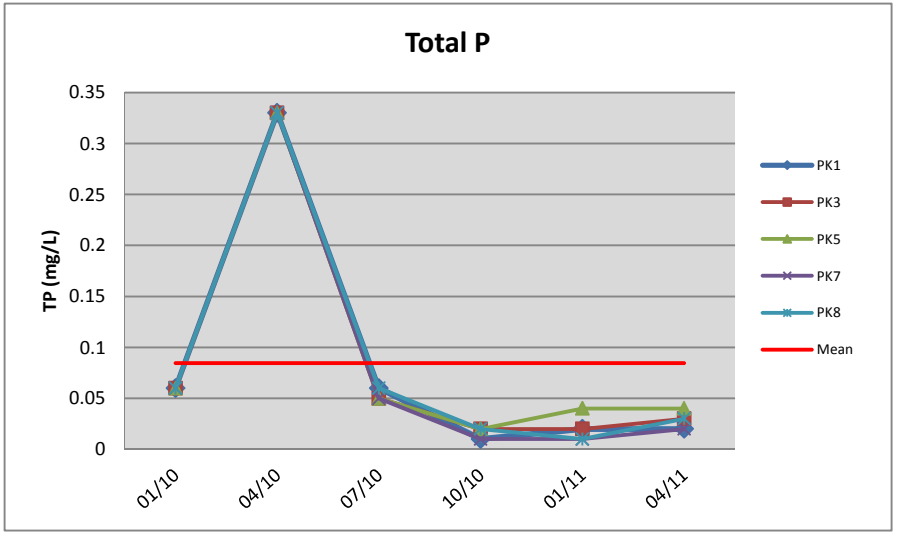
Landcorp
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 3: Groundwater Levels 2010-2011









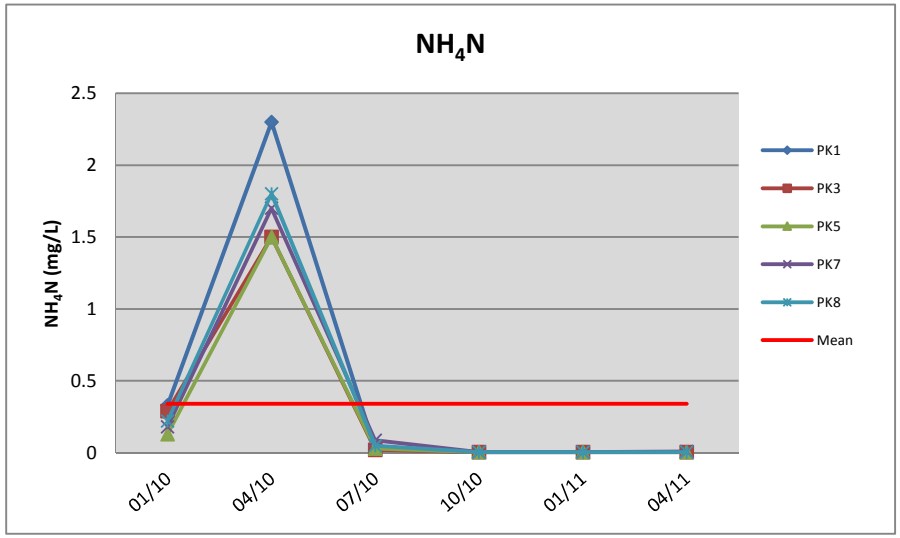
Data Source: JDA (2011)

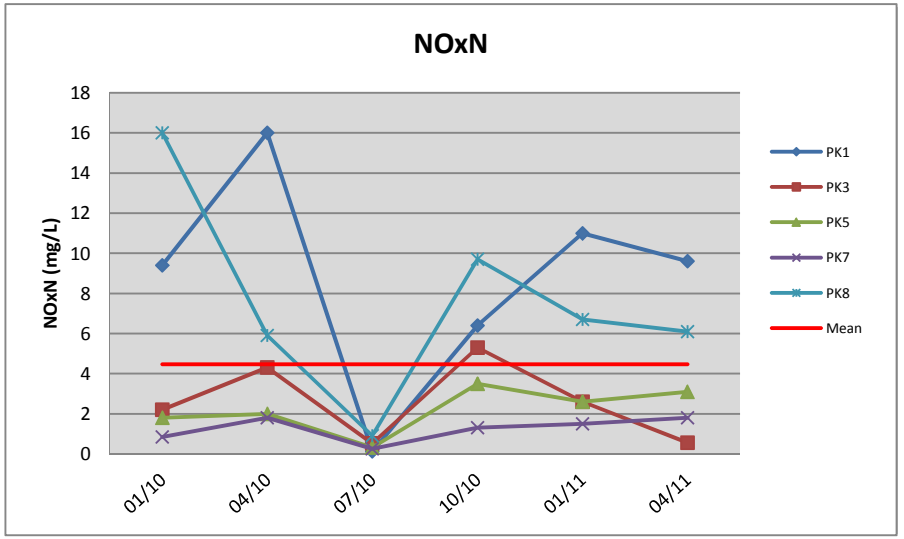
Job No: J4511

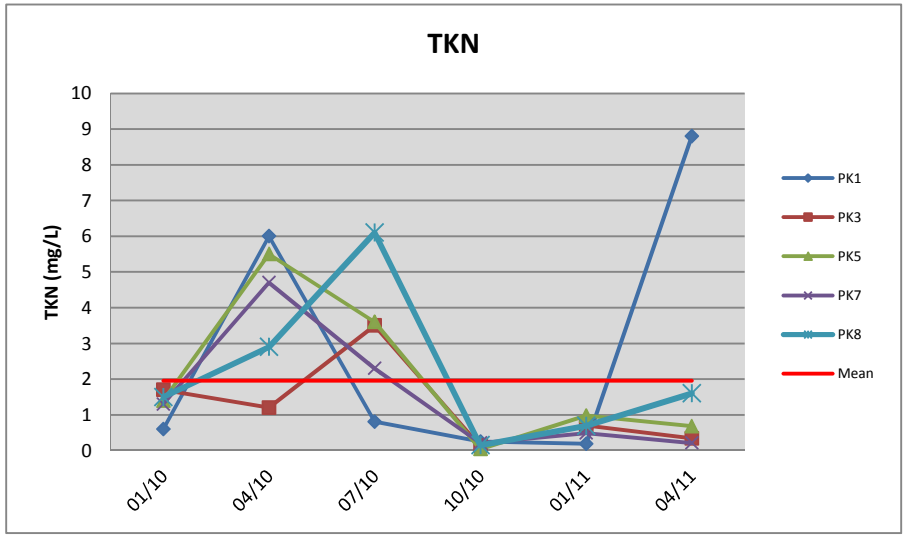
Landcorp

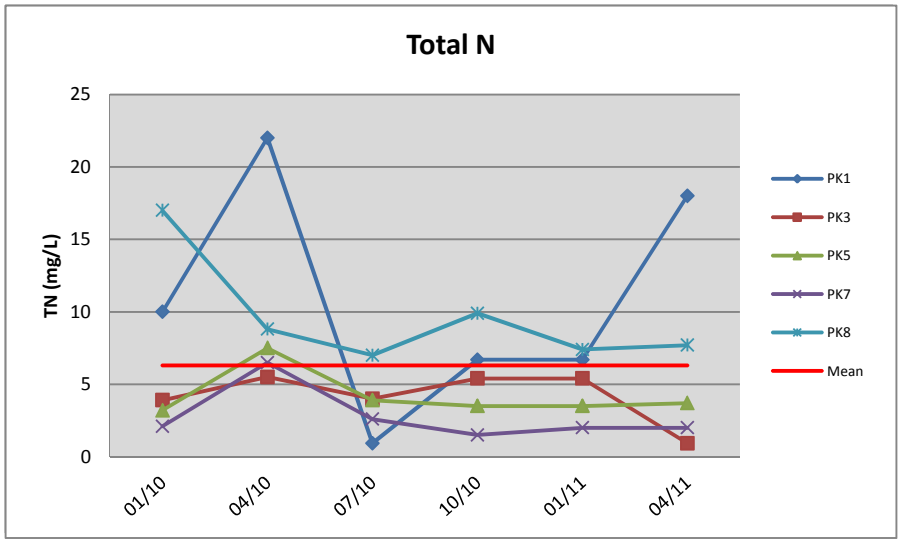
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 4: Monitoring Results 2010- 2011









Data Source: JDA (2011)

Job No: J4511

Landcorp

Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 5: Monitoring Results 2010- 2011

APPENDIX A

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383685 N6417762	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK1	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med round	sand well sorted	nil	nil	
				1.0m						
				1.5m	yellow/white	fine round	Safety Bay Sand well sorted			
				2.0m						
		▽		2.5m						
				3.0m						
				3.5m	yellow / white	fine	Safety Bay Sand some shells		moist	
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383606 N6418210	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK2	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)					Brown	fine	well sorted sand		nil	
				0.5m	light brown / white	fine	well sorted sand		nil	
				1.0m						
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m	light brown / white	fine	well sorted sand		moist	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	2.00pm
Bore location:	E383537 N6418639	Hole completed:	2.34pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK3	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	well sorted sand	some	dry	
				1.0m	yellow / white	fine	Safety Bay Sand well sorted	nil	dry	
		▽		1.5m						
				2.0m	white	fine	Ssfetly Bay sand	nil	moist	
				2.5m						
				3.0m						
				3.5m	yellow / white	med	gravelly sand	nil	moist	
				4.0m	yellow / white	fine	sand well sorted		saturated	
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E384143 N6418034	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK4	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med	sand	nil	nil	
				1.0m	light brown / white	fine	sand well sorted		nil	
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m						
				3.5m	light brown / white	fine	sand well sorted		moist	
				4.0m						
				4.5m			end of bore		saturated	
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	12.20pm
Bore location:	E384161 N6418456	Hole completed:	12.55pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK5	Total Depth:	4.2m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Dark brown	med	sand well sorted	some	dry	
				1.0m	light brown	fine	sand well sorted	nil	dry	
				1.5m						
		▽		2.0m	yellow / white	med	sand sorted some shells		moist	
				2.5m					saturated	
				3.0m						
				3.5m						
				4.0m			end of bore			
				4.5m						
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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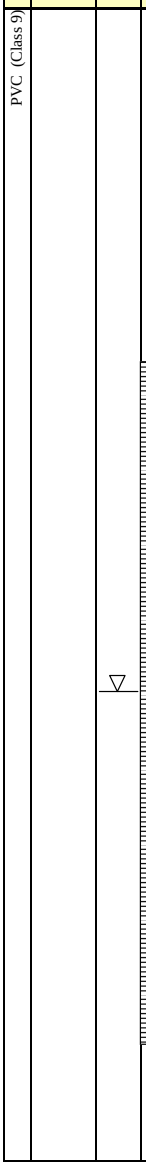
LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	1:05
Bore location:	E384164 N6418647	Hole completed:	1:40
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK6	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
					Dark brown	fine	sand	some	dry	
				0.5m	yellow / white	fine	sand well sorted	nil	dry	
				1.0m						
				1.5m						
									moist	
				2.0m						
				2.5m						
		▽		3.0m						
					yellow / white	fine	sand	nil	saturated	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

JDA Consultant Hydrologists
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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	10:30
Bore location:	E384607 N6418273	Hole completed:	11:.05
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK7	Total Depth:	6.0m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown	fine / med	round sand	nil	dry	
				1.5m						
				2.0m	white	fine	Safetly Bay Sand well sorted		dry	
				2.5m						
				3.0m						
				3.5m						
				4.0m					moist	
		▽		4.5m	white	fine	poorly sorted sand large rocks + shells		saturated	
				6.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……..…m

Stickup above NS: ……m

WL …….. m below NS

JDA Consultant Hydrologists
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Tel: 9388 2436
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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	11:20
Bore location:	E384571 N6418642	Hole completed:	11:55
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK8	Total Depth:	7.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown white	fine	sand well sorted	none	dry	
				1.5m						
				2.0m	yellow / white	fine	sand well sorted	none	dry	
				4.0m						
		▽		5.0m	white	fine	sand some rocks fragments	none	moist	
				6.0m						
					white	fine	sand well sorted		saturated	
				7.0m	white	fine	clayey sand large rocks	end of bore	saturated	
				8.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark Brown, Red, Orange, Yellow, Grey, Blue
Medium Brown, Red, Orange, Yellow, Grey, Blue
Light Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

Appendix D Port Kennedy Business Park – Environmental Assessment Report

PORT KENNEDY BUSINESS PARK

ENVIRONMENTAL ASSESSMENT REPORT

Prepared for:	DevelopmentWA
Report Date:	16 December 2020
Version:	1
Report No.	2020-556

pgv ENVIRONMENTAL

CONTENTS

LIST OF ATTACHMENTS

Tables

Plates

Figures

Appendices

1 INTRODUCTION

1.1 Location

DevelopmentWA is proposing to develop a business park on Lots 4 and 17 Port Kennedy Drive, Port Kennedy (the site). The site is located in the City of Rockingham, approximately 55km south of the Perth Central Business District and 10km from the Rockingham city centre (Figure1). The site is bordered by Ennis Avenue to the east, Port Kennedy Drive to the south, Bakewell Drive to the west and residential housing to the north (Figure 2).

The site is zoned 'Industrial' under the Metropolitan Regional Scheme (MRS) and 'Port Kennedy Business Enterprise' under the City of Rockingham Town Planning Scheme No. 2. The site is currently undeveloped and contains native vegetation.

1.2 Background

1.2.1 State Environmental Approval

The site was rezoned to Industrial in the MRS as part of Major Amendment No. 938/33 in 1994. The Amendment included the following land use changes:

- Creation of a Rapid Transport Reserve for the Perth-Mandurah rail;
- Rezoning of the north-west corner of System 6 Area M103 for Public Purposes;
- Rezoning of the south-west portion of System 6 Area M103 west of Ennis Avenue for Urban and Industrial uses (includes the site); and
- Widening of Safety Bay Road between Ennis Avenue and Mandurah Road.

The Amendment was referred to the Environmental Protection Authority (EPA) by the Department of Planning and Urban Development (now called the Department of Planning, Lands and Heritage) in 1993. The EPA considered that the Amendment had potential for significant impacts on System 6 Areas M103 and M104, and on several lakes and wetlands and their vegetation. As a result, the EPA set the level of assessment as a Public Environmental Review (PER).

The assessment of scheme amendments under Section 38 of the *Environmental Protection Act 1986* (EP Act) was allowable in 1994 as that pre-dates the 1996 amendment to the EP Act which introduced Section 48A that required all schemes and scheme amendments to be referred to the EPA.

The Minister for the Environment approved the Amendment on 11 October 1994 (Ministerial Statement No. 368) (Appendix 1). Condition 4-2 of the approval states that:

Condition 4-2 The Proponent may allow the development of the area west of Ennis Avenue which is currently within System 6 Area M103 subject to the following requirements:

1. *Land owned by the State Planning Commission generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue and between Port Kennedy Drive and*

Secret Harbour and east of the area subject to the Port Kennedy Development Act to be secured and managed for conservation purposes;

2. *Land owned by the State Planning Commission reserved under the Metropolitan Region Scheme for Public Purposes generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue, south of Port Kennedy Drive and west of Ennis Avenue and Mandurah Road to be secured and managed for recreational and conservation purposes;*
3. *A linkage to be provided between the greater part of System 6 Area M103 east of Ennis Avenue through to the coast at Port Kennedy, consistent with recommendations made for System 6 Area M106; and*
4. *Integration of the management of the area referred to in requirements 1, 2 and 3 above with the management of the Port Kennedy conservation area and the greater area of System* Six Area M103.

The 1994 ministerial approval (MS 368) anticipates development of the entire site. The State negotiated a considerable offset package for the protection of conservation significant land south of Port Kennedy Drive to allow the industrial and urban development north of Port Kennedy Drive

1.2.2 Post Approval Environmental Studies

Following the 1994 approval to develop the site for industrial purposes additional environmental investigations have occurred on the site. The most relevant studies are summarised below.

In 1996 the Wetlands of the Swan Coastal Plain Volume 2b mapped for the first time thirteen wetlands on the site. The wetlands included nine Conservation Category wetlands, two Resource Enhancement Category wetlands and two that had a management category of 'not applicable'. Since that publication, further wetland investigations have identified additional wetlands on the site. Currently 22 wetlands are recognised as occurring on the site. Most of the wetlands are located on the western side of Lot 17 while several occur on the eastern side. No wetlands are known to occur on Lot 4.

Since that publication, further wetland investigations have identified additional wetlands on the site. Currently 28 wetlands are recognised on the site (RPS BBG, 2005; Strategen, 2011; PGV Environmental, 2016; PGV Environmental, 2017). Most of the wetlands are located on the western side of Lot 17 with five wetlands mapped on the eastern side. No wetlands are known to occur on Lot 4.

In 2004, the (then) Department of Conservation and Land Management surveyed the site for the presence of the Threatened Ecological Community FCT 19 '*Sedgelands in Holocene Dune Swales*'. A total of 17 occurrences of FCT 19 were recorded.

PGV Environmental (2016) mapped 22 occurrences of FCT 19, of which the majority occur on the western side of Lot 17. All locations of FCT 19 occur within wetlands, however not all wetlands on the site contain FCT 19.

1.3 Super Lot Subdivision 156342

To assist in the protection of the environmental values associated with the western portion of the site (Part Lot 17), DevelopmentWA created two super lots. The western superlot was created for conservation purposes and the remainder of the site (Part Lot 17 and Lot 4) was consolidated into

one lot which will be developed in the future for general industrial purposes in accordance with its zoning under the MRS. The Western Australian Planning Commission (WAPC) approved the subdivision application 156342 on 6 July 2018 (Appendix 2). The subdivision when enacted by DevelopmentWA will establish Lot 1 (conservation) and Lot 2 (General Industry). For the purpose of this report, proposed Lot 2 will be referred to as the 'site'.

1.4 Scope of Work

This Environmental Assessment Report (EAR) has been prepared to facilitate the subdivision of the site and identify strategies to manage the environmental impact of developing the site for General Industry purposes.

The EAR addresses the following key environmental factors:

- Geology and Soils;
- Hydrology;
- Wetlands;
- Vegetation and Flora;
- Fauna; and
- Heritage.

The environmental factors have been validated and refined through:

- Review of environmental studies relating to the site; and
- Undertaking a desktop assessment.

2 EXISTING ENVIRONMENT

2.1 Land Use

The site currently consists of native bushland with a number of tracks traversing the site (Plate 3). Activities occurring on the site include uncontrolled four-wheel driving and illegal dumping of rubbish. The surrounding land uses consist of light commercial and industrial land to the west, residential housing to the north and Rockingham Lakes Regional Park to the south and east including Bush Forever Site 356 and Lake Walyungup.

Historically, construction surrounding the site first commenced between 1979 and 1981 consisting of a road to the east of the site (Plate 1). Vegetation was cleared to the south of the eastern half of the site between 1983 and 1985 (Landgate, 2014a) to construct a motorbike track. The track is still present and can be seen in Plate 1, however it is no longer in use and this area now makes up part of Bush Forever Site 356. Further clearing and construction had commenced to the west of the site by 1995 (Plate 3). The current internal tracks on the site, visible in Plate 3 are not evident in the 1985 photo.

Plate 1: Historical Aerial Photography of the site from 1985 (Landgate, 2020)

Plate 2: Historical Aerial Photography of the site from 1995 (Landgate, 2020)

Plate 3: Aerial Photography of the site from 2020 (Landgate, 2020)

2.2 Topography

The site contains low dunal ridges and swales, with an elevation ranging between 5-12m Australian Height Datum (AHD) (Figure 2).

2.3 Geomorphology, Geology and Soils

The site is located on the Quindalup South System which consists of coastal dunes of the Swan Coastal Plain with calcareous deep sands and yellow sands of aeolian origin over sedimentary rocks (DAFWA, 2014). There are two soil units located on the site, described as (DAFWA, 2014):

- Quindalup South Qf2 Phase (211Qu_Qf2) consists of relict foredunes and gently undulating beach ridge plains on quaternary deposits in the coast between Rockingham and Dunsborough with deep uniform calcareous sands.
- Quindalup South Qf2a Phase (211Qu_Qf2a) consists of more prominent relict foredune ridges than occurring within unit 211Qu_Qf2, with deep uniform calcareous sands.

The majority of the site consists of the Quindalup South Qf2 Phase (Figure 3). Areas of Quindalup South Qf2a Phase are located in the eastern and north-eastern parts of the site and also in the central western and south-western areas.

Douglas Partners (2011) conducted a Preliminary Geotechnical Investigation on the site in 2011. The Investigation was to assess the sub-surface soil and groundwater conditions. Test pit locations are shown in Appendix 3. One location (BH28) contained uncontrolled sand filling to a depth of 0.2m. All test pit locations contained topsoil consisting of brown silty sand mostly to depths between 0.05m and 0.15m. Encountered at all the test pits below the topsoil was medium dense, brown and light yellow-brown sand. At locations TP6, TP8, TP9, TP19, TP22 and TP26 very low strength lithified sand layers were encountered. Test pit BH27 was the only location that contained organic sand consisting of loose, dark grey sand with low plasticity fines from 1.1m to 1.5m depth (Douglas Partners, 2011).

2.4 Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table these soils are benign and not acidic (potential acid sulphate soils). However if the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid (EPA, 2008).

The site is mapped as having a Low Risk of ASS occurring within 3m of the natural soil surface (Figure 4).

2.5 Hydrology

2.5.1 Groundwater

The Perth Groundwater Atlas shows the groundwater at the site to occur between 3-5.5m below the surface (DoW, 2020). These levels were recorded in May of 2003 which is an indication of low groundwater levels (Figure 5).

The site is located on the eastern half of the Stakehill Mound. As such the direction of groundwater flow is to the east towards Lake Walyungup (see groundwater map in Appendix 4 Figure 2).

The groundwater salinity at the site is brackish being between 1000-1500mg/L (DoW, 2014).

Groundwater monitoring for the site was carried out by JDA Consultant Hydrologists (2011). An investigation of the Average Annual Maximum Groundwater Level (AAMGL) for the site was conducted in October 2009 and followed by an 18 month predevelopment hydrological monitoring program. A summary of the groundwater monitoring program is provided below in Tables 1, 2 and 3 and the Ground Water Monitoring Report is provided in Appendix 4.

The summer minimum groundwater levels at the site ranged between 2.30 - 3.63mAHD and the winter maximum ranged between 2.64 - 4.25mAHD (Table 1). The depth to the maximum groundwater levels below the natural surface varied between 1.70 - 5.12m. The seasonal groundwater levels varied in the range of 0.3m - 0.62m across the site (JDA, 2011).

Table 1: Groundwater Data from Site Bores (JDA, 2011)

Bore	Natural Surface (mAHD)	Summer Minimum Feb 2010		Winter Maximum Oct 2009		Seasonal Groundwater Variation (m)
		mBNS	mAHD	mBNS	mAHD	
PK1	5.88	2.89	2.99	2.41	3.47	0.48
PK2	5.81	2.48	3.33	1.91	3.90	0.57
PK3	6.37	2.74	3.63	2.12	4.25	0.62
PK4	5.80	2.91	2.89	2.51	3.29	0.4
PK5	5.32	2.22	3.10	1.70	3.62	0.52
PK6	5.63	2.44	3.19	1.89	3.74	0.55
PK7	6.98	4.64	2.34	4.34	2.64	0.3
PK8	8.00	5.7	2.30	5.12	2.88	0.58

Table 2: Mean Physical Parameter Measurements at Site Bores (JDA, 2011)

Bore	EC (mS/cm)	pH
PK1	0.49	7.63
PK2	0.59	7.34
PK3	0.47	7.62
PK4	0.65	7.18
PK5	0.65	7.42
PK6	0.79	7.16
PK7	0.63	7.62
PK8	0.62	7.46

Table 3: Mean Nutrient Concentrations at Site Bores (JDA, 2011)

Bore	Total P (mg/L)	PO_4-P (mg/L)	Total N (mg/L)	NOx-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)
PK1	0.08	0.01	10.72	8.75	0.44	2.78
PK2						
PK3	0.09	0.01	4.19	2.58	0.30	1.26

PK4						
PK5	0.09	0.01	4.22	2.22	0.28	2.03
PK6						
PK7	0.08	0.01	2.78	1.25	0.33	1.54
PK8	0.09	0.01	9.63	7.55	0.35	2.16

2.5.2 Surface Water

The site does not contain any drainage lines. The sandy nature of the soil allows rapid infiltration of rainfall with very little to no overland flow during rainfall events.

2.6 Wetlands

2.6.1 Geomorphic Wetlands

The site contains four wetlands as mapped by the *Geomorphic Wetlands of the Swan Coastal Plain* Database (National Map, 2020). These are described in Table 4 and shown in Figure 6.

Table 4: Geomorphic Wetlands Located on the Site

Wetland Classification	Wetland Type	UFI Number	Wetland Name
Conservation	Dampland	6259	Point Becher Wetland
Conservation	Dampland	6473	Point Becher Wetland
Conservation	Dampland	6474	Point Becher Wetland
Resource Enhancement	Dampland	14638	Point Becher Wetland

Several studies have shown that the mapped wetlands do not align with the location of wetlands on the ground (Appendix 5). PGV Environmental (2016) undertook a wetland vegetation assessment and a wetland boundary assessment (2017) to resolve the differences in the two previous wetland studies and to assess the vegetation within the proposed conservation area. Eleven wetlands (wetlands 14, 15, 16, 17,18, 19, 20, 21, 22, A and B) were mapped on the site (Plates 4-14). The wetland mapping did not match the mapping in the *Geomorphic Wetlands of the Swan Coastal Plain* Database but aligned closely with the TEC 19 boundaries provided by DBCA (V. English)

The environmental value of each wetland was assessed by PGV Environmental according to its size, condition, and vegetation types (Table 5). Seven of the eleven wetlands were rated as having a Low value due to the small size, poor condition, and low diversity of vegetation types. Several of the Low rated wetlands were considered transitional wetlands/drylands. The remaining four wetlands were rated as having a Medium environmental value.

Plate 4: Wetland A

Plate 5: Wetland B

Plate 6: Wetland 14

Plate 7: Wetland 15

Plate 8: Wetland 16

Plate 9: Wetland 17

Plate 10: Wetland 18

Plate 11: Wetland 19

Plate 12: Wetland 20

Plate 13: Wetland 21

Plate 14: Wetland 22

2.6.2 Becher Point Wetlands

The wetlands on the site are not part of the Becher Point Wetlands site which is listed as a Ramsar site (Wetlands of International Importance). However, the wetlands in the Conservation Area to the west of the development site are proposed to be managed by DBCA and added to the Rockingham Regional Lakes. As such they may be added to the Becher Point Wetlands Ramsar listing and managed accordingly.

Table 5: PGV Environmental Evaluation of Wetlands on the Site

Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments
14	19a	*Ficinia nodosa* Sedgeland mixed with *Bromus diandrus,* Oats, *Acacia saligna, Hakea prostrata.*	Good - Degraded	M	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
15	19b	*Melaleuca rhaphiophylla* Low Forest over weeds, some *Ficinia nodosa.*	Degraded	M	Good stand of Paperbark (*Melaleuca rhaphiophylla*) trees with degraded understorey.
16	No	*Xanthorrhoea preissii, Acacia saligna, Lepidosperma longitudinale,* some *Baumea juncea, Ficinia nodosa*.	Good	L	Small, wetland in average condition. Lack of diversity of wetland vegetation types.
17	19a	Central area of *Lepidosperma longitudinale, Ficinia nodosa, Gahnia trifida* Sedgeland and *Adriana quadripartita* shrubs surrounded by *Acacia saligna, Xanthorrhoea preissii* Shrubland	Good	M	Very small wetland, good surrounding vegetation.
18	No	*Xanthorrhoea preissii/Acacia rostellifera* Shrubland with few *Ficinia nodosa, Lepidosperma longitudinale* sedges.	Good - Degraded	L	Small marginal wetland in poor condition, very low wetland diversity.
19	No	Dense *Acacia saligna* Tall Shrubland over *Bromus diandrus* dense grassland. Some *Lepidosperma longitudinale* sedges.	Degraded	L	Poor quality marginal wetland.
20	19a	*Acacia rostellifera/ A. saligna* Shrubland over *Melaleuca systena, Bromus diandrus, Euphorbia terracina,* Oats. Very small amount of *Ficinia nodosa, Baumea juncea, Gahnia trifida, Lepidosperma longitudinale*.	Degraded	L	Poor quality marginal wetland.
21	19a	*Ficinia nodosa/Baumea juncea* Sedgeland with *Bromus diandrus* and Oats weeds. Surrounded by *Acacia rostellifera.*	Good - Degraded	M	Moderate size wetland in average condition, low wetland diversity.
22	19a	*Ficinia nodosa, Centella asiatica, Baumea juncea* surrounded by *Hakea prostrata, Acacia rostellifera, Acacia saligna*	Good	L	Small wetland in average condition, low wetland diversity.
A	19a	*Ficinia nodosa* Sedgeland mixed with weeds *Bromus diandrus*, Oats.	Good - Degraded	L	Poor condition wetland with low diversity.
B	19a	Some *Ficinia nodosa* sedges among *Xanthorrhoea preissii/Acacia rostellifera* Shrubland	Good	L	Very small wetland in average condition and low wetland diversity.

Environmental Value H – High M – Medium L - Low

2.7 Vegetation and Flora

2.7.1 Vegetation Complex

The vegetation on the site consists of the Quindalup Vegetation Complex (RPS-BBG, 2006) as identified by Heddle *et al.* (1980).

Assessments made in 1998 and quoted in Bush Forever estimated that there is approximately 47% of the Quindalup Vegetation Complex remaining on the Swan Coastal Plain of which 20% is protected or proposed for protection at that time (Government of Western Australia, 2000).

2.7.2 Vegetation Types

RPS-BBG (2006) conducted a Level 2 Spring Vegetation and Flora Survey in accordance with *Guidance Statement No. 51* (EPA, 2004). The report is provided at Appendix 6.

The following vegetation types were recorded (Appendix 6 - Figure B1):

- Dune System
    - 1a Open Low Heath of *Acacia rostellifera*, *Melaleuca systena* on Dune Swales and Crests
    - 1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
- Wetlands, Damplands and Depressions in Dune Swales
    - 2a Closed Sedgeland of *Baumea juncea*, *Baumea articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*
    - 2b Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
    - 2c Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

2.7.3 Vegetation Condition

RPS-BBG (2006) rated the condition of the vegetation based on the vegetation condition rating scale provided by Keighery in Bush Forever (Government of Western Australia, 2000) (Table 6).

Table 6: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
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.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. 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.

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.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These 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.

The vegetation condition was assessed by PGV Environmental in September 2014 during a survey of weeds and in October 2016 during the spring flora survey.

PGV Environmental considered that the rating of Very Good for most of the western half of the site was a bit high and rated it as Good to Very Good with small areas of Degraded to Completely Degraded adjacent to the tracks and around the perimeter. The eastern half was considered to be Good with some areas Good to Degraded. The main weed species on the site were:

- *Avena fatua* (Wild Oats);
- *Bromus diandrus* (Great Brome);
- *Euphorbia terracina* (Geraldton Carnation Weed);
- *Lolium perenne* (Annual Ryegrass); and
- *Trachyandra divaricata* (Onion Weed)

The vegetation condition mapping for the site is shown in Appendix 6 - Figure B1.

2.7.4 Conservation Significant Vegetation

The Threatened Ecological Community (TEC) SCP 19 '*Sedgelands in Holocene dune swales of the southern Swan Coastal Plain'* is known to occur on the site. The TEC is listed as Endangered under the EPBC Act and Critically Endangered at the State level.

Two sub-types of SCP 19 are recognised at State level although the TEC listing is for the overall SCP type (DEC, 2011). SCP 19a includes 'sedgelands in Holocene dune swales' while SCP 19b includes 'woodlands over sedgelands in Holocene dune swales'. SCP 19b is generally associated with the older occurrences of the community.

Six occurrences of TEC 19 are mapped on the site by DBCA (Figure 6). Five of the six occurrences are the sub-type 19a while one contains trees and is mapped as sub-type 19b. The three northern most TEC 19 areas were recognised by DBCA as being degraded due to firebreaks and weed impacts.

According to the wetland/TEC assessment undertaken by PGV Environmental (2016) the TEC mapping on the site is reasonably accurate, with some minor modifications (Figure 8). PGV Environmental (2016) mapped one additional occurrence of TEC 19a (Wetland B) on the site and assessed the vegetation in wetland 19 as not beingTEC19.

In total, PGV Environmental consider there are 8 occurrences of TEC19 in the development lot and 14 in the proposed conservation lot.

The vegetation types of the dryland vegetation on the site were analysed by RPS-BBG (2006) to be representative of SCP 29b ''*Acacia shrublands on taller dunes, southern Swan Coastal Plain*" which is recognised as a Priority 3 Ecological Community at State level. PGV Environmental concurs with the identification of 29b for the dryland vegetation.

2.7.5 Flora

A search of the EPBC Act Protected Matters Search Tool and the Naturemap database was conducted by PGV Environmental and identified eight species of significant flora that may potentially occur within 5km of the site (Table 7). The likelihood of these species occurring on the site is shown in Table 8. Strategen (2012) conducted a DPaW Declared Rare Flora and Priority Flora database search with a 10km radius around the site for which they found three records of *Jacksonia sericea* (P4) and one record of *Acacia benthamii* (P2) occurring within 10km of the site.

Table 7: Conservation Significant Flora likely to occur within 5km of the Site

Taxa	Common Name	Status under Biodiversity Conservation Act	Status under EPBC Act
Caladenia huegelii	King Spider Orchid	Schedule 1	Endangered
Drakaea elastica	Glossy-leafed Hammer Orchid	Schedule 1	Endangered
Drakaea micrantha	Dwarf Hammer Orchid	Schedule 2	Vulnerable
Diuris purdiei	Purdie's Donkey Orchid	Schedule 2	Endangered
Diuris drummondii	Tall Donkey Orchid	Schedule 3	Endangered
Diuris micrantha	Dwarf Bee-orchid	Schedule 3	Vulnerable
Beyeria cinerea subsp. *cinerea*		Priority 3	
Jacksonia sericea	Waldjumi	Priority 4	

Table 8: Likelihood of Identified Significant Flora Species Occurring on the Site

Species	Preferred Habitat*	Likelihood to be present on the site
Diuris drummondii	The Tall Donkey Orchid grows in low-lying depressions, swamps, in areas that contain surface water well into summer (Brown et al., 2013).	No
Caladenia huegelii	The Grand Spider-orchid prefers sand or clay loam. This species generally does not survive in disturbed areas.	No
Diuris micrantha	The Dwarf Bee-orchid is usually found on cleared firebreaks or open sandy patches that have been disturbed with in Jarrah Banksia woodland or thickets of Spearwood (Kunzea ericifolia/glabrescens) (Williams et al., 2001).	No
Diuris purdiei	Purdie's Donkey Orchid occurs in grey-black sand in moist winter-wet swamps.	No
Drakaea elastica	The Glossy-leafed Hammer Orchid prefers low-lying situations adjoining winter-wet swamps. This species does not survive in disturbed areas.	No

Species	Preferred Habitat*	Likelihood to be present on the site
Drakaea micrantha	Dwarf Hammer-orchid occurs in grey sands over dark, grey to blackish, sandy clay-loam substrates in winter wet depressions or swamps.	No
Beyeria cinerea subsp. *cinerea*	Beyeria cinerea subsp. cinerea grows in sand over limestone on road verges, gullies	No
Jacksonia sericea	Calcareous & sandy soils.	No

*sourced from Florabase, DoE SPRAT Database as well as the DPaW database searches.

A level 2 flora and vegetation survey of the site was undertaken in 2006 (RPS-BBG, 2006). The survey included sampling from sixteen 10m x 10m quadrats as well as recording species outside of the quadrats over a period spanning 31 August to 23 November 2006.

A more recent spring flora survey was also undertaken by PGV Environmental on 18 and 27 October 2016 by Dr Paul van der Moezel. The survey did not include sampling from quadrats as the 2006 survey was considered adequate in that regard. The 2016 survey included a thorough walk over the site to record plant species within the site and the proposed conservation area.

A total of 119 species were recorded from the site in the 2006 RPS survey. The total included 117 naturally occurring species and two planted ornamental species. Of the 119 species, 61 were native and 58 were introduced. The percentage of introduced species (49%) is relatively high and reflects the low quality of vegetation particularly on the eastern half of the site as well as along the tracks and edges of the site next to developed areas and roads.

The 2016 spring survey by PGV Environmental recorded 101 species, including 55 native and 46 introduced species. The percentage of introduced species (46%) was similar to that recorded by RPS in 2006.

PGV Environmental recorded 13 additional species not recorded in 2006 including six native and seven introduced species.

The total number of species recorded on the site between the two surveys is 132 (Lots 1 and 2), comprising 63 native and 69 introduced (46%) (Appendix 7).

2.7.6 Conservation Significant Flora

No Threatened (Declared Rare) or Priority Flora were recorded in the RPS-BBG survey in 2006 or the PGV Environmental survey in 2016.

2.8 Fauna

2.8.1 Fauna Habitat

A Level 1 fauna survey was undertaken by Bamford Consulting Ecologists (Bamford) in June 2011 to identify the fauna values over Lots 1 and 2 (Appendix 8). Bamford recorded two major fauna habitat types which were further divided into sub-units. These were:

- Sand dunes system

- Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes, sandplain and swales;
- Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes;

- Wetlands, Damplands and Seasonal Drainage Depressions in Dune Swales

  - Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*;
  - Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*;
  - Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgland of *Ficinia nodosa* and *Baumea juncea*.

The fauna habitat present is not considered to be key habitat for Priority or Threatened species.

2.8.2 Conservation Significant Fauna

A search of the EPBC Act Protected Matters Search Tool and the Naturemap database was conducted by PGV Environmental and identified 41 species of significant fauna that may potentially occur within 5km of the site (Table 9). Marine mammals, marine birds (albatross), turtles and fish were not included in Table 8.

Table 9: List of Fauna Species Identified from Database Searches

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Birds			
Anous tenuirostris melanops	Australian Lesser Noddy	Schedule 1	Vulnerable
Botaurus poiciloptilus	Australasian Bittern	Schedule 1	Endangered
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	Schedule 1	Endangered
Leipoa ocellata	Malleefowl	Schedule 1	Vulnerable
Numenius madagascariensis	Eastern Curlew	Schedule 1	
Limosa lapponica menzbieri	Bar-tailed Godwit	Schedule 1	Critically Endangered
Numenius madagascariensis	Eastern Curlew	Schedule 1	Critically Endangered
Calidris ferruginea	Curlew Sand Piper	Schedule 1	Critically Endangered
Botaurus poiciloptilus	Australasian Bittern	Schedule 2	Endangered
Calidris canutus	Red Knot	Schedule 2	Endangered
Rostratula australis	Australian Painted Snipe	Schedule 3	Endangered
Sternula nereis nereis	Australian Fairy Tern	Schedule 3	Vulnerable
*Actitis hypoleucos (*also listed as *Tringa hypoleucos)*	Common Sandpiper	Schedule 3	Marine/Migratory
Apus pacificus	Fork-tailed Swift	Schedule 3	Marine/Migratory
*Puffinus carneipes (*also listed as *Ardenna carneipes)*	Flesh-footed Shearwater	Schedule 3	Marine/Migratory
Calidris melanotos	Pectoral Sandpiper	Schedule 5	Marine/Migratory
Pandion haliaetus	Osprey	Schedule 5	Marine/Migratory
Tringa nebularia	Common Greenshank	Schedule 3	Marine/Migratory
Motacilla cinerea	Grey Wagtail	Schedule 5	Migratory
Mammals			
Pseudocheirus occidentalis	Western Ringtail Possum	Schedule 1	Critically Endangered
Bettongia penicillata ogilbyi	Woylie	Schedule 1	Endangered

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Dasyurus geoffroii	Chuditch	Schedule 3	Vulnerable
Isoodon fusciventer	Southern Brown Bandicoot	Priority 4	
Reptiles			
Morelia spilota subsp. *imbricata*	Carpet Python	Schedule 4	
Lerista lineata	Perth Slider, Lined Skink	Priority 3	
Insects			
Synemon gratiosa	Graceful Sunmoth	Priority 4	

Outlined below in Table 10 is a short description of each of the species that were identified in the NatureMap Species Report search and the EPBC Protected Matters Search Tool in Table 9. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present was determined.

Table 10: Likelihood of Conservation Significant Species being Present on the Site

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Birds			
Anous tenuirostris melanops	Australian Lesser Noddy	The Australian Lesser Noddy usually occupies coral-limestone islands that are densely fringed with White Mangrove *Avicennia marina* (DoE, 2014).	Species *unlikely* within the site.
Botaurus poiciloptilus	Australasian Bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands (DoE, 2014).	Species *unlikely* visitor to the site.
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Forest Red-tailed Black-Cockatoos frequent the humid to subhumid south-west from Gingin in the north, Albany in the south and west to Cape Leeuwin and Bunbury (DoE, 2014). It nests in tree hollows with a depth of 1-5m, that are predominately Marri, Jarrah and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri and Jarrah (Johnstone and Kirkby, 2011).	Species *unlikely* within the site.
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	Baudin's Black-Cockatoo mainly occurs in eucalypt forests, especially Jarrah (*E. marginata*), Marri (*Corymbia calophylla*), also Karri (*E. diversicolor*) forest, often feeding in the understorey on proteaceous trees and shrubs, especially banksias (Johnstone and Kirkby, 2011).	Species *unlikely* within the site.
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell) (SEWPaC, 2012)	Species *unlikely* within the site.

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Leipoa ocellata	Malleefowl	Malleefowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards in mallee bushland (DoE, 2014).	Species *unlikely* within the site.
Numenius madagascariensis	Eastern Curlew	The Eastern Curlew is a large wading bird most commonly found along sheltered coasts, particularly estuaries, bays, harbours, inlets and coastal lagoons that have large intertidal mudflats or sandflats, often containing seagrass. They often occur where there are mangroves (DoE, 2014).	Species *unlikely* within the site.
Limosa lapponica	Bar-tailed Godwit	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays (DoE, 2014).	Species *unlikely* within the site.
Calidris ferruginea	Curlew Sand Piper	Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms.	Species *unlikely* within the site.
Botaurus poiciloptilus	Australasian Bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands.	Species *possible* infrequent visitor to the site.
Calidris canutus	Red Knot	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs.	Species *unlikely* within the site.
Rostratula australis	Australian Painted Snipe	The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses (DoE, 2014).	Species *possible* infrequent visitor to the site.
Sternula nereis nereis	Australian Fairy Tern	The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation (DoE, 2014).	Species *unlikely* within the site.
*Actitis hypoleucos (*also listed as *Tringa hypoleucos)*	Common Sandpiper	The Common Sandpiper can be found in saltwater and freshwater wetlands, however it is mostly found around muddy margins or rocky shores and often associated with mangroves (DoE, 2014).	Species *unlikely* within the site.
Apus pacificus	Fork-tailed Swift	The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (DoE, 2014).	Species *possible* infrequent visitor to the site.
Calidris melanotos	Pectoral Sandpiper	The Pectoral Sandpiper prefers shallow fresh to saline wetlands and is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	Species *unlikely* within the site.

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Pandion haliaetus	Osprey	Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals.	Species *unlikely* within the site.
Tringa nebularia	Common Greenshank	The Common Greenshank is a wader and does not breed in Australia. This species can be found in many types of wetlands and has the widest distribution of any shorebird in Australia. This species typically feeds on molluscs, crustaceans, insects, and occasionally fish and frogs (DoE, 2014)	Species *possible* infrequent visitor to the site.
Motacilla cinerea	Grey Wagtail	The Grey Wagtail is mostly recorded in coastal areas in Western Australia (ALA, 2015) however is widespread. There is non-breeding habitat only in Australia and the species has a strong association with water, particularly rocky substrates along water courses but also lakes and marshes.	Species *possible* infrequent visitor to the site.
Mammals			
Dasyurus geoffroii	Chuditch	The Chuditch have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles (DoE, 2014).	Species *unlikely* within the site.
Bettongia penicillata ogilbyi	Woylie	The Woylie habitat types ranged from forest to grassland, coastal and inland. During the day the Woylie shelters under patches of dense undergrowth, logs and rock-cavities and occasionally in burrows (DoE, 2014)	Species *unlikely* within the site.
Pseudocheirus occidentalis	Western Ringtail Possum	The Western Ringtail Possum is confined to the south-west of Western Australia where it occurs mainly in coastal forests with *Agonis flexuosa*. The species is an arboreal and nocturnal herbivorous marsupial with a relatively small home range of 0.5-6ha, dependent on habitat type. It builds dreys for shelter in tree canopies and uses tree hollows. They are primarily arboreal, but will often move through the understorey or open ground to feed or gain shelter (DoE, 2014).	Species *unlikely* within the site.
Isoodon. fusciventer	Southern Brown Bandicoot	Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2012)	Species occurs within the site.
Reptiles			

Scientific Name	Common Name	Habitat	Likelihood to occur on the site
Morelia spilota subsp. *imbricata*	Carpet Python	The Carpet Python is a large snake found across the south-west of Western Australia, from Northampton, south to Albany and eastwards to Kalgoorlie including undisturbed remnant bushland near Perth and the Darling Ranges. This subspecies has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands and grasslands (AROD, 2012).	Species *possible* within the site.
Lerista lineata	Perth Slider, Lined Skink	The Perth Slider inhabits loose soil and leaf litter particularly in association with Banksias and white sands underneath shrubs and heath (PES, 2011).	Species *possible* within the site.
Insects			
Synemon gratiosa	Graceful Sun-moth	The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of *Lomandra maritima* and *Lomandra hermaphrodita* exclusively and therefore require the presence of one or both of these species to be present in an area (Bishop *et al.,* 2011).	Species occurs within the site.

2.8.3 Significant Fauna under the *WA Wildlife Conservation Act* 1950

Two species of conservation significance were recorded by Bamford (2011) within the site, Southern Brown Bandicoot (*Isoodon fusciventer)* which is listed as Priority 5 fauna by DPaW and the Graceful Sun-moth (*Synemon gratiosa*) which is a listed as a Priority 4 fauna by DPaW.

2.8.4 Significant Fauna under the EPBC Act 1999

Two species of conservation significance under the EPBC Act were recorded as being possible infrequent visitors to the site the Fork Tailed Swift (*Apus pacificus)* and Rainbow Bee-eater (*Merops ornatus.* Both of these species are migratory and are not reliant on the site for their survival.

The Forest Red-tailed Black Cockatoo was recorded flying over the site by Bamford (2011). The site does not contain foraging habitat for Black Cockatoos and there is no suitable breeding or roosting habitat.

2.8.5 Potential Pest Species

Feral cats would frequent the site due to the existing adjoining residential housing. Foxes may also be present on the site. These pest species would prey on the native species. Rabbits are a potential issue and will cause damage to native vegetation and limit the rehabilitation of native flora.

2.9 Heritage

2.9.1 Aboriginal Heritage

There are no registered aboriginal sites recorded in the Aboriginal Heritage Inquiry System as occurring on the site (National Map, 2020).

2.9.2 Cultural Heritage

There are no cultural sites recorded in the Heritage Council WA- States Register as occurring on the site (National Map, 2020).

2.10 Contaminated Sites

There are no reported Department of Environment and Regulation contaminated sites occurring on or adjacent to the site (National Map, 2020).

3 LEGISLATION, POLICY AND GUIDELINES

The environmental assessment of this site has taken into consideration the following legislation, policy and guidelines and these will guide the required and expected management outcomes from the Commonwealth, State and Local government agencies.

3.1 State Legislation

3.1.1 Ministerial Statement 368

The site was rezoned to Industrial in the MRS as part of major Amendment No. 938/33 in 1994. The Amendment included the following land use changes:

- Creation of a Rapid Transport Reserve for the Perth-Mandurah rail;
- Rezoning of the north-west corner of System 6 Area M103 for Public Purposes;
- Rezoning of the south-west portion of System 6 Area M103 west of Ennis Avenue for Urban and Industrial uses; and
- Widening of Safety Bay Road between Ennis Avenue and Mandurah Road.

The Amendment was referred to the Environmental Protection Authority (EPA) by the Department of Planning and Urban Development (now called the Department of Planning) in 1993. The EPA considered that the Amendment had potential for significant impacts on System 6 Areas M103 and M104, and on several lakes and wetlands and their vegetation. As a result, the EPA set the level of assessment as a Public Environmental Review (PER).

The assessment of scheme amendments under Section 38 of the *Environmental Protection Act 1986* (EP Act) was allowable in 1994 as that pre-dates the 1996 amendment to the EP Act which introduced Section 48A that required all schemes and scheme amendments to be referred to the EPA.

The Minister for the Environment approved the Amendment on 11 October 1994 (Ministerial Statement No. 368)

3.1.2 Vegetation Clearing under the Environmental Protection Act 1986

Under the EP Act, clearing of native vegetation requires a permit from DWER unless there is an exemption under the Schedule 6 of the EP Act or under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Proposals that have approval by means of a Ministerial Statement and which are implemented in accordance with that Statement have a Schedule 6 (Clause 2) exemption from requiring a clearing permit to clear native vegetation. Clearing in accordance with an approved subdivision is exempt under Clause 9 of Schedule 6.

The Department of Water and Environmental Regulation has confirmed with DevelopmentWA that any clearing that will be required for the development will be exempt from the requirement of a clearing permit as the site has been formally assessed under section 38 of the EP Act.

3.1.3 Biodiversity Conservation Act

The *Biodiversity Conservation Act 2016* (BC Act) protects all native species and Threatened Ecological Communities. The BC Act recognises that activities involving the taking of flora or fauna (other than threatened species) and the disturbing of fauna (including threatened species) that are approved under the EP Act do not require further approval under the BC Act if they are undertaken in accordance with any biodiversity conservation conditions that are applied to an authorisation. These activities include clearing of native vegetation done in accordance with an implementation decision under Part IV of the EP Act.

The occurrences of TEC19a that will be cleared for development will not require approval under the BC Act due to the original environmental approval (MS 368) giving approval to clear all native vegetation on the site.

3.2 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important heritage places, ecological communities, flora and fauna that are defined in the Act as matters of national environmental significance.

The EPBC Act applies to the following seven matters of national environmental significance:

- World heritage sites;
- National heritage places;
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed);
- Nationally threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions.

A significant impact, under the EPBC Act, is determined by the value, quality and sensitivity of the environment which is to be impacted and the magnitude, duration, intensity and geographic extent of the impacts (DoE, 2013). *The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DoE, 2013) provides a guide for determining the significance of an impact. Proposed actions that are deemed to have a significant impact should be referred to the Minister.

The EPBC Act applies to 'actions' which:

- Have a 'significant impact' on 'matters of national environmental significance';
- Are undertaken by Commonwealth government agencies and have a significant impact on the environment anywhere in the world; or
- Are undertaken by any person and have a significant impact on Commonwealth land (even if the activity is not actually carried out on the Commonwealth land).

One Threatened Ecological Community (TEC 19) that occurs on the site is listed under the EPBC Act. However, the State environmental approval (MS 368) predates the EPBC Act, and according to Section 43A of the EPBC Act, the prior approval, which is still valid, means the EPBC Act does not apply in this case.

3.3 State Policy

3.3.1 State Planning Policy No. 2.8 Bushland Policy for the Perth Metropolitan Region

SPP 2.8 in conjunction with Bush Forever (Government of Western Australia, 2000) seeks to ensure the protection of at least 10 per cent of the original extent of each vegetation complex within the Perth Metropolitan Region. SPP 2.8 was developed to ensure that bushland protection and management issues are appropriately addressed and integrated as a part of future land use. Bush Forever identified approximately 51,200 hectares of regionally significant vegetation for retention. The management of these areas include reservation and acquisition by the State government, negotiated planning solutions with owners who are seeking urban and/or industrial development and advice, assistance and incentive programs to support private conservation.

There are no Bush Forever sites within the site. Bush Forever Site No. 356 is located south of the site separated by Port Kennedy Drive. However, SPP 2.8 also applies to Local Bushland which includes the site. SPP 2.8 encourages local government to prepare a local bushland protection strategy which should aim at a number of things including identifying significant bushland sites for protection and management based on environmental, social and economic criteria, taking into consideration existing approvals and commitments.

3.3.2 State Planning Policy No. 2.9 Water Resources

SPP 2.9 aims to ensure the protection and appropriate management of water resources in line with state guidelines as included within the planning framework. The broad aims of this policy are to:

- Protect, conserve and enhance water resources;
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and other biological life and to maintain or improve the quality and quantity of water resources; and
- Promote and assist in the management and sustainable use of water resources.

As a part of implementing this policy, the Better Urban Water Management framework was developed (WAPC, 2008). The framework provides detail on how water resources should be considered at each stage of planning by identifying the various actions and investigations required with regard to regional and local planning strategies, town planning schemes, structure plans, subdivisions, strata subdivision and development applications (WAPC, 2008).

At subdivision, an Urban Water Management Plan will be prepared in accordance with the WAPC Better Urban Water Management Framework.

3.3.3 State Planning Policy No. 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning

SPP 5.4 addresses transport noise from within major transport corridors, including freight routes, and its impact on noise sensitive land uses. The policy aims to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best-practice design and construction standards for new development proposals and new or redeveloped transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

Major transport (road) corridors are defined as:

- State roads and national highways;
- Urban primary distributors as described on the metropolitan functional road hierarchy (MRWA, local government) network;
- Other urban roads carrying more than 20,000 vehicles per day;
- Primary freight roads (Perth metropolitan region);
- Primary freight roads (South-West region); and
- Primary freight roads (State-wide).

The noise criteria outlined in SPP 5.4 is applied to the outdoor areas of sensitive premises and describes the level of noise which must be met.

3.3.4 State Planning Policy 3.7 – Planning for Bushfire Prone Areas

The intent of this policy is to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfire on property. The policy objectives are to:

The objectives of this policy are to:

- Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.
- Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.
- Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.
- Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change

A Fire Management Plan will be prepared in accordance with SPP3.7 as part of the detailed subdivision process.

3.3.5 Wetlands Conservation Policy for Western Australia

The *Wetland Conservation Policy for Western Australia* (Government of Western Australia, 1997) outlines the State government's commitment to identify, maintain and manage the State's wetland resources which include lakes, swamps, marshes, springs, damplands, impoundments, intertidal flats and mangroves.

The objectives of the Policy are to:

- Prevent further loss or degradation of valuable wetlands and wetland types;
- Include viable representation of all major wetland types within the conservation reserve;
- Maintain viable wild populations which include the species and genetic diversity of wetland dependant flora and fauna; and
- Increase community awareness and appreciation for wetlands.

The site contains 3 Conservation wetlands (6259, 6473, 6474) and one Resource Enhancement (14638) wetland as mapped in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset. PGV Environmental mapped five additional wetlands on the site (Figure 7).

One wetland mapped as wetland 15 has been retained in the proposed subdivision. DBCA recognise the industrial zoning approved in 1994 (allowed complete development of both Lots 4 and 17) which was environmentally acceptable to the EPA.

3.3.6 Environmental Protection Authority Guidance Statement No. 33 Environmental Guidance for Planning and Development

The purpose of EPA Guidance Statement No. 33 *Environmental Guidance for Planning and Development* (EPA, 2008) is to outline the significance of environmental factors and to provide the key definitions associated with the environmental factors. Ensuring that environmental factors are considered in line with the EPA's principals and objectives and within the planning framework is what this EAR is primarily targeted at. In particular, EPA Guidance Statement No. 33 aims to:

- Provide an overview to environmental protection processes and information;
- Describe the referral and environmental impact assessment process under Part IV of the EP Act; and
- Provide the EPA's position and advice on a range of environmental factors, outlining how to protect, conserve and enhance the environmental values.

3.3.7 Environmental Protection Authority Guidance Statement No. 3 Separation Distances between Industrial and Sensitive Land Uses

This guidance statement specifically addresses generic separation distances between industrial and sensitive land uses to avoid conflicts between these land uses. It takes into account protection of the environment as defined by the *Environmental Protection Act 1986* (EP Act) with a focus on protecting sensitive land uses from unacceptable impacts on amenity that may result from industrial activities, emissions and infrastructure.

A number of emissions are generated by industrial, commercial and rural activities and infrastructure. These include noise and air emissions (gases, dust and odours). The levels of emissions may at times exceed amenity levels considered acceptable in residential areas and at other sensitive land uses.

4 CONCEPT PLAN

A Concept Plan has been prepared by Element for the site (Appendix 9). The plan creates 117 Lots for General Industry use in accordance with the MRS zoning.

The central wetland identified by PGV Environmental as wetland 15 and containing a small area of TEC19b has been retained with a management buffer of 50m as Public Open Space in the Concept Design. The core area of the wetland will be managed for conservation purposes. Some public facilities such as seating and tables may be included around the central core area.

The interface with proposed Lot 1 (conservation lot) has a road separating the conservation area from the development along the eastern side and a pedestrian path along the northern side separating lots from the development to meet the requirements of DBCA. The hard interface will assist in managing weeds and also provide additional setback for fire management purposes.

5 ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

5.1 Landform and Soils

The landforms and soils contained on the site are not a constraint to development.

The geotechnical investigation did not identify any constraints to development and a classification 'Class A" in accordance with AS2870-2011 would be suitable for the site provided the site preparation identified in the Geotechnical Report is carried out.

5.2 Acid Sulphate Soils

The site is mapped as having a low risk of Acid Sulphate soils and therefore is not a constraint to development.

5.3 Stormwater Management

5.3.1 Water Sensitive Urban Design Principles and Objectives

WAPC (2008) outlines the principal objectives of Water Sensitive Urban Design (WSUD) as:

Implementation of sustainable best practice in water management which should:

- Encourage environmentally responsible development to meet catchment management intentions;
- Provide clarity for agencies involved with implementation;
- Facilitate adaptive management responses to the monitored outcomes of development;
- Minimise public risk, including risk of injury or loss of life; and
- Maintain the total water cycle.

5.3.2 Potential Impacts

Surface and groundwater can be impacted by a variety of activities:

- Groundwater level changes can occur as a result of a change in land use;
- Removal of vegetation and installation of impervious surfaces can lead to an increase in runoff during rainfall events;
- Development can increase the potential for industrial pollutants such as nutrients, hydrocarbons, metals and sediment being discharged via runoff and can influence the water chemistry of wetlands;
- Nutrient loading to the groundwater and surface water can occur; and
- Stormwater drainage can facilitate the transportation of nutrients (through surface run-off) and potential contaminants (e.g. litter) through the subject land.

5.3.3 Management Measures

To ensure that the quantity and quality of water is maintained to protect the receiving and surrounding environments, an Urban Water Management Plan (UWMP) will be prepared as part of the detailed subdivision design:

The UWMP will include the following Water Sensitive Urban Design (WSUD) principles:

- Provide protection to life and property from a 1 in 100 year flood event;
- Manage stormwater to minimise run off as high in the catchment as possible;
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features, regimes and processes and integrate these into the industrial landscape;
- Maximise water use efficiency and reduce potable water demand;
- Minimise pollutant inputs through implementation of appropriate non-structural source controls.

A summary of the WSUD strategies to be applied are:

- Compliance with environmental quality criteria;
- Compliance with relevant stormwater management policies;
- Application of WSUD treatment trains (where applicable);
- Preparation of water management strategies;
- Minimum percentage area of deep rooted perennial vegetation;
- Building and landscape guidelines; and
- Construction and building site management.

5.4 Sewer Connection

The development is required by the Western Australian Water Corporation to tie into the sewer main to the west of the conservation lot adjacent to Bessemer Road that services the existing western sector of the Business Park. It is proposed that the sewer main will be installed through the conservation area using horizontal boring to a depth of 6m. Other options have been investigated, however they will all require fill being brought into the site to get the required levels for the sewer main operation. The costs and indirect impacts (import of fill, potential vegetation clearing to source fill) of raising the lot are greater than horizontal boring.

The impact on the groundwater and conservation area (wetlands and vegetation) from the horizontal boring for the connection into the sewer line to the west have been considered. The horizontal drilling method will avoid any surface impacts to the conservation area and will minimise impacts on the hydrological regime of the wetlands. Both the direction of the sewer line and the groundwater flow will be in an easterly direction, therefore a barrier to the groundwater flow will not be formed and interruption of flows are expected to be negligible, if any.

As with all construction activities, there are risks that need to be managed in connecting the sewer line. In addition, the Water Corporation will need to operate the asset in the future. It is proposed to build in redundancy with the drill shot under the conservation area to manage the above. This will be achieved by:

- Drilling a larger diameter sleeve under the conservation area. A larger diameter sleeve (approximately 800mm diameter) brings greater accuracy and the ability to manage variable ground conditions. This minimises the risk of any excavations within the conservation area.
- The larger sleeve also allows two parallel sewers to be installed internally. This provides a backup line for the Water Corporation in case of a blockage. Flows can be transferred to the alternate line very easily and any maintenance works can occur without the need to bypass flows.

This is an accepted common practice where access over the sewer is not available.

To manage the extent of dewatering during these sewer works, it is suggested the Contractor utilise plugged base caissons at the bore and receival pits. This will remove the need to dewater, minimising the impact on the water levels under the wetlands in the conservation area.

5.5 Wetlands

5.5.1 Potential Impacts

Nine wetlands detailed in Table 11 will be impacted by the development while wetlands 14 and 15 will be retained.

Table 11: Wetlands on the Development Lot

PGV Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments	Retained in Concept Plan Y/N
14	19a	*Ficinia nodosa* Sedgeland mixed with *Bromus diandrus,* Oats, *Acacia saligna, Hakea prostrata.*	Good - Degraded	M	Small, wetland in average condition. Lack of diversity of wetland vegetation types.	Y will be included in conservation lot
15	19b	*Melaleuca rhaphiophylla* Low Forest over weeds, some *Ficinia nodosa.*	Degraded	M	Good stand of Paperbark (*Melaleuca rhaphiophylla*) trees with degraded understorey. Likely to be retained as POS in the future development plan.	Y included in POS
16	No	*Xanthorrhoea preissii, Acacia saligna, Lepidosperma longitudinale,* some *Baumea juncea, Ficinia nodosa*.	Good	L	Small, wetland in average condition. Lack of diversity of wetland vegetation types.	N
17	19a	Central area of *Lepidosperma longitudinale, Ficinia nodosa, Gahnia trifida* Sedgeland and *Adriana quadripartita* shrubs surrounded by *Acacia saligna, Xanthorrhoea preissii* Shrubland	Good	M	Very small wetland, good surrounding vegetation.	N
18	No	*Xanthorrhoea preissii/Acacia rostellifera* Shrubland with few *Ficinia nodosa, Lepidosperma longitudinale* sedges.	Good - Degraded	L	Small marginal wetland in poor condition, very low wetland diversity.	N
19	No	Dense *Acacia saligna* Tall Shrubland over *Bromus diandrus* dense grassland. Some *Lepidosperma longitudinale* sedges.	Degraded	L	Poor quality marginal wetland.	N
20	19a	*Acacia rostellifera/ A. saligna* Shrubland over *Melaleuca systena, Bromus diandrus, Euphorbia terracina,* Oats. Very small amount of *Ficinia nodosa, Baumea juncea, Gahnia trifida, Lepidosperma longitudinale*.	Degraded	L	Poor quality marginal wetland.	N
21	19a	*Ficinia nodosa/Baumea juncea* Sedgeland with *Bromus diandrus* and Oats weeds. Surrounded by *Acacia rostellifera.*	Good - Degraded	M	Moderate size wetland in average condition, low wetland diversity.	N
22	19a	*Ficinia nodosa, Centella asiatica, Baumea*	Good	L	Small wetland in average condition, low wetland	N

PGV Wetland No.	TEC 19	Vegetation Description	Vegetation Condition	Environmental Value	Comments	Retained in Concept Plan Y/N
		juncea surrounded by *Hakea prostrata, Acacia rostellifera, Acacia saligna*			diversity.	
A	19a	*Ficinia nodosa* Sedgeland mixed with weeds *Bromus diandrus*, Oats.	Good - Degraded	L	Poor condition wetland with low diversity.	N
B	19a	Some *Ficinia nodosa* sedges among *Xanthorrhoea preissii/Acacia rostellifera* Shrubland	Good	L	Very small wetland in average condition and low wetland diversity.	N

5.5.2 Management Measures

The Concept Plan has retained the highest environmental value wetland (Wetland 15) that contains a mature stand of Paperbarks in POS. The wetland has been retained with a 50m buffer and will be managed for conservation. Some public facilities may be placed around the periphery of the management buffer to provide seats and tables.

Wetland 14 will be added to the conservation area through a variation to the WAPC 156342 approval. The variation will move the boundary between the lots so that Wetland 14 is within the conservation area (see Appendix 2).
For the wetlands retained in the proposed Lot 1 (Conservation Area) the concept plan provides road around the eastern interface and a pedestrian path along the northern end to provide a hard management buffer to the conservation area. The wetlands in the proposed Lot 1 conservation area will be managed for conservation purposes with the end goal being to include the conservation area in the Rockingham Lakes Regional Park and managed by DBCA.

No stormwater from the development area will be disposed of into the POS or the Conservation Area. Groundwater under the future development area flows to the east towards Lake Walyungup. As a result, the groundwater under the development site is moving away from the wetlands in the Conservation Area reducing any potential impacts of development on the wetlands. Nevertheless, a Water Sensitive Urban Design approach to stormwater management will be undertaken for the development.

Construction activities need to be managed to minimise the impact to the conservation area during the bulk earthworks and construction phases. Impacts may include nuisance dust generation during bulk earthworks, accidental release of pollutants (fuel storage), vehicular activities, disturbance of acid sulphate soils and associated dewatering. These impacts are manageable through appropriate engineering design and good site management practices.

A Conservation Area Management Plan (CAMP) will be prepared in accordance with WAPC 156342 Condition 2 and will cover the following aspects prior to any construction works on the site:

- Fencing the boundary of the Conservation Area;
- Removal of rubbish;
- Rehabilitating areas of degraded vegetation to a suitable standard that the Conservation Public Open Space can be handed to City of Rockingham for management;
- Retaining or creating appropriate access tracks for the public and fire management;
- Closing and rehabilitating existing tracks where appropriate;
- Installing signage for public awareness of environmental values;
- Undertaking weed control;
- Monitoring vegetation health; and
- Implementation, monitoring, reporting and responsibility.

The CAMP will be submitted to the DBCA for approval.

The two wetlands to be retained in the development lot, together with the 17 included in the Lot 1 conservation area, will result in a total of 19 wetlands being protected. Existing environmental approval allows for all vegetation and wetlands on the Lots 4 and 17 to be cleared. Therefore, the retention of 19 wetlands is an excellent environmental outcome.

5.6 Vegetation and Flora

5.6.1 Potential Impacts

The main potential impact to native vegetation within the subject land from the proposed development is removal of vegetation from the site.

5.6.2 Vegetation Retention

The only vegetation retained on the site is associated with wetland 15 and its management buffer, the remainder of the native vegetation will be cleared for development.

The occurrences of TEC19 on the site are described in Table 11. Five small occurrences of TEC19a will be cleared for development (Table 12). The TEC19b occurrence in wetland 15 has been retained in the POS and the area of TEC19 in wetland 14 will be added to the conservation area.

Fourteen instances of the TEC have been retained in the conservation area to the west.

Table 12: Summary of TECs

Subdivision Design	TEC		
	19a	19b	Total
Inside Conservation Area - retained	13	1	14
In Development Area - retained	1	1	2
In Development Area - cleared	6	0	6

5.6.1 Management Measures

A CAMP will be prepared and implemented to ensure the protection and improvement of the flora, vegetation, wetlands and fauna in the proposed conservation area.

The conservation area will be separated from the development area by a road reserve which will assist in providing a buffer between the development and the conservation area.

The following measures will be undertaken in the area to be cleared of native vegetation:

- The location and limit of clearing of vegetation within all work areas will be clearly identified on site and delineated on appropriate plans. These will be supplied to contractors and site personnel prior to commencement of works;
- The conservation Public Open Space will be surveyed, fenced and if required dust curtains will be put in place to minimise dust impacts form the construction area;
- Native vegetation to be cleared will be removed in a systematic manner and stockpiled where appropriate for later use in rehabilitation and landscaping of POS areas.
- The stockpiling of cleared vegetation of a poor quality will be separate to that of good quality to minimise the spread of weeds. Only good quality vegetation will be used for mulch and rehabilitation.
- No burning of cleared vegetation will be permitted during any stage of construction.

5.7 Fauna

5.7.1 Potential Impacts

The main impact to fauna and fauna habitat on the site includes:

- Loss of habitat through vegetation clearing;
- Land clearing and vehicle movement may result in death or injury of fauna as a result of collisions;
- Species interactions, including predation and competition; and
- Disturbance of fauna off-site from light spill, noise and human disturbance.

5.7.2 Management Measures

Prior to clearing, a fauna trapping exercise will be undertaken to relocate as much fauna as possible to nearby reserves. Following that, clearing should be undertaken from east to west to allow any remaining fauna to move into the Conservation Area.

5.8 Noise and Dust Management

Land use around the site includes the following:

- Residential development to the north;
- Rockingham Lakes Regional Park to the east and south; and
- Light industry to the west.

Port Kennedy Drive and Ennis Ave are main roads and the Perth-Mandurah passenger rail line is located on the east side of Ennis Ave.

5.8.1 Potential Impacts

Existing noise sources are considered unlikely to impact on the development of the site for light industrial purposes.

With respect to noise emissions from the site, future development must comply with the *Environmental Protection (Noise) Regulations 1997.*

Dust emissions during the construction phase have the potential to impact on the residential area to the north.

5.8.2 Management Measures

Land uses considered suitable for light industrial areas under the Town Planning Scheme are generally unlikely to exceed the *Environmental Protection (Noise) Regulations 1997.*

The residential land to the north of the site is considered to be a 'sensitive land uses' under EPA *Guidance Statement No. 3: Separation Distance between Industrial and Sensitive Land Uses* (2005). The proposed development will comply with the Guidance Statement to ensure adequate separation distances and or management measures for any industry that may cause noise emissions.

The northern interface to the residential area will consider appropriate low impact industrial land uses to preserve the amenity of adjoining residences.

A Dust Management Plan will be prepared to meet the City of Rockingham guidelines in accordance with the subdivision approval prior to commencement of construction.

5.9 Fire Management

The proposed development will be near bushland to the south of Port Kennedy Drive, to the west in the proposed Conservation Area. A bushfire hazard assessment and management plan will be prepared in accordance with *State Planning Policy 3.7 and Guidelines -Policy and regional information for planning in bushfire prone areas.*

6 SUMMARY AND CONCLUSIONS

This Environmental Assessment Report has reviewed the environmental values of proposed Lot 2 (the site) Port Kennedy Drive, Port Kennedy and assessed the potential environmental impact of a Concept Plan and the future development of the site for industrial purposes. The conclusions of the assessment are:

- Full development of the 50.67ha site has environmental approval as a result of the EPA assessment of the rezoning to Industrial in 1994 and Ministerial Statement No. 368 which approved the rezoning. Nevertheless, DevelopmentWA is not seeking full development of the site;
- Development of the whole site includes industrial development on 34.3ha and the creation of a conservation area on the western 16.4ha;
- The conservation area protects a large proportion of the significant wetlands, TEC19 and native vegetation types on the whole site;
- The development site's key environmental values are:
  - eleven individual wetlands, rated as having medium and low environmental values;
  - Threatened Ecological Community (TEC) 19a and 19b in eight of the wetlands; and
  - Fauna habitat for some conservation significant fauna species;
- The Concept Plan will retain the most important wetland (number 15) and an example ofTEC19b in POS (1.7452ha). The Conservation Area will be expanded to include an additional wetland/TEC19 (wetland 14) on the southern boundary;
- ;
- remaining occurrences of TEC19a proposed to be cleared are mostly small and in poor quality, some of which are considered marginal TECs;
- No Declared Rare or Priority Flora occur within the site;
- Fauna relocation, including Quenda, will be undertaken prior to clearing native vegetation from the development site;
- An Urban Water Management Plan will be prepared to facilitate stormwater development of the site in accordance with Water Sensitive Urban Design principles;
- The proposed sewer connection from the development site westwards through the conservation area can be installed without any environmental impact on the vegetation and wetlands in the conservation area;
- With respect to noise emissions from the site, future development must comply with the *Environmental Protection (Noise) Regulations 1997*; and
- A bushfire hazard assessment and Bushfire Management Plan will be required to guide the future subdivision of the development lot.

This Environmental Assessment Report concludes that development of the site in accordance with the Concept Plan and the associated management measures outlined in this report, as well as the retention of a conservation area in the western part of Lot 17, will protect the important environmental assets of the site.

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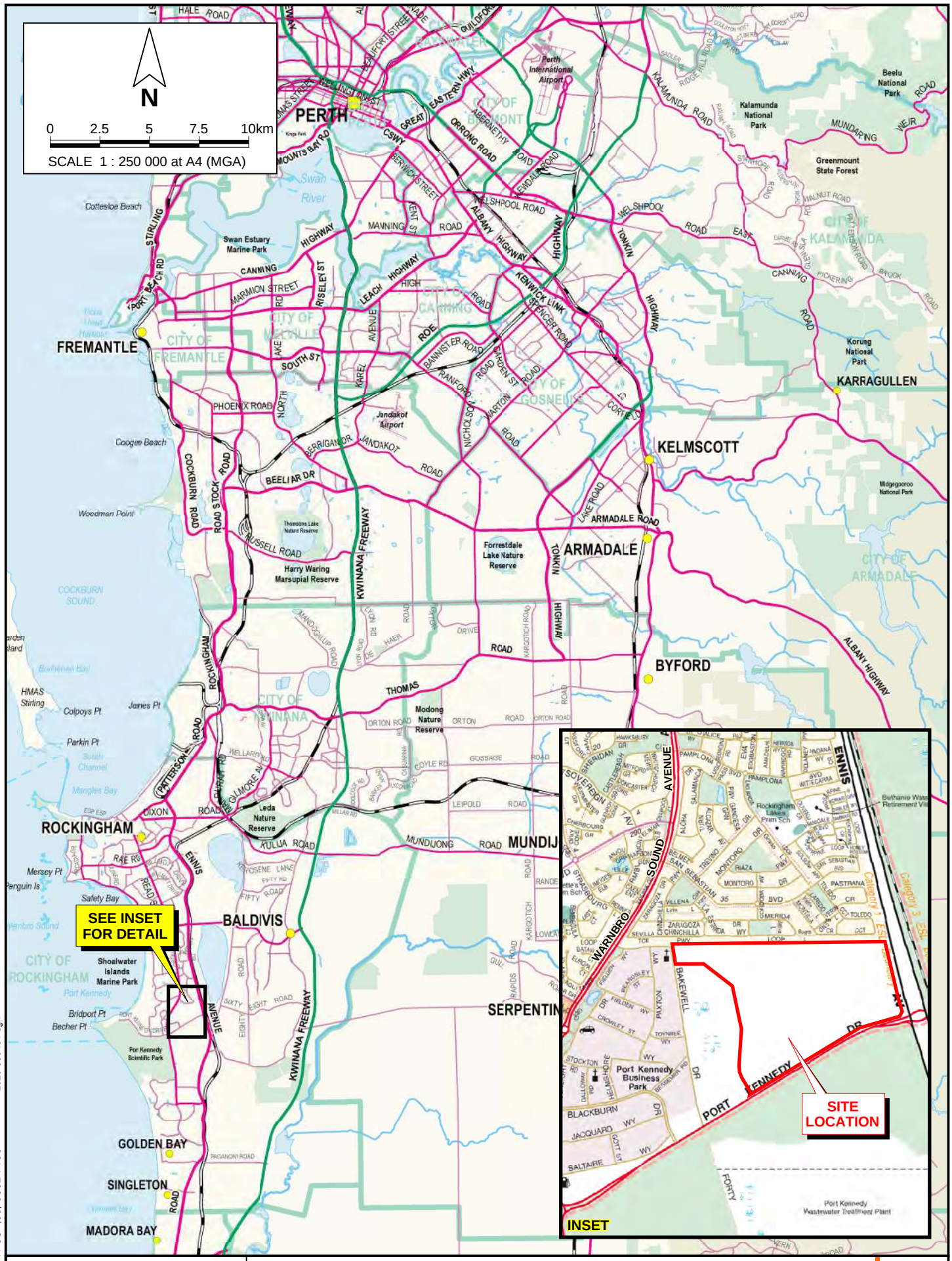
FIGURES



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LandCorp
ENVIRONMENTAL ASSESSMENT REPORT
PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

SITE LOCATION

Figure 1

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

KENNEDY DRIVE

PORT

ENNIS AVENUE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

4830 R 47412

4831

4920

8045

8046

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- Topographic Contour

CADASTRAL SOURCE: Landgate, December 2020.
CONTOUR SOURCE: Department of Agriculture, 2000.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

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2020-556-f02.dgn

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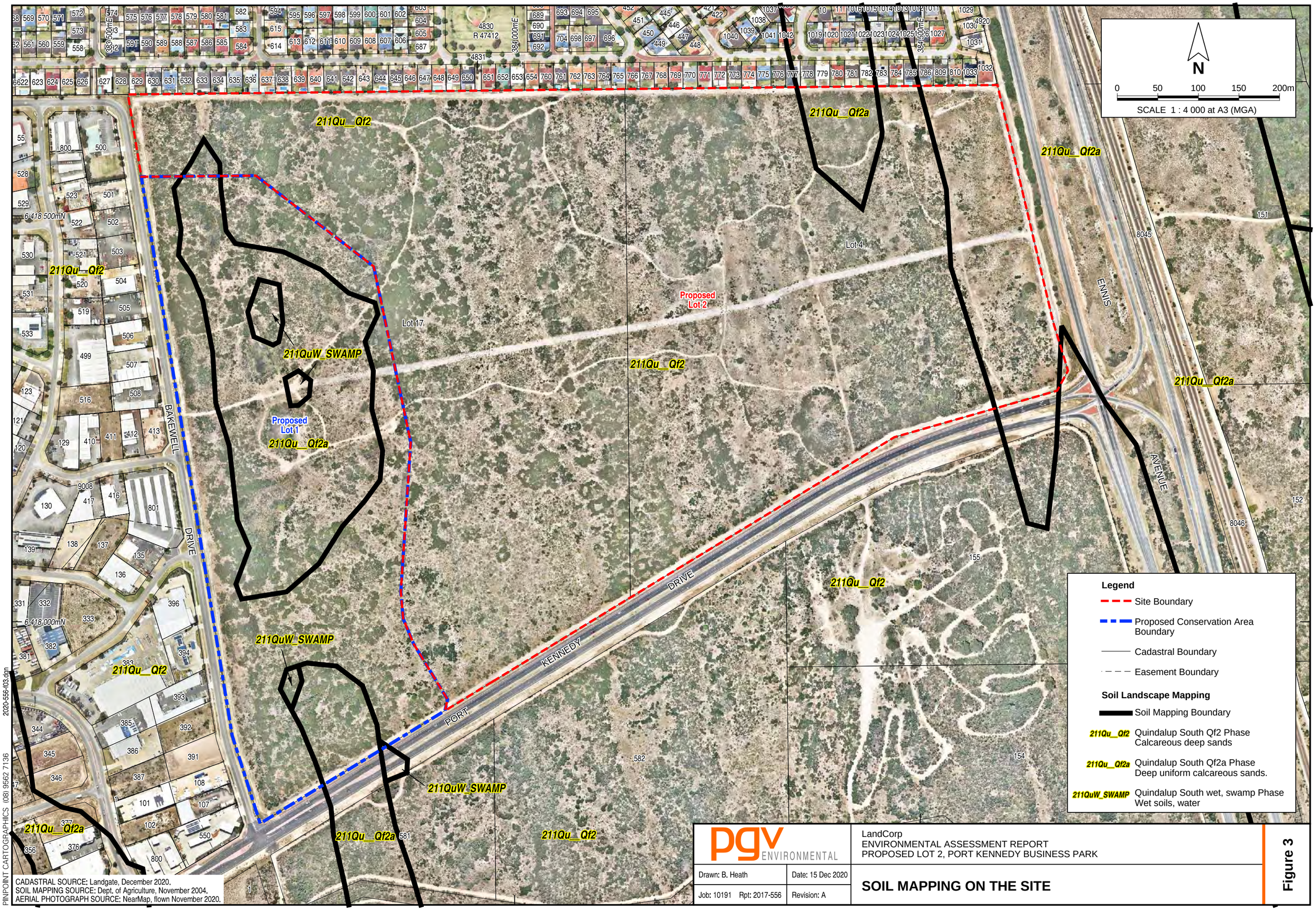
SITE BOUNDARY AND TOPOGRAPHY

Figure 2



CADASTRAL SOURCE: Landgate, December 2020.
SOIL MAPPING SOURCE: Dept. of Agriculture, November 2004.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f03.dgn

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SOIL MAPPING ON THE SITE

Figure 3

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

383 500mE

384 000mE

384 500mE

385 000mE

6 418 500mN

6 418 000mN

BAKEWELL DRIVE

ENNIS AVENUE

KENNEDY DRIVE

PORT

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary

Acid Sulfate Soil Risk

- High to Moderate Risk

ASS SOURCE: DER, January 2010.
CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f04.dgn

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ACID SULFATE SOIL RISK MAPPING

Figure 4

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

383 500mE

384 000mE

384 500mE

385 000mE

6 418 500mN

6 418 000mN

BAKEWELL DRIVE

PORT KENNEDY DRIVE

ENNIS AVENUE

Proposed Lot 1

Proposed Lot 2

Lot 4

Lot 17

1

2

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- Minimum Groundwater Contour

CADASTRAL SOURCE: Landgate, December 2020.
GROUNDWATER CONTOUR SOURCE: DoW, May 2003.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

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REGIONAL GROUNDWATER

Figure 5

2020-556-f05.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

14638
14639
6259
6471
6472
6260
6261
6262
6263
6265
6452
6235
6473
6474
6453
6234
6238
6240

Lot 17
Lot 4
Proposed Lot 1
Proposed Lot 2

BAKEWELL DRIVE
ENNIS AVENUE
KENNEDY DRIVE
PORT

6418 500mN
6418 000mN
383 500mE
384 000mE
384 500mE

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary

Threatened Ecological Community

- SCP19a
- SCP19b

Geomorphic Wetlands

- Conservation Category (CCW)
- Resource Enhancement (REW)
- 6263 Wetland UFI

TEC SOURCE: DPaW, August 2016.
WETLANDS SOURCE: DPaW, March 2016.
CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f06.dgn

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ENVIRONMENTAL ASSESSMENT REPORT
PROPOSED LOT 2, PORT KENNEDY BUSINESS PARK

DBCA GEOMORPHIC WETLAND AND FCT 19 MAPPING

Figure 6

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

KENNEDY DRIVE

PORT ENNIS AVENUE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

4830 R 47412

4831

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- PGV Wetland Mapping

Environmental Value

- H
- M
- L

CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

PINPOINT CARTOGRAPHICS (08) 9562 7136 2020-556-f07.dgn

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PGV ENVIRONMENTAL WETLAND MAPPING

Figure 7

N

0 50 100 150 200m

SCALE 1 : 4 000 at A3 (MGA)

Proposed Drill Alignment for Sewer

Proposed Lot 1

Proposed Lot 2

Lot 17

Lot 4

BAKEWELL DRIVE

ENNIS AVENUE

KENNEDY DRIVE

PORT KENNEDY DRIVE

6 418 500mN

6 418 000mN

383 500mE

384 000mE

384 500mE

Legend

- Site Boundary
- Proposed Conservation Area Boundary
- Cadastral Boundary
- Easement Boundary
- PGV Wetland Mapping
- TEC 19a
- TEC 19b

Environmental Value

- H
- M
- L

CADASTRAL SOURCE: Landgate, December 2020.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2020.

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Job: 10191 Rpt: 2017-556 | Revision: A

PGV ENVIRONMENTAL FCT19 MAPPING

Figure 8

APPENDIX 1

MINISTERIAL STATEMENT 368

Ass # 838

Bull # 746

State # 368

WESTERN AUSTRALIA

MINISTER FOR THE ENVIRONMENT

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

CHANGES OF LAND USE AFFECTING SYSTEM SIX AREAS AND LAKES PROTECTED UNDER THE ENVIRONMENTAL PROTECTION POLICY TO URBAN, INDUSTRIAL, SPECIAL USES AND TRANSPORTATION PURPOSES, TO BE REFLECTED IN THE MAJOR METROPOLITAN REGION SCHEME AMENDMENTS FOR THE SOUTH-WEST CORRIDOR (838)

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

This proposal may be implemented subject to the following conditions:

1 Proponent Commitments
The proponent has made a number of environmental management commitments in order to protect the environment.

1-1 In implementing the proposal, the proponent shall fulfil the commitments made in the Public Environmental Review and in response to issues raised following public submissions; provided that the commitments are not inconsistent with the conditions or procedures contained in this statement. These commitments are consolidated in Environmental Protection Authority Bulletin 746 as Appendix 4. (A copy of the commitments is attached.)

2 Implementation
Changes to the proposal which are not substantial may be carried out with the approval of the Minister for the Environment.

2-1 Subject to these conditions, the manner of detailed implementation of the proposal shall conform in substance with that set out in any designs, specifications, plans or other technical material submitted by the proponent to the Environmental Protection Authority with the proposal. Where, in the course of that detailed implementation, the proponent seeks to change those designs, specifications, plans or other technical material in any way that the Minister for the Environment determines on the advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

Published on

11 OCT 1994

12th FLOOR, DUMAS HOUSE, 2 HAVELOCK STREET, WEST PERTH, 6005 TELEPHONE (09) 321 3333 FAX (09) 322 5140

3 Rapid Transport Reserve Alignment

3-1 The proponent shall modify the Metropolitan Region Scheme amendments 937/33 and 938/33 to be consistent with the alignment of the Rapid Transport Reserve as shown in Figures 1 to 12 (Copies attached).

3-2 Prior to construction commencing, to ameliorate and minimise the environmental impacts associated with the construction and operation of the Rapid Transport System, the proponent shall prepare an Environmental Management Programme to the requirements of the Minister for the Environment on advice of the Department of Environmental Protection and the Department of Conservation and Land Management. (See procedure 3).

This Programme, which shall be released for public review for four weeks, shall address, but not be limited to:

1 impacts on vegetation, fauna, hydrology and wetlands; and

2 access to reserves.

4 Deletions from System Six Area M103

4-1 The proponent shall not take any action which will remove the north-west part of System Six Area M103 in Hillman from 'Parks and Recreation Reserve' for 'Public Purposes', or any other purpose which will jeopardise its tenure and management for conservation. (See Figure 14 attached).

4-2 The proponent may allow the development of the area west of Ennis Avenue which is currently within System 6 Area M103 subject to the following requirements:

1 Land owned by the State Planning Commission generally known as Lark Hill shown on Figure 13 (copy attached) west of Warnbro Sound Avenue between Port Kennedy Drive and Secret Harbour and east of the area subject to the Port Kennedy Development Act to be secured and managed for conservation purposes;

2 Land owned by the State Planning Commission reserved under the Metropolitan Region Scheme for Public Purposes generally known as Lark Hill shown on Figure 13 (copy attached) east of Warnbro Sound Avenue, south of Port Kennedy Drive and west of Ennis Avenue and Mandurah Road to be secured and managed for recreational and conservation purposes;

3 A linkage to be provided between the greater part of System 6 Area M103 east of Ennis Avenue through to the coast at Port Kennedy, consistent with recommendations made for System 6 Area M106; and

4 Integration of the management of the area referred to in requirements 1, 2 and 3 above with the management of the Port Kennedy conservation area and the greater area of System Six Area M103.

4-3 Prior to 31 December 1995, the proponent shall ensure that a single integrated Management Plan is prepared for the entire area of the conservation estate (i.e. System Six Area M103, Lark Hill and Port Kennedy conservation areas), to the requirements of the Environmental Protection Authority on advice of the Department of Conservation and Land Management and the Commissioner for Soil and Land Conservation.

This Plan shall identify:

1 the management purpose of specific areas;

2 linkages provided between the greater part of System 6 Area M103 east of Ennis Avenue and the coast at Port Kennedy; and

3 agencies responsible for its implementation; and

4 provide a timetable for implementation.

5 Widening of Safety Bay Road

5-1 Prior to construction of Safety Bay Road between Ennis Avenue and Mandurah Road, Rockingham, the proponent shall prepare an Environmental Management Programme to the requirements of the Minister for the Environment on advice of the Department of Environmental Protection. (See procedure 4).

This Programme shall address, but not necessarily be limited to the following elements:

1 selection of an alignment and construction to minimise the clearing of vegetation;

2 selection of an alignment and construction to minimise or avoid impacts on wetlands;

3 management of fauna; and

4 maintenance and improvement of hydrological connections in the area.

6 Proponent

These conditions legally apply to the nominated proponent.

6-1 No transfer of ownership, control or management of the project which would give rise to a need for the replacement of the proponent shall take place until the Minister for the Environment has advised the proponent that approval has been given for the nomination of a replacement proponent. Any request for the exercise of that power of the Minister shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the project in accordance with the conditions and procedures set out in the statement.

7 Compliance Auditing

In order to ensure that environmental conditions and commitments are met, an audit system is required.

7-1 To help verify environmental performance, the proponent shall prepare periodic Progress and Compliance Reports in consultation with the Department of Environmental Protection.

Procedure

1 The Department of Environmental Protection is responsible for verifying compliance with the conditions contained in this statement, with the exception of conditions stating that the proponent shall meet the requirements of either the Minister for the Environment or any other government agency.

2 If the Department of Environmental Protection, other government agency or proponent is in dispute concerning compliance with the conditions contained in this statement, that dispute will be determined by the Minister for the Environment.

3 At an appropriate time prior to construction of the Rapid Transport System, the Minister for the Environment will effect a transfer of proponent, under Section 38(7) of the

Environmental Protection Act, from the current proponent to the agency responsible for the construction of the System. (See condition 3-2).

4 At an appropriate time prior to construction of Safety Bay Road between Ennis Avenue and Mandurah Road, Rockingham, the Minister for the Environment will effect a transfer of proponent, under Section 38(7) of the Environmental Protection Act, from the current proponent to the agency responsible for the construction of the road. (See condition 5-1).

Kevin Minson MLA
MINISTER FOR THE ENVIRONMENT

10 OCT 1994

PROPONENT'S ENVIRONMENTAL MANAGEMENT COMMITMENTS

CHANGES OF LAND USE AFFECTING SYSTEM SIX AREAS & LAKES PROTECTED UNDER THE ENVIRONMENTAL PROTECTION POLICY

TO URBAN, INDUSTRIAL, SPECIAL USES & TRANSPORTATION PURPOSES,

TO BE REFLECTED IN THE MAJOR METROPOLITAN REGION SCHEME AMENDMENTS FOR THE SOUTH-WEST CORRIDOR (838)

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT

10.0 COMMITMENTS BY THE PROPONENT

Subject to the understanding that DPUD is not a statutory decision making body (except in a minor way by delegation) and that DPUD has only an advisory role to the Minister for Planning, the State Planning Commission and the Metropolitan Planning Council, and subject to the understanding that many decisions made on the advice of DPUD can be overturned on appeal, and subject to the understanding that DPUD does not have responsibility for the actual construction of major roads and other items of transport infrastructure, DPUD, as proponent of this PER makes the following commitments.

1. The additional areas proposed for rezoning to Parks and Recreation in the 1993 Structure Plan for the South West Corridor will be zoned for this purpose. That is, subsequent to implementation of the current Stage A and B Amendments, DPUD will recommend that additional amendments are initiated to achieve all of the Parks and Recreation allocations as proposed in the Structure Plan.

2. In the event that minor modifications to proposed Parks and Recreation Reserves are considered desirable prior to formal zoning, then DPUD will recommend that adjustments be made to ensure that there will not be a reduction in the overall allocation of open space for conservation purposes in the South West Corridor.

3. During future implementation of infrastructure proposals within transport reserves established by the Stage A and B Amendments, DPUD will recommend that a detailed Environmental Management Program (EMP) is required prior to construction (to be prepared to the satisfaction of the EPA). In particular, the following elements will be addressed by future EMP's:

    - the rapid transport route and its effects on important areas of natural environment, including but not limited to System 6 area M103 (Rockingham Lakes), The Spectacles, Stakehill Swamp and Anstey Swamp;

    - the Eighty Road extension and its impingement on the Tamworth Hill EPP wetland;

    - the proposed Beeliar Drive and its crossing of M92 and an EPP wetland;

- the widening of Russell Road through the Beeliar Regional Park (M93), and

- the proposed upgrading of Safety Bay Road through System 6 area M103.

4. As urbanisation of the South West Corridor progresses, DPUD will endeavour to ensure that the environmental protection requirements implicit to this PER are implemented, where appropriate, in Town Planning Schemes, District and Local Structure Plans and Subdivision Plans. In general, the aim will be to achieve adequate protection of Structure Plan wetlands (including EPP wetlands) and the following specific environmental features;

- the EPP wetland in the proposed regional sporting centre for the City of Cockburn (part of a proposed Parks and Recreation Reserve north of Beeliar Drive and east of the new Forest Road alignment) will be protected from recreational development;

- the two small wetlands in an area of proposed Urban Deferred (west of Hammond Road and north of Russell Road) will be incorporated within open space;

- the extreme north-eastern side of Tamworth Hill Swamp extends into a proposed urban area and, whilst completely degraded, it will be protected from adverse drainage and water quality changes which may affect Tamworth Hill Swamp;

- the small areas of System 6 area M92 which are not included as Parks and Recreation Reserve will be incorporated into local open space; and

- the southern 'spur' of System 6 area M93, which includes two wetlands, will be protected in local open space.

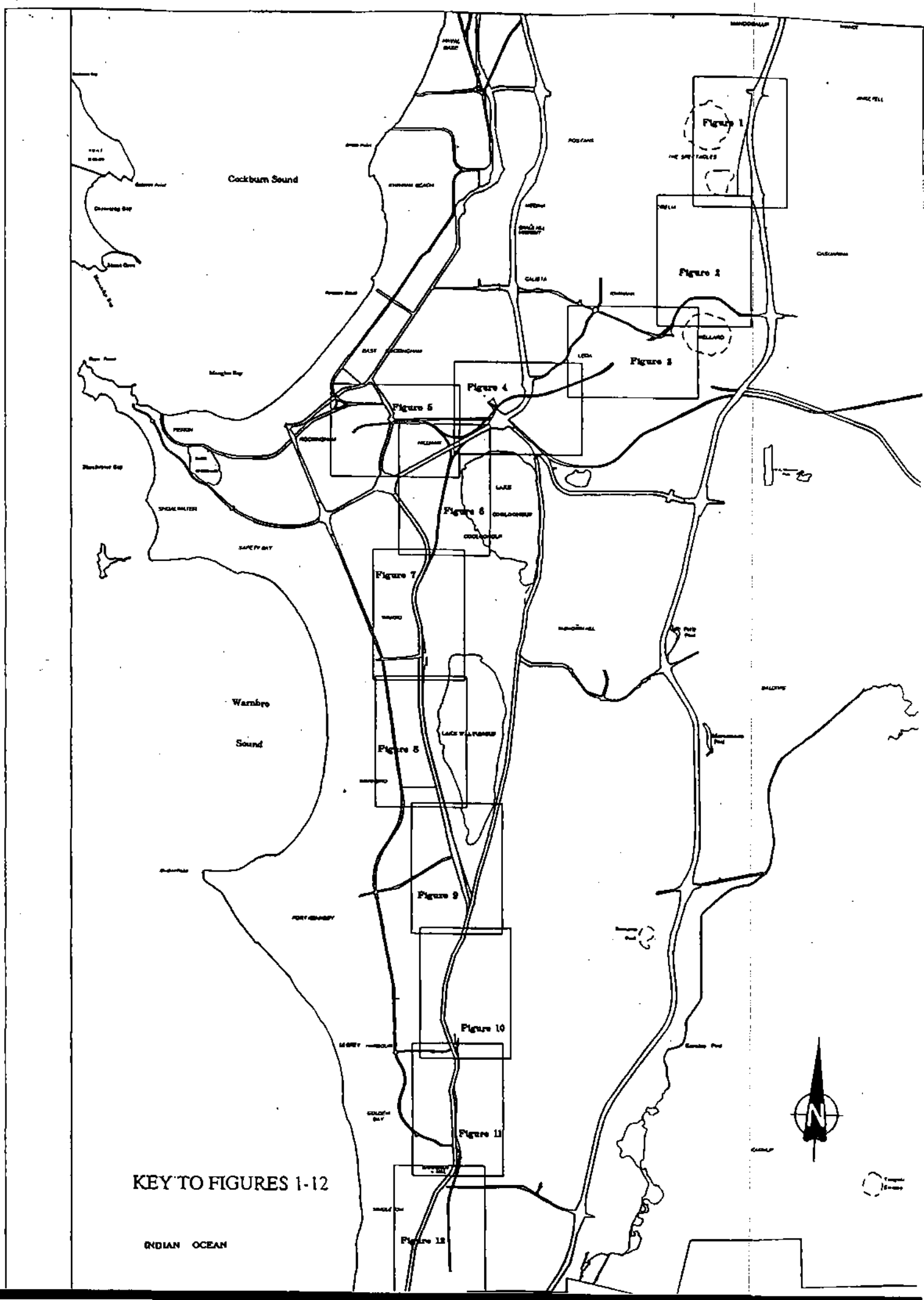
5. Where the rapid transport reserve crosses public land, such as the Leda open space and northern sector of M103, flexibility in the alignment will be accommodated via minor amendments to the MRS in the event that detailed environmental assessment (during preparation of the EMP) identifies an alternative, acceptable alignment with reduced environmental impact.

6. A detailed re-assessment of the configuration of the Garden Island Highway and rapid transport reserve will be conducted for the interchange area in the vicinity of Dixon Road (east) and the Mundijong railway, to determine whether or not the EPP wetland can be avoided and the rapid transport route deviated further to the north from Lake Cooloongup.

7. DPUD will prevail upon the City of Rockingham to negotiate with Special Rural landholders adjacent to the Naim Road reserve to attempt to avoid the EPP wetland which will currently be affected by future road construction. The option of wetland replacement will be discussed with the City of Rockingham.

8. DPUD will conduct further assessment of the alternatives for the rapid transport reserve in the vicinity of The Spectacles, with a view to minimising potential adverse effects on this important area.

9. DPUD will recommend that the proposed Hillman Public Purposes Reserve be deleted from the Stage B Major Amendment to the Metropolitan Region Scheme on the basis of findings of this PER.


Cockburn Sound
Figure 1
Figure 2
Figure 3
Figure 4
Figure 5
Figure 6
Figure 7
Figure 8
Figure 9
Figure 10
Figure 11
Figure 12
Warnbro
Sound
KEY TO FIGURES 1-12
INDIAN OCEAN
N

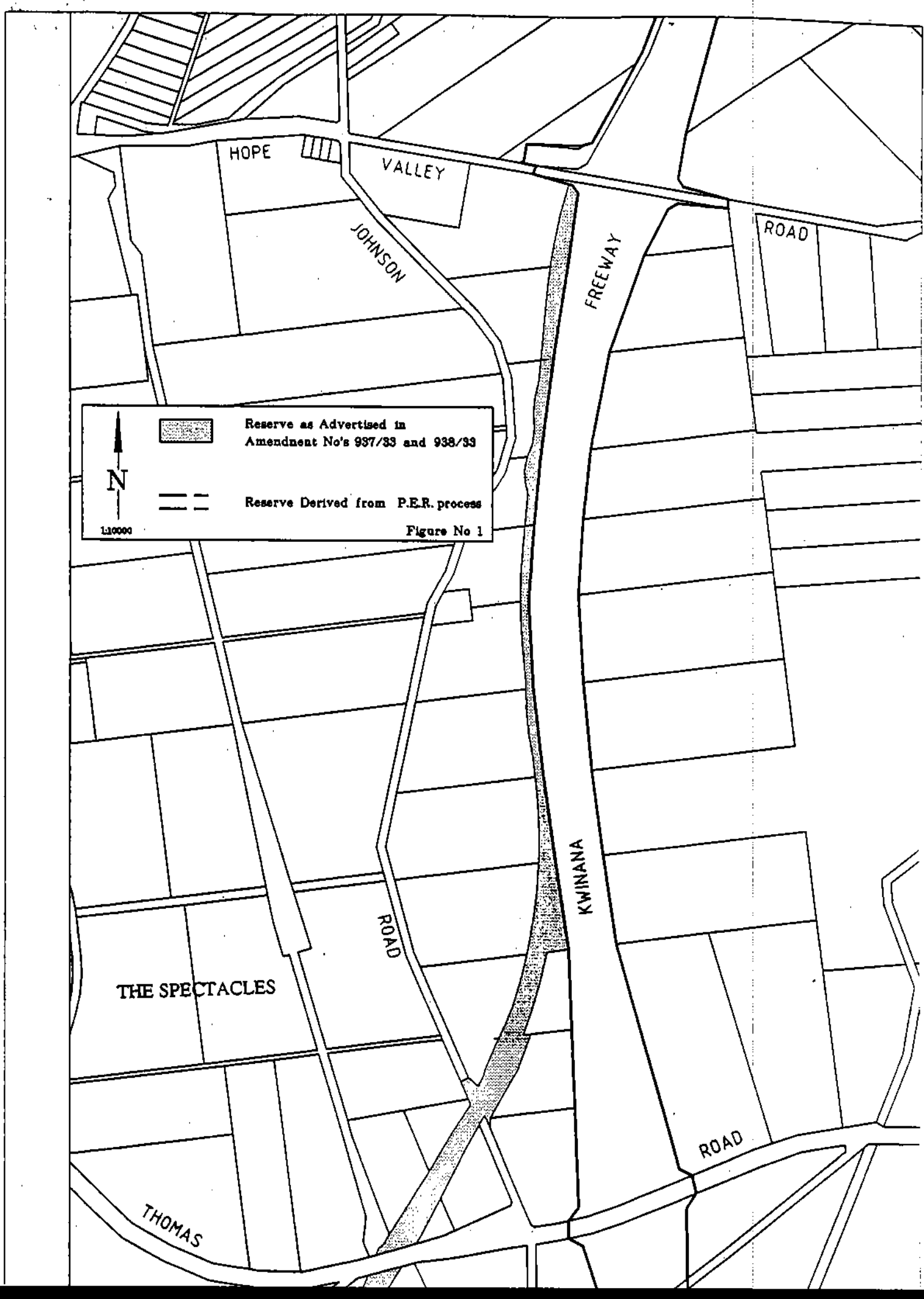

HOPE
VALLEY
ROAD
JOHNSON
FREEWAY
Reserve as Advertised in Amendment No's 937/33 and 938/33
N
Reserve Derived from P.E.R. process
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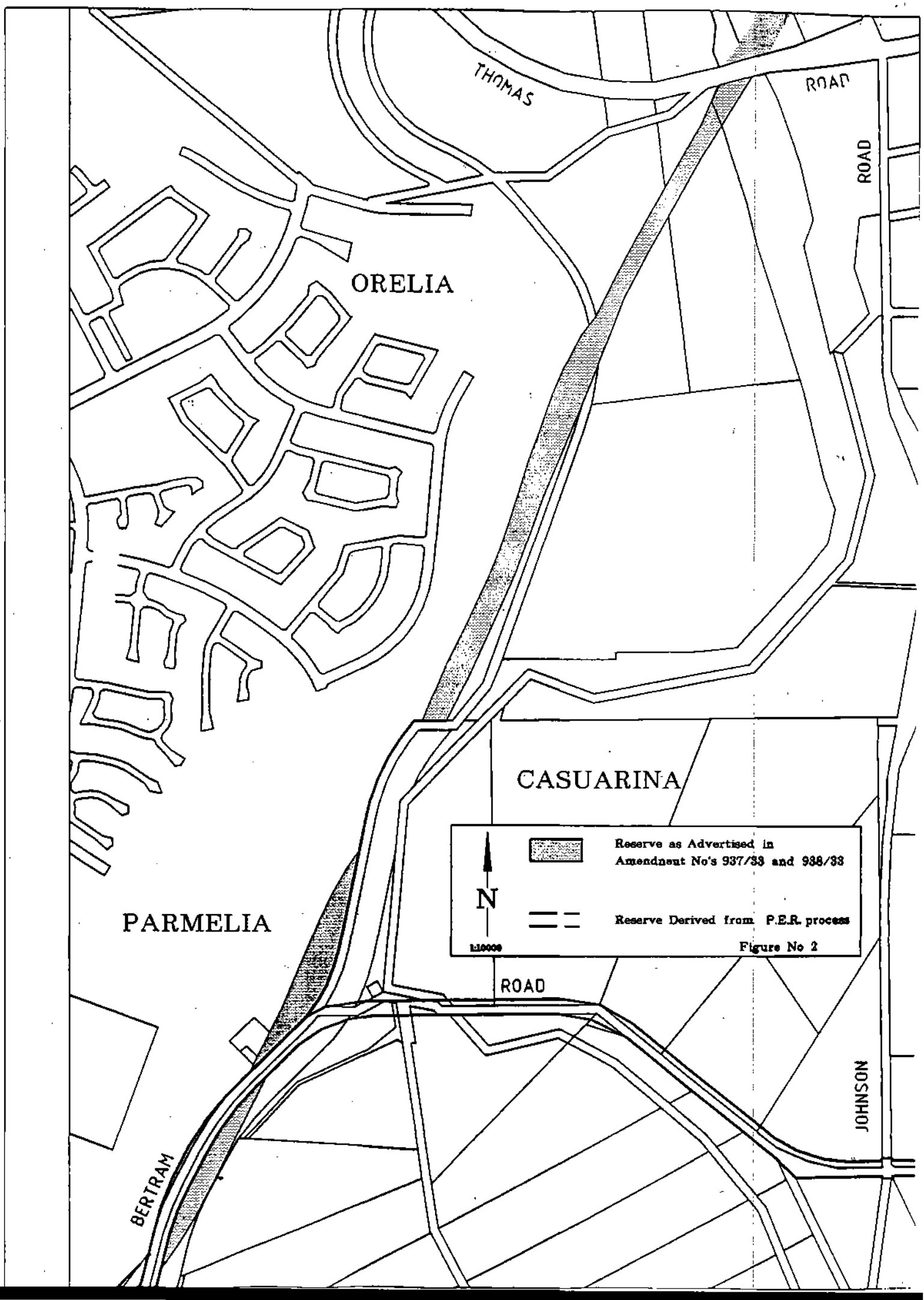
Figure No 1
KWINANA
ROAD
THE SPECTACLES
ROAD
THOMAS


THOMAS
ROAD
ROAD
ORELIA
CASUARINA
PARMELIA
Reserve as Advertised in
Amendment No's 937/33 and 938/33
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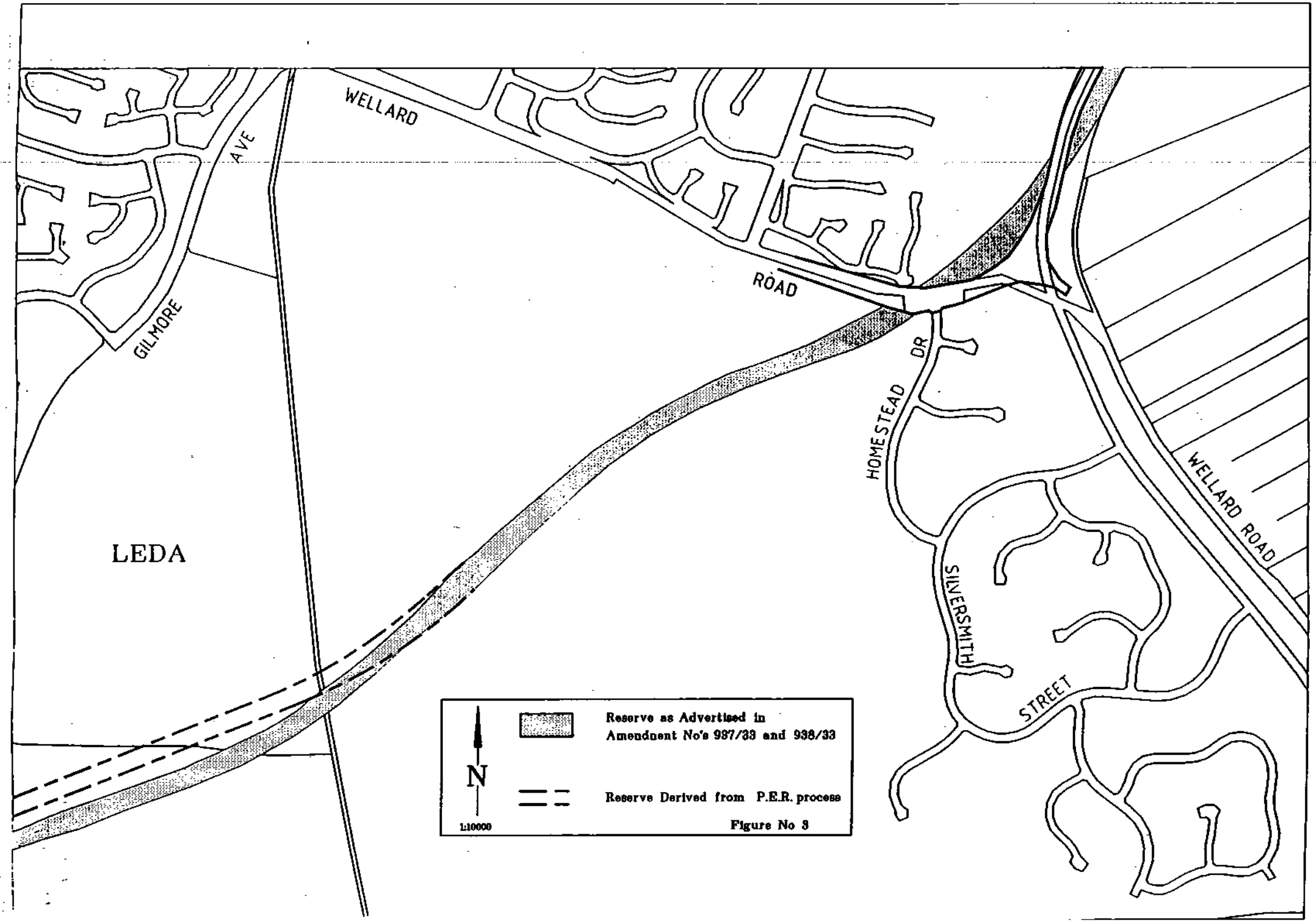
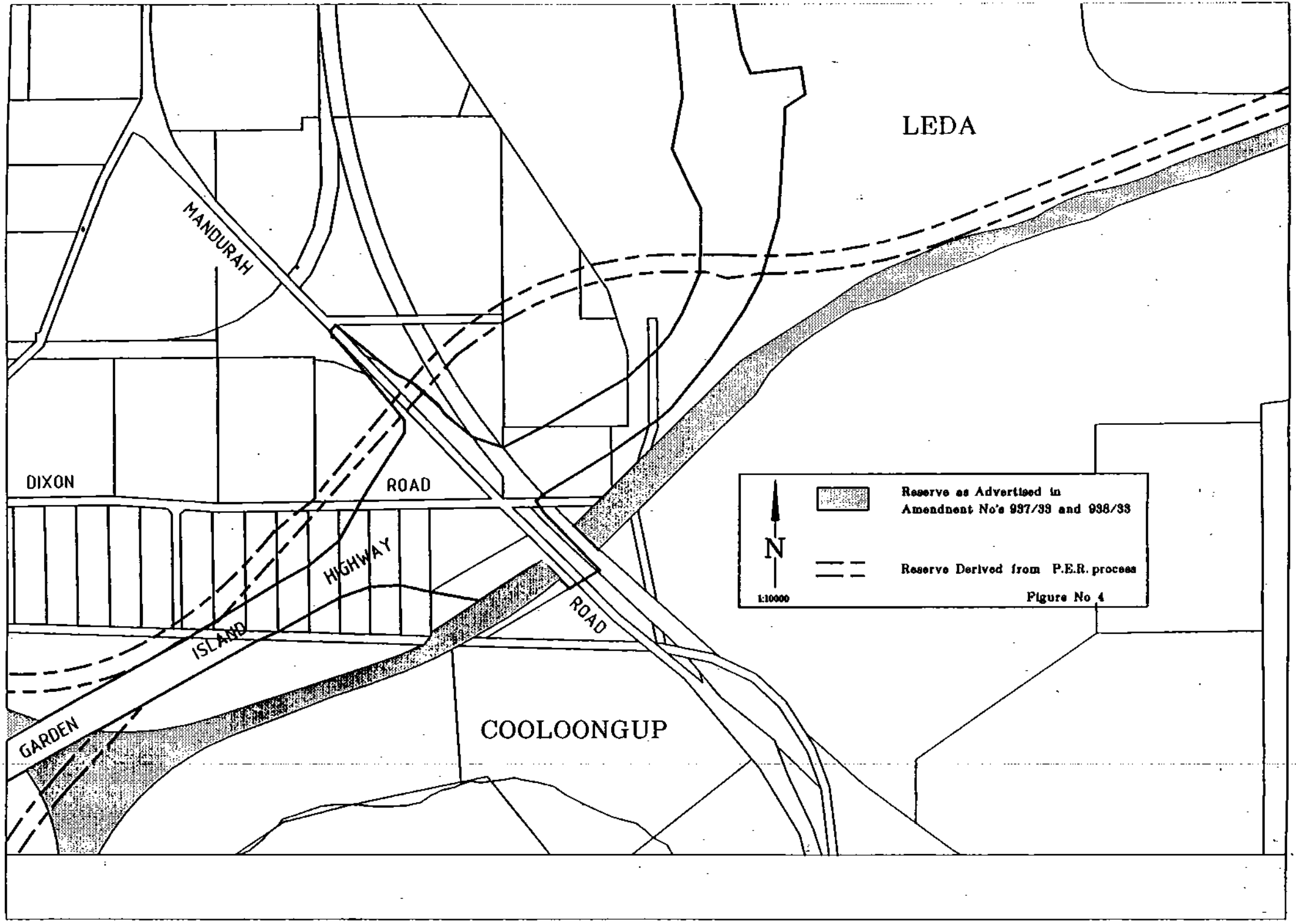
Reserve Derived from P.E.R. process
Figure No 2
ROAD
JOHNSON
BERTRAM


WELLARD
AVE
ROAD
GILMORE
HOMESTEAD DR
WELLARD ROAD
SILVERSMITH
STREET
LEDA
N
1:10000
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
Figure No 3


LEDA
MANDURAH
DIXON
ROAD
HIGHWAY
ISLAND
ROAD
GARDEN
COOLOONGUP
N
1:10000
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
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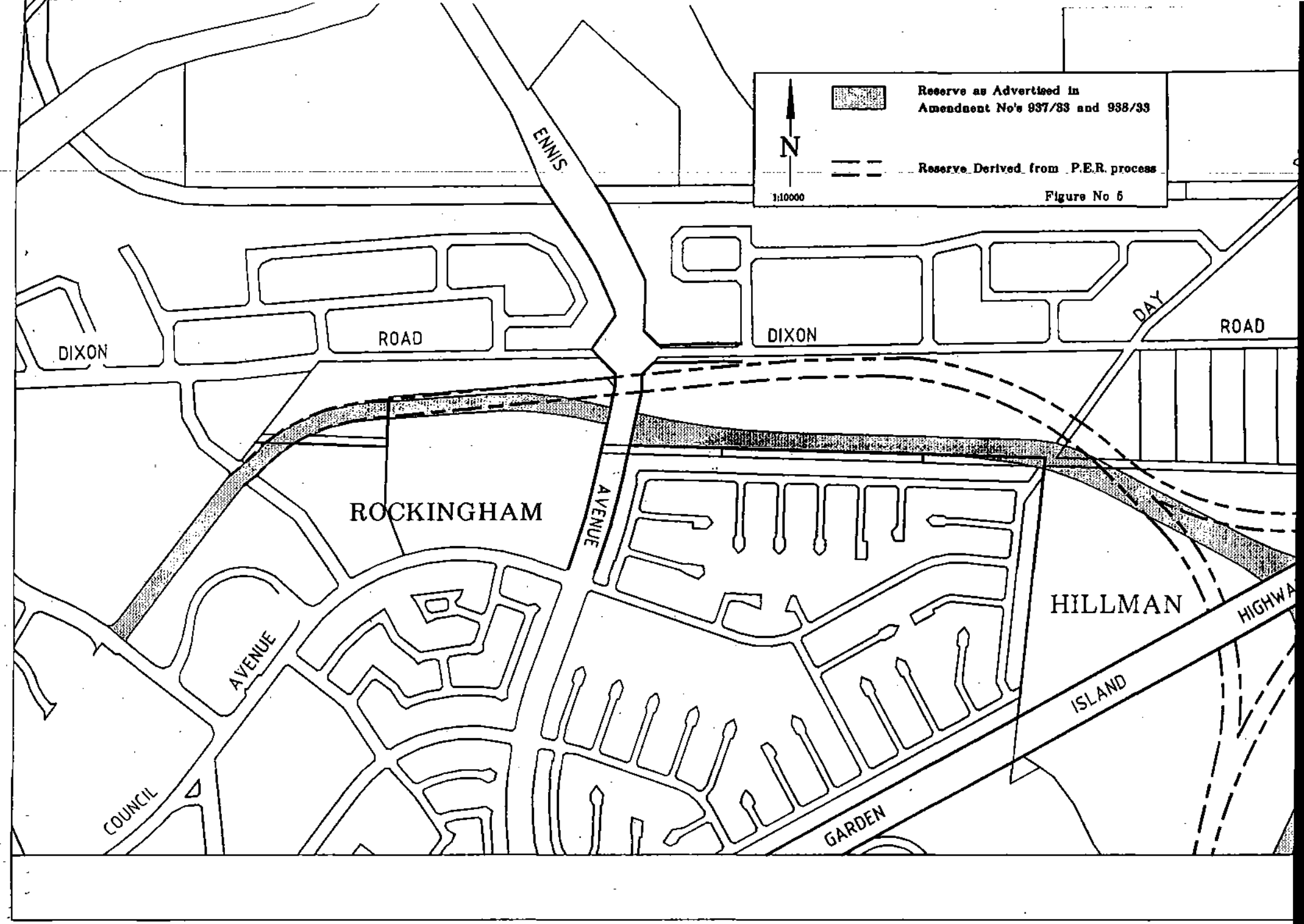
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Reserve Derived from P.E.R. process
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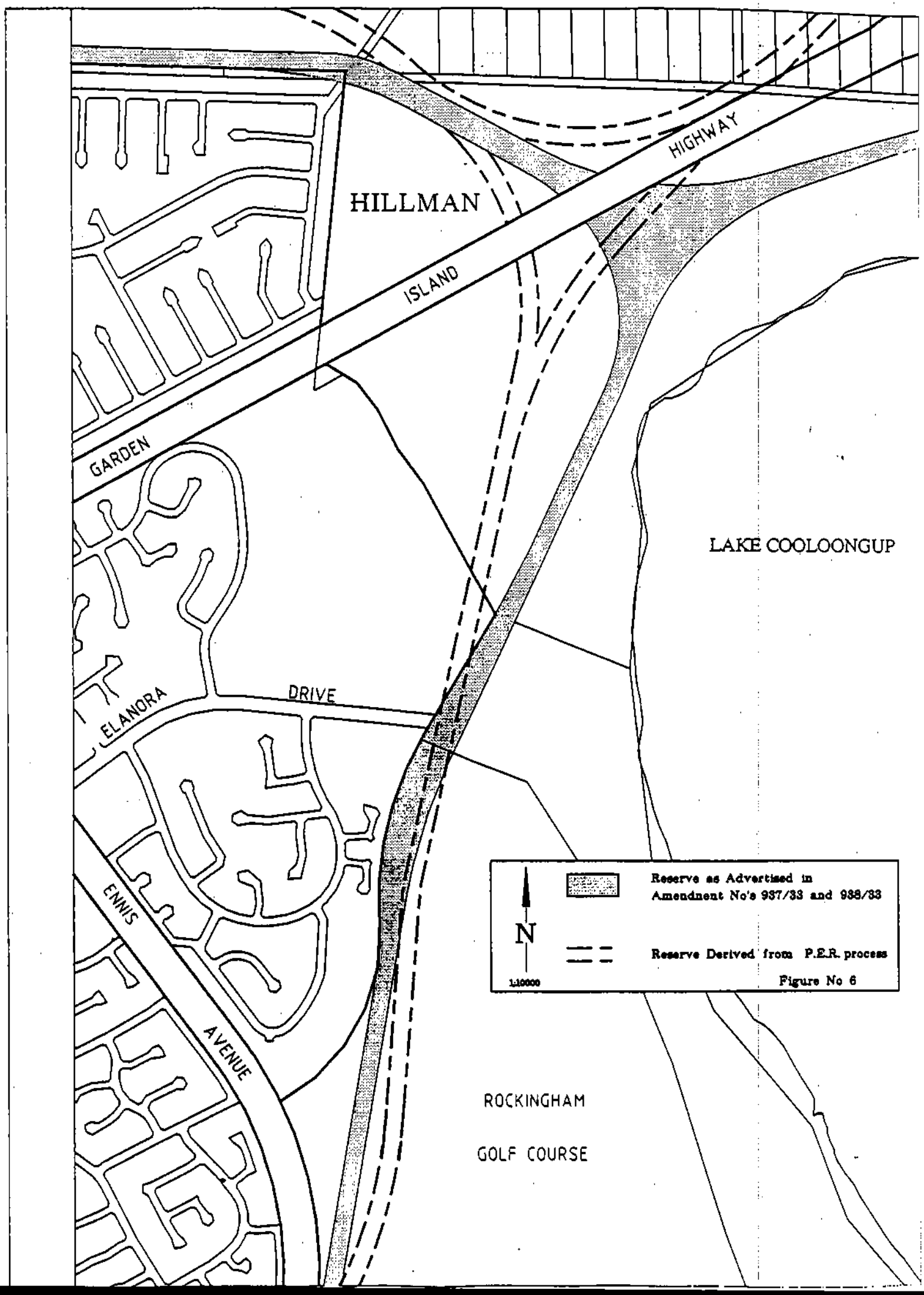
Figure No 5
ENNIS
DIXON
ROAD
DIXON
DAY
ROAD
ROCKINGHAM
AVENUE
AVENUE
HILLMAN
HIGHWA
ISLAND
COUNCIL
GARDEN


HILLMAN
HIGHWAY
ISLAND
GARDEN
LAKE COOLOONGUP
ELANORA
DRIVE
ENNIS
AVENUE
ROCKINGHAM
GOLF COURSE
N
1:10000
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
Figure No 6

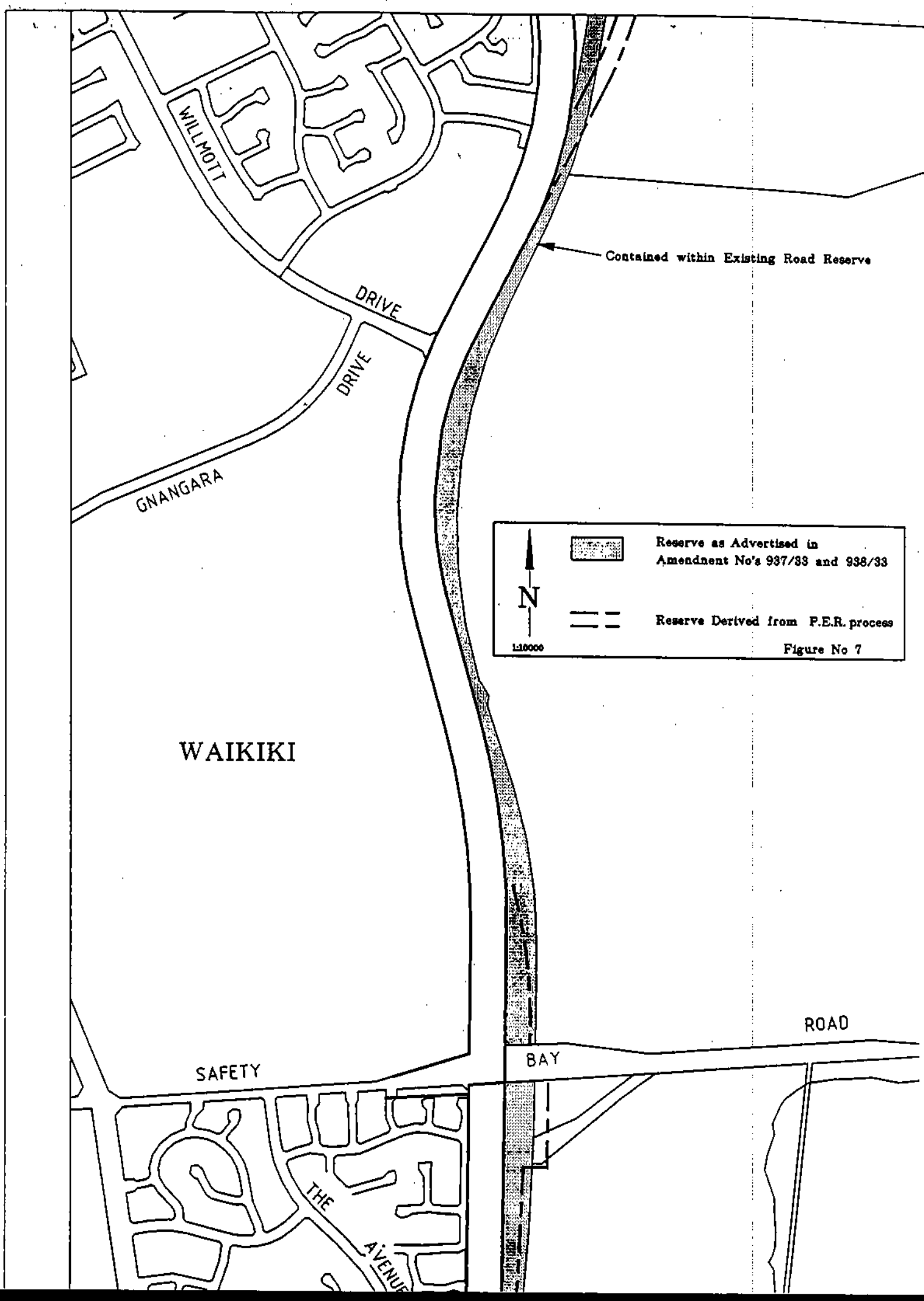

WILLMOTT
DRIVE
DRIVE
GNANGARA
Contained within Existing Road Reserve
N
1:10000
Reserve as Advertised in Amendnent No's 937/33 and 938/33
Reserve Derived from P.E.R. process
WAIKIKI
ROAD
BAY
SAFETY
THE
AVENUE

Figure No 7

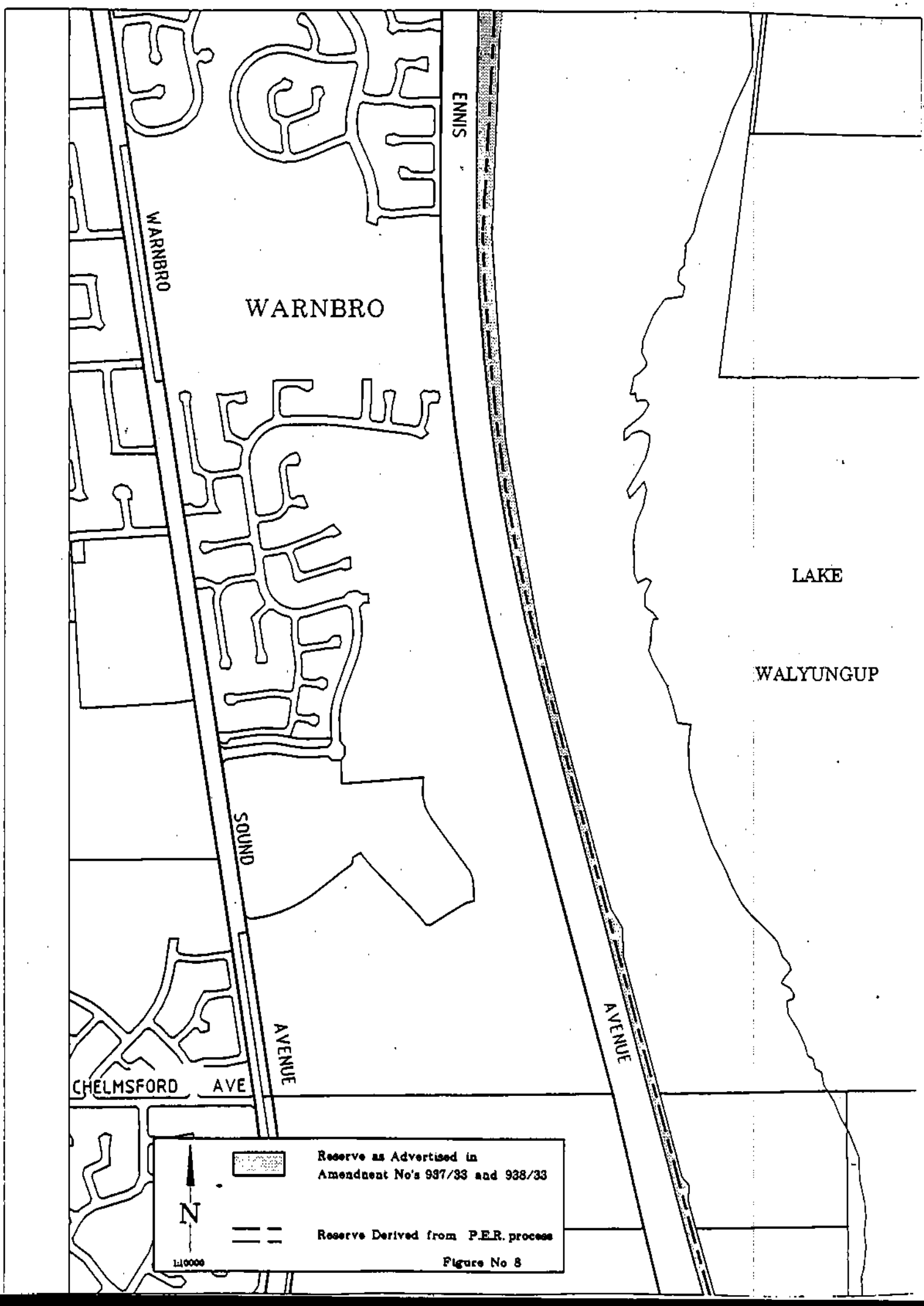

ENNIS
WARNBRO
WARNBRO
LAKE
WALYUNGUP
SOUND
AVENUE
AVENUE
CHELMSFORD
AVE
Reserve as Advertised in
Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
N
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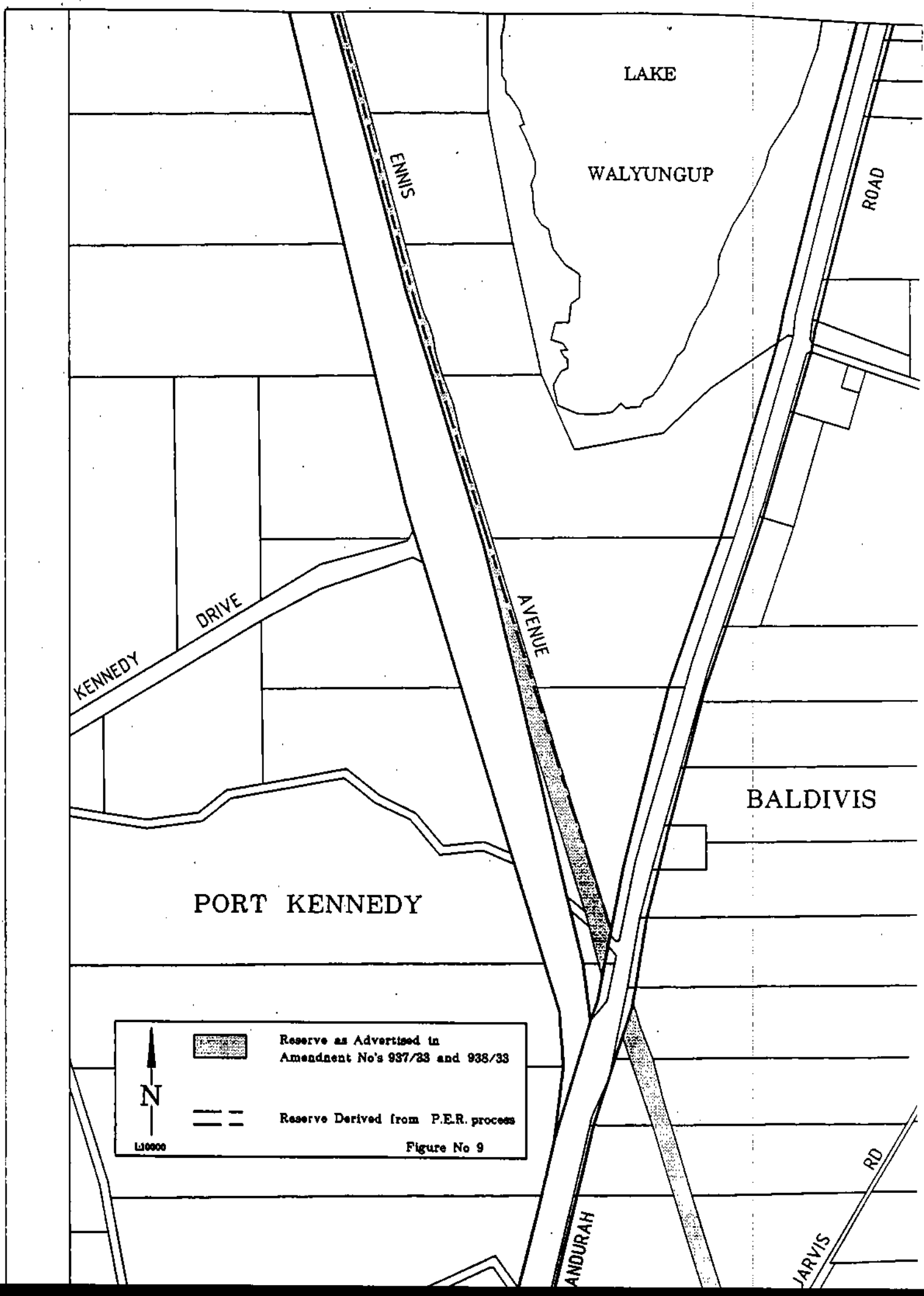
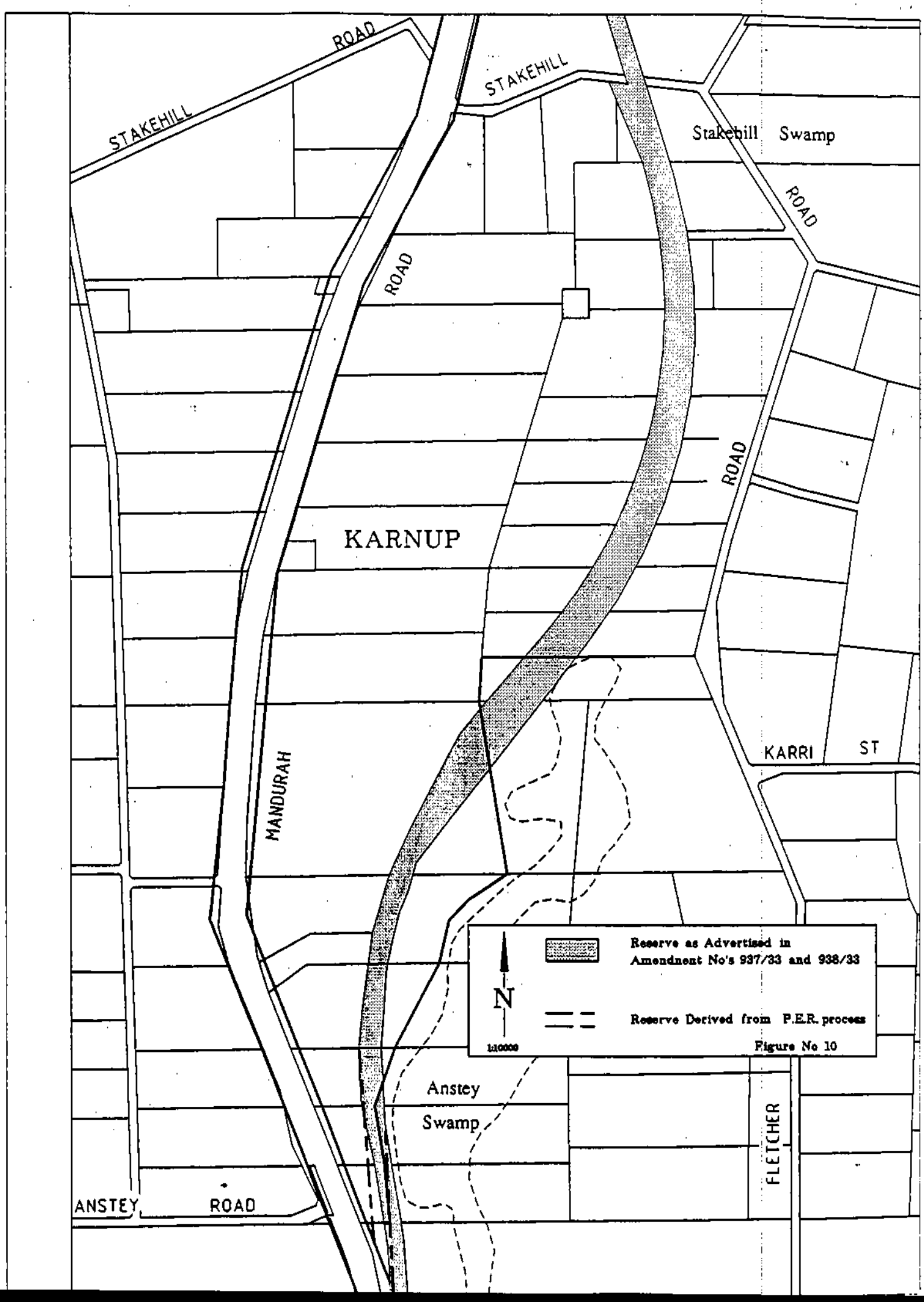
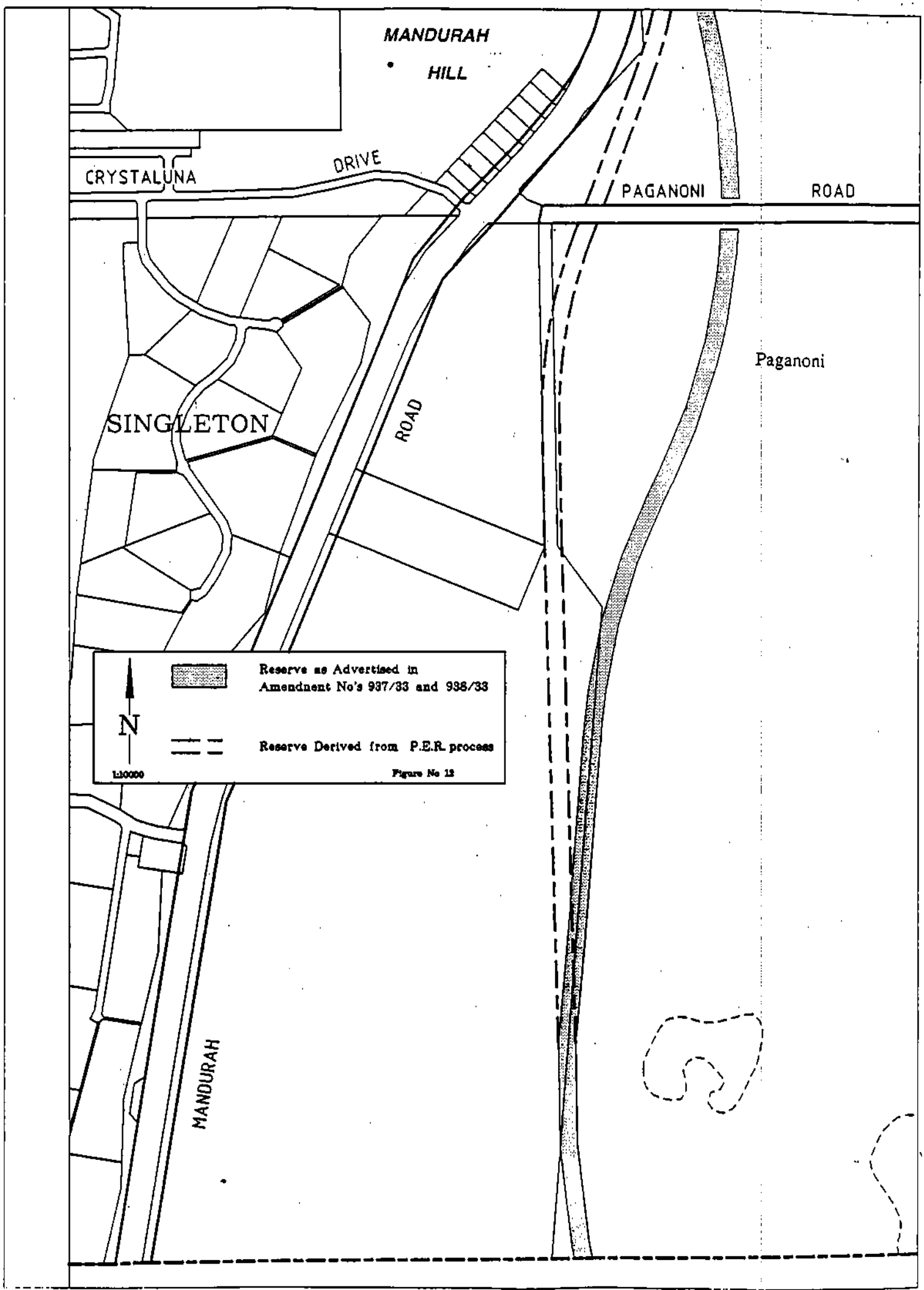
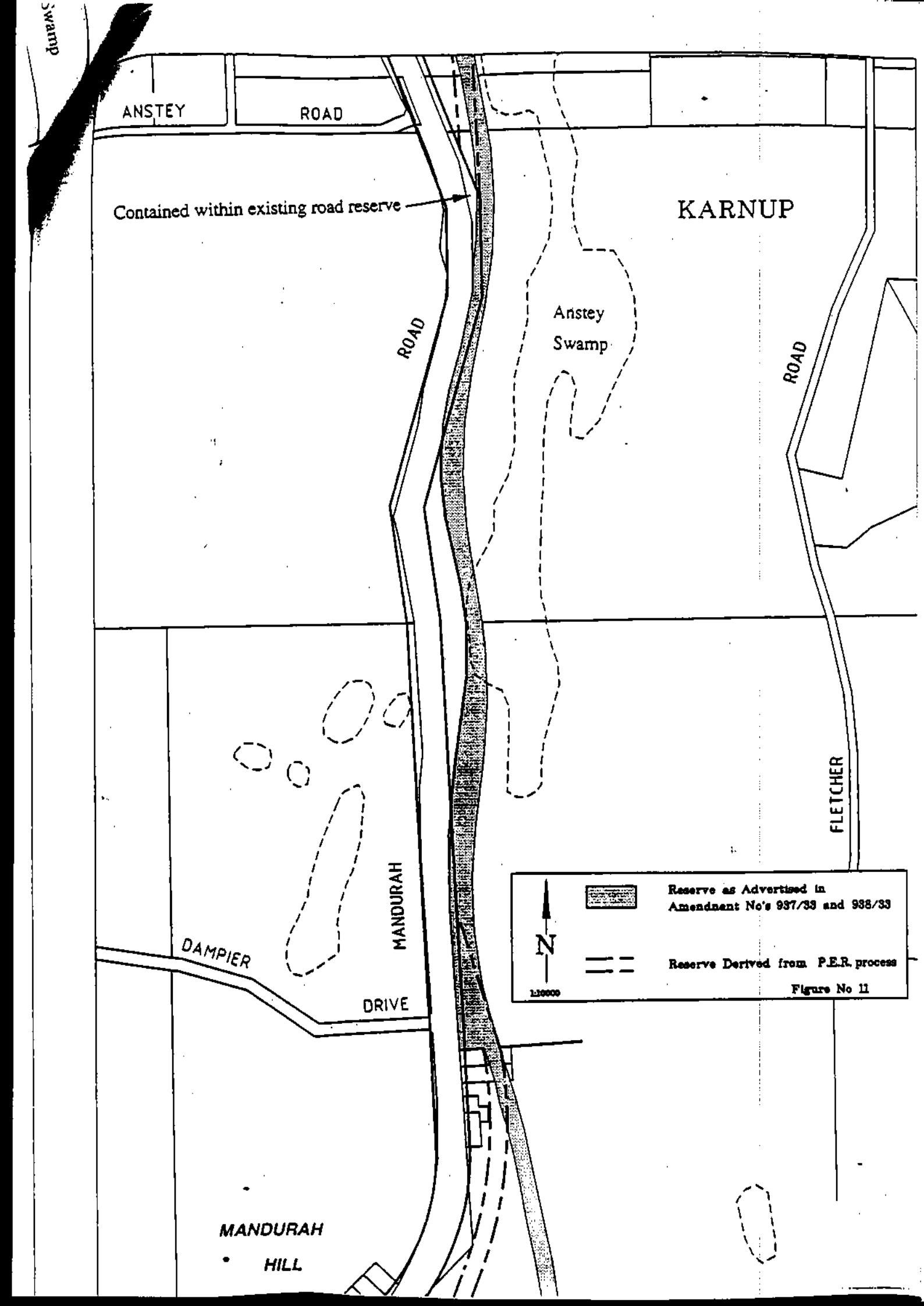
Figure No 8


LAKE
WALYUNGUP
ENNIS
ROAD
KENNEDY
DRIVE
AVENUE
BALDIVIS
PORT KENNEDY
N
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
1:10000
Figure No 9
RD
JARVIS


STAKEHILL ROAD
STAKEHILL
Stakehill Swamp
ROAD
ROAD
ROAD
KARNUP
MANDURAH
KARRI ST
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
N
1:10000
Figure No 10
Anstey Swamp
FLETCHER
ANSTEY ROAD


MANDURAH
HILL
CRYSTALUNA
DRIVE
PAGANONI
ROAD
Paganoni
SINGLETON
ROAD
MANDURAH
N
Reserve as Advertised in Amendment No's 937/33 and 938/33
Reserve Derived from P.E.R. process
L10000
Figure No 12


ANSTEY
ROAD
Contained within existing road reserve
KARNUP
ROAD
Anstey
Swamp
ROAD
FLETCHER
MANDURAH
DAMPIER
DRIVE
MANDURAH
HILL
Reserve as Advertised in Amendment No's 937/33 and 938/33
N
Reserve Derived from P.E.R. process
1:10000
Figure No 11

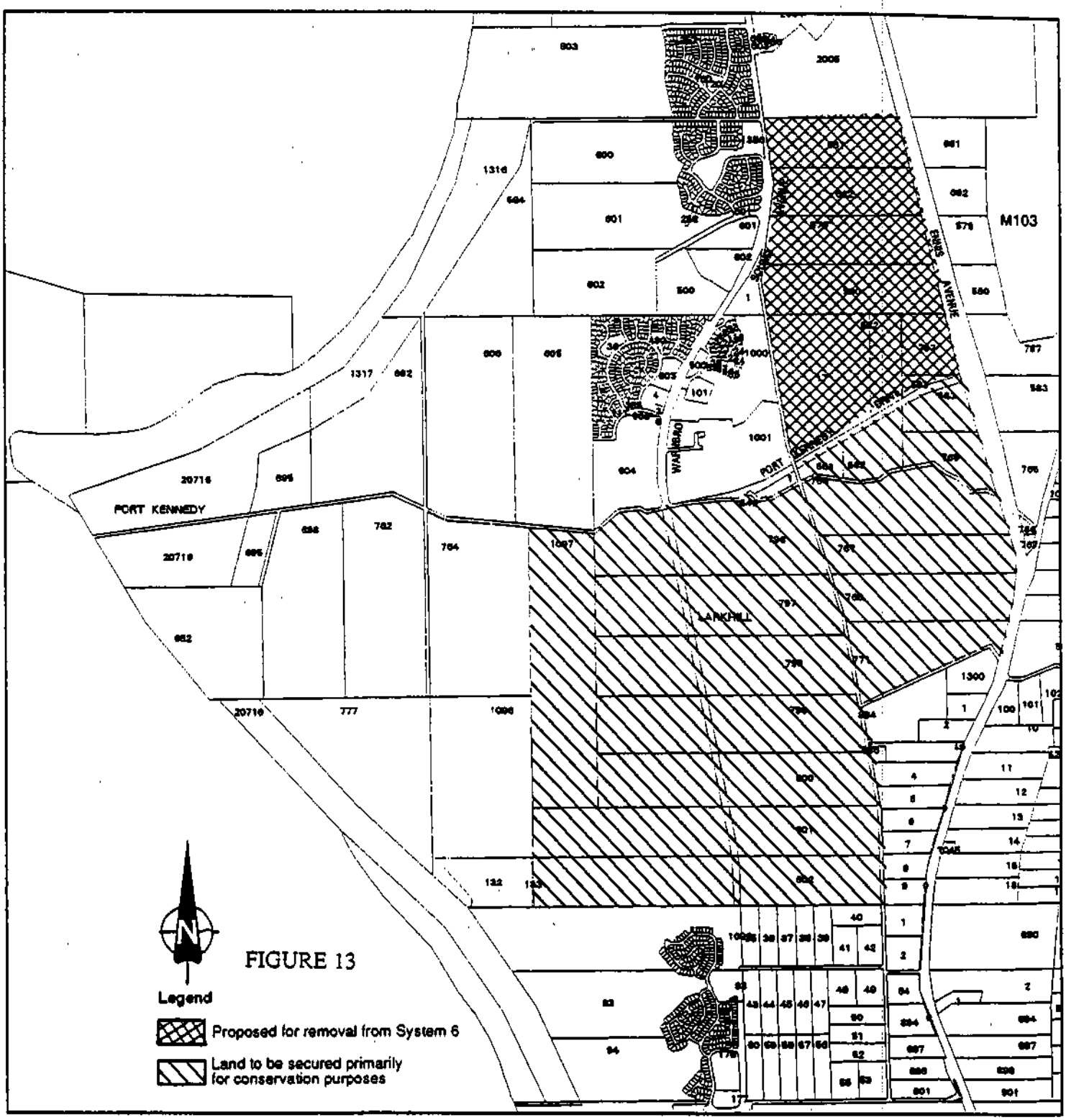

M103
PORT KENNEDY
LANKHILL
ENNIS AVENUE
WARREN RD
PORT KENNEDY DRIVE
N
Legend
Proposed for removal from System 6
Land to be secured primarily for conservation purposes

FIGURE 13

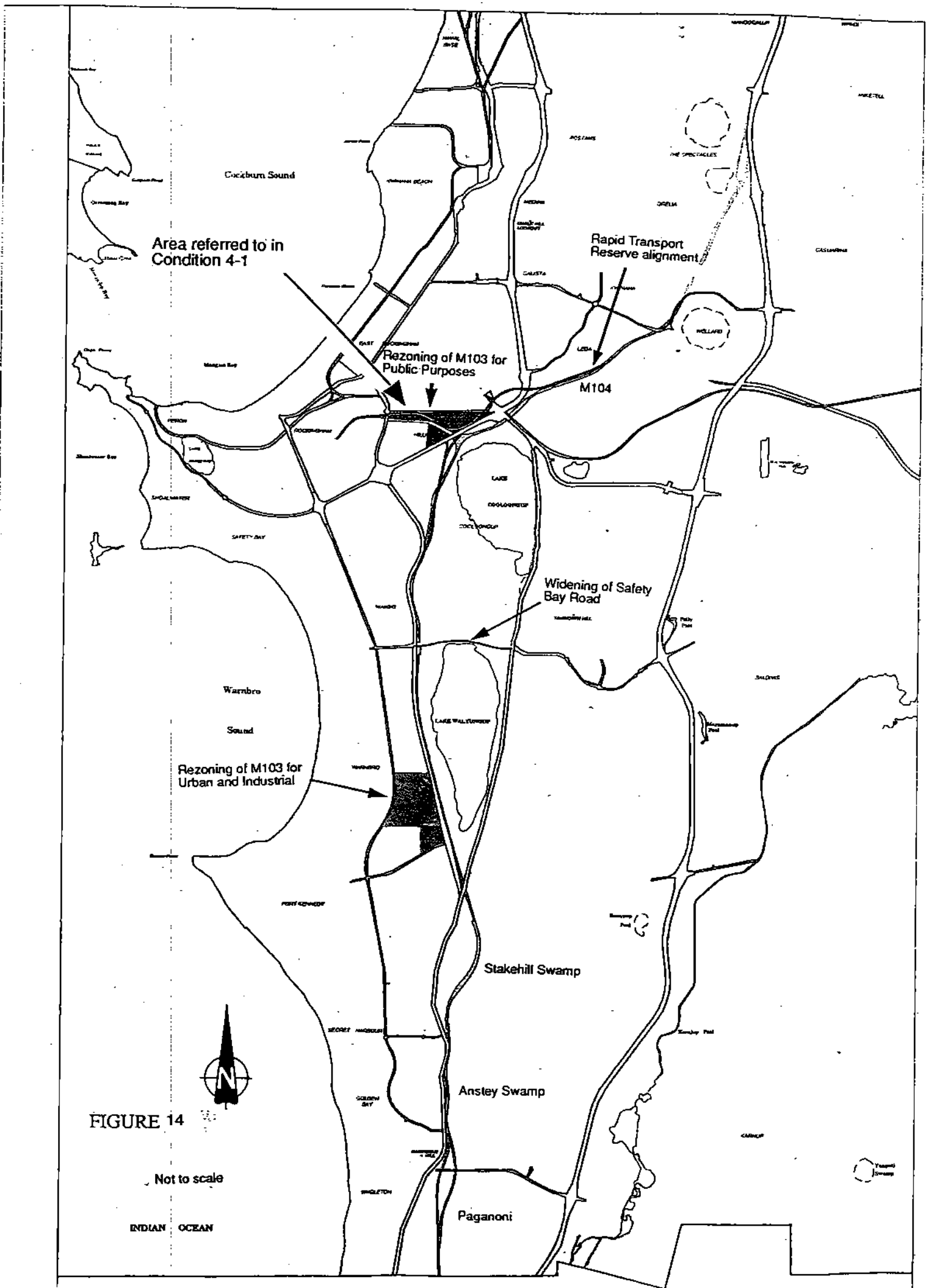

Cockburn Sound
Area referred to in Condition 4-1
Rapid Transport Reserve alignment
Rezoning of M103 for Public Purposes
M104
Widening of Safety Bay Road
Warnbro Sound
Rezoning of M103 for Urban and Industrial
Stakehill Swamp
Anstey Swamp
Paganoni
N
Not to scale
INDIAN OCEAN

FIGURE 14

APPENDIX 2

WAPC APPROVAL 156342

Your Ref : 17-278

TPG Town Planning, Urban Design And Heritage
Level 18 191 St Georges Terrace
PERTH WA 6000

Approval Subject To Condition(s)
Freehold (Green Title) Subdivision

Application No : 156342

Planning and Development Act 2005

Applicant	:	TPG Town Planning, Urban Design And Heritage Level 18 191 St Georges Terrace PERTH WA 6000
Owner	:	Landcorp The Esplanade PERTH WA 6000
Application Receipt	:	1 March 2018

Lot Number	:	4 & 17
Diagram / Plan	:	D065566, D094300
Location	:	
C/T Volume/Folio	:	1663/339, 2126/431
Street Address	:	Lots 4 And 17 Port Kennedy Drive, Port Kennedy
Local Government	:	City of Rockingham

The Western Australian Planning Commission has considered the application referred to and is prepared to endorse a deposited plan in accordance with the plan date-stamped **01 March 2018** once the condition(s) set out have been fulfilled.

This decision is valid for **three years** from the date of this advice, which includes the lodgement of the deposited plan within this period.

The deposited plan for this approval and all required written advice confirming that the requirement(s) outlined in the condition(s) have been fulfilled must be submitted by **06 July 2021** or this approval no longer will remain valid.

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

Reconsideration - 28 days

Under section 151(1) of the *Planning and Development Act 2005*, the applicant/owner may, within 28 days from the date of this decision, make a written request to the WAPC to reconsider any condition(s) imposed in its decision. One of the matters to which the WAPC will have regard in reconsideration of its decision is whether there is compelling evidence by way of additional information or justification from the applicant/owner to warrant a reconsideration of the decision. A request for reconsideration is to be submitted to the WAPC on a Form 3A with appropriate fees. An application for reconsideration may be submitted to the WAPC prior to submission of an application for review. Form 3A and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Right to apply for a review - 28 days

Should the applicant/owner be aggrieved by this decision, there is a right to apply for a review under Part 14 section 251 of the *Planning and Development Act 2005*. The application for review must be submitted in accordance with part 2 of the *State Administrative Tribunal Rules 2004* and should be lodged within 28 days of the date of this decision to: the State Administrative Tribunal, Level 6, State Administrative Tribunal Building, 565 Hay Street, PERTH, WA 6000. It is recommended that you contact the tribunal for further details: telephone 9219 3111 or go to its website: http://www.sat.justice.wa.gov.au

Deposited plan

The deposited plan is to be submitted to the Western Australian Land Information Authority (Landgate) for certification. Once certified, Landgate will forward it to the WAPC. In addition, the applicant/owner is responsible for submission of a Form 1C with appropriate fees to the WAPC requesting endorsement of the deposited plan. A copy of the deposited plan with confirmation of submission to Landgate is to be submitted with all required written advice confirming compliance with any condition(s) from the nominated agency/authority or local government. Form 1C and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Condition(s)

The WAPC is prepared to endorse a deposited plan in accordance with the plan submitted once the condition(s) set out have been fulfilled.

The condition(s) of this approval are to be fulfilled to the satisfaction of the WAPC.

The condition(s) must be fulfilled before submission of a copy of the deposited plan for endorsement.

The agency/authority or local government noted in brackets at the end of the condition(s) identify the body responsible for providing written advice confirming that the WAPC's requirement(s) outlined in the condition(s) have been fulfilled. The written advice of the agency/authority or local government is to be obtained by the applicant/owner. When the written advice of each identified agency/authority or local government has been obtained, it

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

should be submitted to the WAPC with a Form 1C and appropriate fees and a copy of the deposited plan.

If there is no agency/authority or local government noted in brackets at the end of the condition(s), a written request for confirmation that the requirement(s) outlined in the condition(s) have been fulfilled should be submitted to the WAPC, prior to lodgement of the deposited plan for endorsement.

Prior to the commencement of any subdivision works or the implementation of any condition(s) in any other way, the applicant/owner is to liaise with the nominated agency/authority or local government on the requirement(s) it considers necessary to fulfil the condition(s).

The applicant/owner is to make reasonable enquiry to the nominated agency/authority or local government to obtain confirmation that the requirement(s) of the condition(s) have been fulfilled. This may include the provision of supplementary information. In the event that the nominated agency/authority or local government will not provide its written confirmation following reasonable enquiry, the applicant/owner then may approach the WAPC for confirmation that the condition(s) have been fulfilled.

In approaching the WAPC, the applicant/owner is to provide all necessary information, including proof of reasonable enquiry to the nominated agency/authority or local government.

The condition(s) of this approval, with accompanying advice, are:

CONDITIONS

1. The boundary between proposed Lots 1 and 2 being amended as per the attached plan dated 3 July 2018. (Local Government)

Environment

2. Prior to the commencement of subdivisional works a Conservation Area Management Plan is to be prepared for Conservation Area Lot 1 in consultation with the Department of Biodiversity, Conservation and Attractions and the City of Rockingham and approved to ensure the protection and management of the site's environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Biodiversity, Conservation and Attractions)

Fire and emergency infrastructure

3. Prior to the commencement of subdivision works, the proposed lots are to be searched for unexploded ordnance to a depth of at least one metre. (Department of Fire and Emergency Services)

4. A notification pursuant to section 165 of the *Planning and Development Act 2005* is to be placed on the certificate of title of the proposed lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification to state as follows:

   "This land has been used as an artillery range and for heavy explosive ordnance dumping and may contain unexploded ordnance. While the land has been searched to a depth of one metre no guarantee can be given that all unexploded ordnance have been located. Any ordnance found should be treated as dangerous and its location reported to police or defence establishment." (Western Australian Planning Commission)

Transport

5. Pursuant to Section 150 of the *Planning and Development Act 2005* and Division 3 of the *Planning and Development Regulations 2009* a covenant preventing vehicular access onto Ennis Avenue and part of Port Kennedy Drive (as per the attached plan dated 3 July 2018) being lodged on the certificate of title of proposed Lot 2 at the full expense of the landowner/applicant. The covenant is to prevent access, to the benefit of Main Roads Western Australia, and the covenant is to specify:

   "*No vehicular access is permitted to or from Ennis Avenue or this section of Port Kennedy Drive*." (Main Roads Western Australia)

ADVICE

1. With regard to Condition 2, the Conservation Area Management Plan is to include measures to rehabilitate degraded areas and monitor hydrology and vegetation health. Weed control, rubbish removal, safe management access and the installation of appropriate fencing or barriers is also be addressed. The Plan is to include a commitment and timeline for amending the classification of the Conservation Area with the vesting in the appropriate authority.

2. The City of Rockingham favours the retention of wetlands 15 and 17 within proposed Lot 2 as part of its future development.

3. The Department of Fire and Emergency Services (DFES) advises that historical research has revealed that during the past 100 years, former elements of the Australian Defence Forces may have conducted training and/or operational activities within or close to the area of the proposed subdivision. It is possible that as a result of these activities, the subject area may contain unexploded ordnance (UXO). Whilst it is considered that the possible risk from UXO on the land subject to this approval is minimal, an absolute guarantee that the area is free from UXO cannot be given. Should, during subdivisional works, or at any other time, a form or suspected form of UXO be located, DFES has advised that the following process should be initiated:

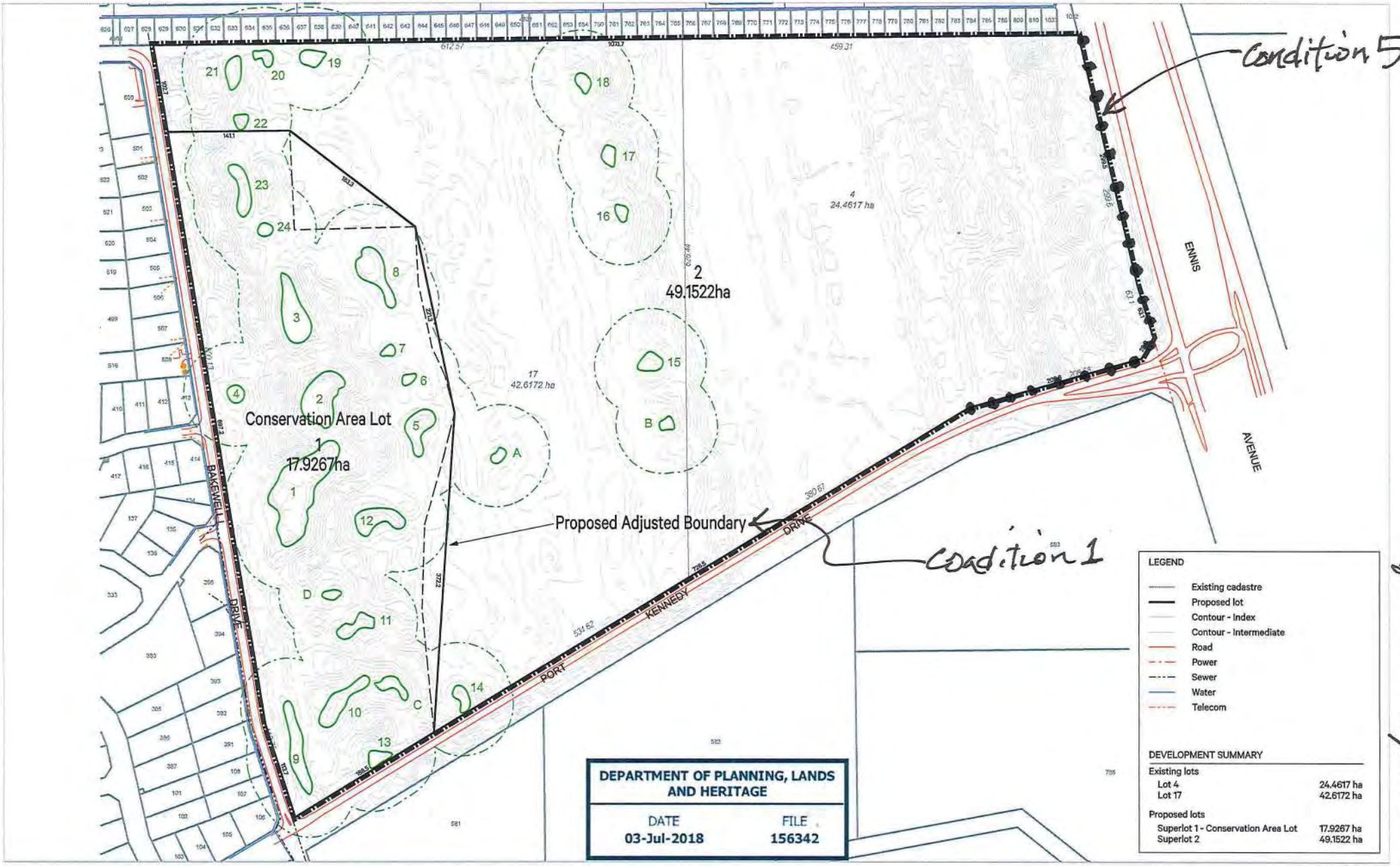
a) do not disturb the site of the known or suspected UXO;
b) without disturbing the immediate vicinity, clearly mark the site of the UXO;
c) notify Police of the circumstances/situation as quickly as possible; and
d) maintain a presence near the site until advised to the contrary by a member of the WA Police Service or Defence Forces.

Further advice on this issue may be obtained by contacting the Unexploded Ordnance Unit, Department of Fire and Emergency Services.

Ms Sam Fagan
Secretary
Western Australian Planning Commission
6 July 2018

Enquiries : Regan Douglas (Ph 6551 9289)

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493



Subdivision Plan - Amended

Lots 4 & 17 Port Kennedy Drive, Port Kennedy

Date: 7 May 2018 Scale: 1:4000 @A3 Drawing No. 717.278 SU1A Staff: LC/MR Checked: MR

element.

APPENDIX 3

GEOTECHNICAL REPORT

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Preliminary Geotechnical Investigation

Proposed Industrial and Commercial Development
Port Kennedy Business Park
Port Kennedy, WA

Prepared for
Porter Consulting Engineers

Project 76219
July 2011

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	76219	Document No.	1
Document title	Report on Preliminary Geotechnical Investigation Proposed Industrial and Commercial Development		
Site address	Port Kennedy Business Park		
Report prepared for	Porter Consulting Engineers		
File name	P:\76219 Port Kennedy Business Park\Docs\76219 Report on Preliminary Geotechnical Investigation, Port Kennedy Business Park.doc		

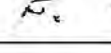
Document status and review

Revision	Prepared by	Reviewed by	Date issued
0	S Seenu	F Verheyde	15 July 2011

Distribution of copies

Revision	Electronic	Paper	Issued to
0	1	1	Porter Consulting Engineers

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		15/7/2011
Reviewer		15/7/2011

NCS INTERNATIONAL CERTIFIED QUALITY MANAGEMENT SYSTEM

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
36 O'Malley Street
Osborne Park WA 6017
Phone (08) 9204 3511
Fax (08) 9204 3522

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Report on Preliminary Geotechnical Investigation
Proposed Industrial and Commercial Development
Port Kennedy Business Park, Port Kennedy

1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken for a proposed industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA. The investigation was commissioned in an email, dated 27 May 2010, by David Porter of Porter Consulting Engineers, and was undertaken in accordance with Douglas Partners' proposal dated 19 April 2011.

The aim of the investigation was to assess the sub-surface soil and groundwater conditions across the site and thus:

- Provide a description of the soil, rock and groundwater conditions beneath the site.
- Determine the suitability of the site for the proposed development.
- Provide an appropriate classification of the site in accordance with the requirements of AS 2870-2011, and the earthworks requirements to achieve a 'Class A' classification.
- Provide recommendations on site preparation, compaction, earthworks and remediation, if required, so as to allow the proposed development.
- Suggest appropriate foundation system(s), including the assessment of allowable bearing pressures and likely settlements.
- Provide suitable parameters, including California Bearing Ratio (CBR) for the design of new pavements, based on field observations and limited laboratory testing.
- Provide permeability values for the soils encountered at the site based on observations made in the field and laboratory testing.

The investigation included the excavation of 26 test pits and laboratory testing on selected samples.

2. Site Description

The site comprises an area of approximately 67 ha, and is identified as Lots 4 and 17 Port Kennedy Drive in Port Kennedy, WA. It is bounded by Port Kennedy Drive to the south, Ennis Avenue to the east, Bakewell Drive to the west and a residential subdivision to the north.

At the time of the investigation, the site was generally covered with dense shrubs, medium length grasses and several small to medium sized trees and bushes. Several sand tracks transect the site. The ground surface, where exposed across the site, was sandy. A few stockpiles of filling approximately up to 1.0 m high, possibly associated with the construction of adjacent existing roads, were noted along the Bakewell Drive and Ennis Avenue.

The site topography was undulating owing to the presence of numerous sand dunes up to approximately 4.0 m high across the site. The surface levels generally vary from RL 5 in the level areas across the site to RL 10 in the eastern end of the site. At the western part of the site, the surface level reduces up to RL 3.7.

The Rockingham 1:50 000 Geology sheet indicates that shallow sub surface conditions beneath the site consist of calcareous sand of the Safety Bay Sand unit.

3. Field Work Methods

Field work was carried out on 1 June 2011 and 12 July 2011, and comprised the excavation of 26 test pits, drilling of four boreholes and Perth sand penetrometer (PSP) testing adjacent to each test locations.

It should be noted that dense vegetation and a requirement to undertake testing from existing tracks to minimise the impact of the investigation on vegetation, precluded access to some parts of the site. Boreholes (BH27 to BH30) were drilled to a depth of 2.0 m using a 110 mm diameter hand auger in these areas.

The test pits (TP1 to TP26) were excavated to a maximum depth of 2.6 m, using a 5 tonne Komatsu excavator equipped with a 600 mm wide toothed bucket.

Test pits and boreholes were logged in general accordance with test procedure AS 1726–1993 by a suitably experienced geotechnical engineer from Douglas Partners. Representative soil samples were recovered from selected locations for subsequent laboratory testing.

PSP tests were carried out in accordance with AS 1289.6.3.3 to assess the density of the shallow soils.

Test locations were determined using a GPS and are shown on Drawing 1. Surface elevations at each test location were interpolated from a survey provided by Porter Consulting Engineers and are quoted in metres above Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix A, together with notes defining descriptive terms and classification methods.

Ground conditions encountered generally comprised topsoil overlying sand. The intersected subsurface profile can be summarised as:

- **Filling** - loose, light yellow, uncontrolled sand filling was encountered at BH28 to a depth of 0.2 m;

- **Topsoil** - brown silty sandy topsoil generally to depths of between 0.05 m and 0.15 m observed at all test locations;
- **Sand** – generally medium dense, brown and light yellow-brown, sand was encountered at all test locations underlying topsoil to the terminated depth (2.6 m) of investigation. Extremely low strength lithified sand layers were encountered at TP6, TP8, TP9, TP19, TP22 and TP26.
- **Organic sand** – loose, dark grey, organic sand with some low plasticity fines was encountered at BH27 from a depth of 1.1 m to 1.5 m.

4.2 Groundwater

Free groundwater was observed at TP2 at a depth of 2.5 m (RL 3.0 AHD) below existing surface level on 1 June 2011. The test pits were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels.

The Perth Groundwater Atlas (2004) indicates that the groundwater level was approximately 1.7 m (RL 2 AHD) below the lowest part of the site, in May 2003.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory and comprised the determination of the particle size distribution on six samples.

Detailed test report sheets are given in Appendix B and the results are summarised in Table 1.

Table 1: Results of Laboratory Testing

Pit	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	Material
TP3	0.3	2	0.17	0.27	Sand – light brown with trace silt
TP6	0.8	2	0.16	0.27	Sand – light grey with trace silt
TP9	0.5	1	0.16	0.26	Sand – light yellow-brown with trace silt
TP13	0.5	1	0.16	0.27	Sand – light yellow-brown with trace silt
TP15	1.4	1	0.17	0.30	Sand – light yellow-brown with trace silt
TP23	0.6	1	0.17	0.29	Sand – light yellow-brown with trace silt

Where:

-The % fines is the amount of particles smaller than 75 µm.

-A d_{10} of 0.21 mm means that 10% of the sample particles are finer than 0.21 mm.

-A d_{60} of 0.50 mm means that 60% of the sample particles are finer than 0.50 mm.

6. Proposed Development

It is understood that the proposed development comprises the subdivision of the site into industrial allotments and associated access roads. The concept plan provided by the client indicates that a proposed public open space (POS) occupies the western part of the site (shown on Drawing 1 in Appendix A).

7. Comments

7.1 Site Classification

The shallow ground conditions beneath the site comprise generally medium dense sand. Based on the results of the investigation, a site classification 'Class A' in accordance with AS 2870-2011 should be suitable for this site provided site preparation is carried out as detailed in Section 7.2.

As detailed in Section 4.2, organic sand was encountered at BH27, which was located within the proposed public open space area. Organic soils are considered unsuitable for the support of structures. If similar soil is encountered within the proposed allotment areas during detailed investigation, then the above mention site classification would be affected.

7.2 Site Works, Preparation and Compaction

Prior to excavation for foundations and/or placement of fill, all deleterious material, including vegetation and topsoil, should be stripped from the proposed allotments and road reserve areas, and either removed from site or stockpiled for possible re-use for landscaping purposes only.

As detailed in the above section, organic sand is unsuitable for the support of structures. If such soil is encountered within the proposed allotments during detailed investigation, then it should be excavated and removed from the site or stockpiled for re-use as landscaping only.

Following removal of unsuitable material and prior to any filling, it is recommended that the exposed subgrade beneath the building envelopes and pavement areas be proof rolled using a medium to heavy (minimum of 12 tonne) vibrating smooth drum roller. Any areas that show signs of excessive deformation during compaction should be continually compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural filling compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Care should be taken not to operate heavy plant and vibrating roller immediately adjacent to existing buildings and services.

Naturally occurring sand excavated from the site should be suitable for re-use as structural fill, provided it is free from organic material and particles greater than 150 mm in size. Imported filling, if required, should comprise free draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size. It is recommended that naturally occurring sand at this site and imported sand filling be placed in loose lift thickness of not more than 300 mm, within 2% of its optimum moisture content

with each layer compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Compaction control of the sand at the site could be carried out using a PSP in accordance with test method AS 1289.6.3.3.

All proposed building envelopes and pavement areas should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 1.0 m and 0.75 m below foundation level of the proposed buildings and proposed pavement subgrade respectively. Compaction control of the sand at the site could be carried out using a Perth sand penetrometer (PSP), as suggested above.

During construction, some loosening of the surface sands in foundation excavations is expected. Therefore the top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings.

7.3 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for 'Class A' conditions, provided that site preparation is carried out as detailed in Section 7.2.

AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. For buildings not covered by AS 2870-2011, a presumptive allowable bearing pressure of 200 kPa is suggested for foundation design of strip and pad footings founded at a minimum depth of 0.5 m in at least medium dense sand. This should ensure that total and differential settlements will be less than 5 mm.

7.4 Pavement Design Parameters

Based on field observations it is recommended that a subgrade CBR of 12% be used for the design of flexible pavements on sand subgrade encountered at this site, provided that such subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction, as determined by AS 1289.5.2.1.

7.5 Soil Permeability and Stormwater Disposal

The shallow soil conditions beneath the site comprise sand, therefore it is considered that stormwater disposal using soakwells and sumps should be feasible at this site.

A permeability value was derived using grading results of soil samples and the Hazen's formula, which applies for sand in a loose state. Results of the permeability analysis are summarised in Table 2.

Table 2: Summary of the Derived Permeability Values

Pit	Depth (m)	Derived Permeability (m/s)	Material
TP3	0.3	2.9×10^{-4}	Sand – light brown with trace silt
TP6	0.8	2.6×10^{-4}	Sand – light grey with trace silt
TP9	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP13	0.5	2.6×10^{-4}	Sand – light yellow-brown with trace silt
TP15	1.4	2.9×10^{-4}	Sand – light yellow-brown with trace silt
TP23	0.6	2.9×10^{-4}	Sand – light yellow-brown with trace silt

Results of the analyses indicate permeability values ranging between 2.6×10^{-4} m/s and 2.9×10^{-4} m/s for the sand encountered at this site. Given that the density of the sand at the site is likely to be increased during earthworks operations, a design permeability value of 1×10^{-4} m/s is suggested. It is emphasised that a lower permeability value than that indicated may be appropriate for a long-term design value which takes into account long term bio-build up and/or siltation of the infiltration surface.

8. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
3. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
4. Australian Standard AS 2870-2011, Residential Slabs and Footings
5. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.

9. Limitations

Douglas Partners (DP) has prepared this report for an industrial and commercial development for the Port Kennedy Business Park in Port Kennedy, WA in accordance with DP's proposal dated 19 April 2011 and acceptance received from Mr David Porter of Porter Consulting Engineers on 27 May 2011. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Porter Consulting Engineers for this project only and for the purposes described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and

also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings
Results of Field Work

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

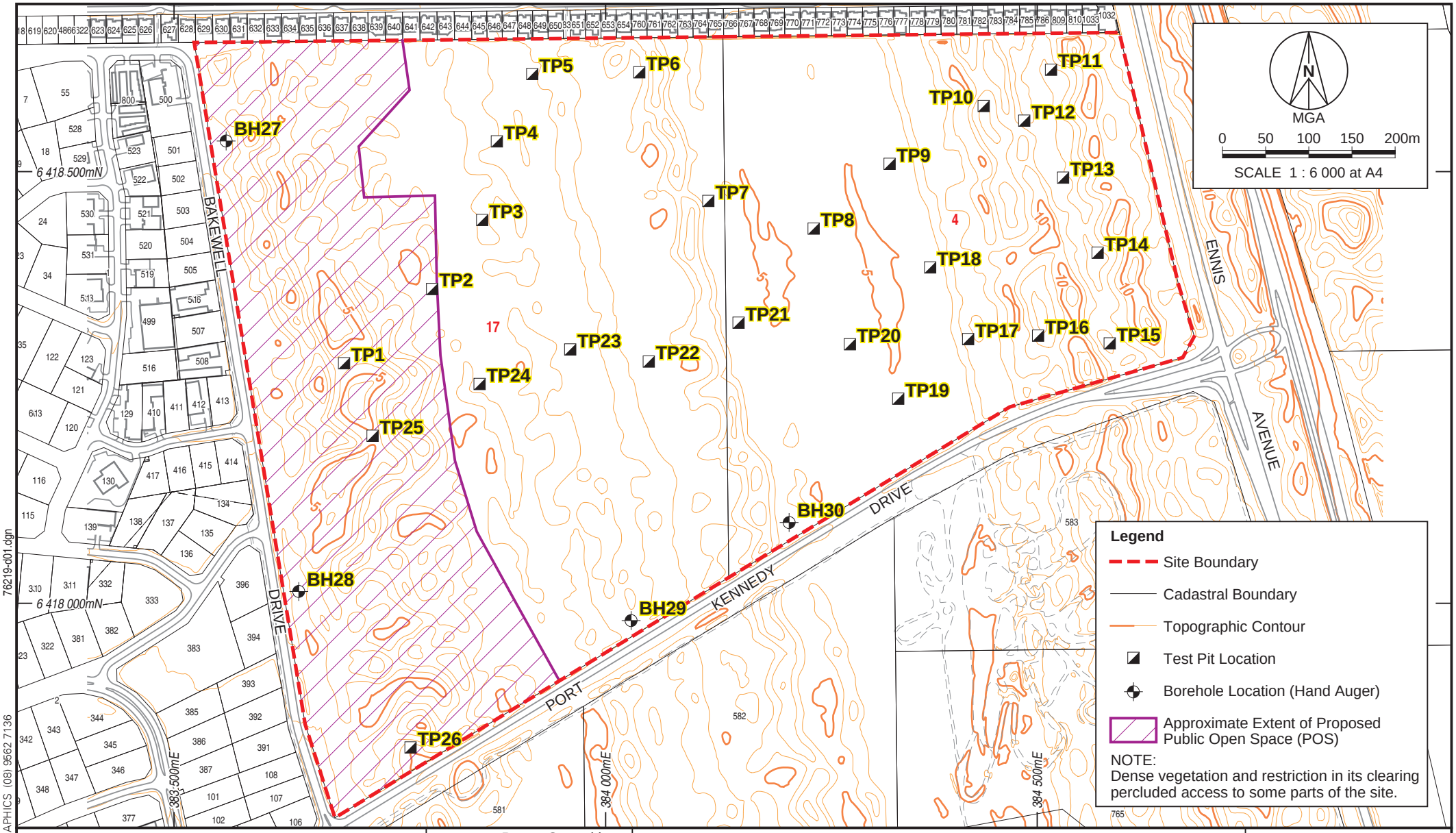
Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.



76219-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Porter Consulting Engineers
OFFICE:	Perth
DATE:	13 Jul 2011

Location of Tests
Port Kennedy Business Park
Port Kennedy, WA

PROJECT No.:	76219
DRAWING No.:	1
REVISION:	A

APPENDIX 4

GROUNDWATER REPORT

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Email :	*NicolaPopenhagen@landcorp.com.au*	**Pages :**	19
cc :			

LOT 4 & 17 PORT KENNEDY DRIVE, PORT KENNEDY
Pre-Development Annual Monitoring Report 2010-2011

1 Introduction

This monitoring report has been prepared by JDA Consultant Hydrologists on behalf of Landcorp for Lot 4 &17 Port Kennedy Drive, Port Kennedy herein referred to as the Study Area (Figure 1).

JDA Consultant Hydrologists completed an investigation of the Average Annual Maximum Groundwater Level (AAMGL) for the Study Area in October 2009 (JDA 2009), which has been followed by an 18 month pre development hydrological monitoring program.

This report constitutes the first and final annual hydrological monitoring report for the Study Area. It presents a brief summary of groundwater data collected over the 18 month monitoring period from October 2009 to April 2011 with 16 months of predevelopment data.

2 Monitoring Program

On 28 September 2009 JDA installed eight shallow aquifer monitoring bores at the Study Area (PK1 – PK8). The bores were installed by 75mm push probe drill to depths between 4.5 m and 8.0 m. All bores were cased in 50 mm PVC pipe with end caps, and slotted 3m into the water table. Bore locations are shown in Figure 2 and details in Table 1.

Lithological logs recorded during the installation of the bores, indicate the general soil profile over the entire site consist of 0.5 m brown topsoil overlying white cream Safety Bay sands. Bore logs are included as Appendix A.

Department of Water (DoW) bores T430 OBS and T480 are the closest long term monitoring bores to the Study Area and were included in the monthly groundwater level monitoring program.

The following parameters were monitored over the 18 month period:

- Monthly monitoring of groundwater levels in the superficial aquifer of 8 JDA bores and the nearby DoW long term monitoring bore. Levels were measured using an electrical depth probe in metres below natural surface. Survey of the bores was used to convert measured levels to mAHD.
- Quarterly groundwater quality sampling of the JDA bores PK1, PK3, PK5, PK7 and PK8. Bores were analysed for nutrients (TN, NH_4, NOx, TKN, TP and PO_4); pH and EC were tested in situ. Samples were submitted to a NATA certified laboratory for analysis of the nutrients.

Table 1: JDA Groundwater Bore Details

Bore	Location (GDA 94)		Natural Surface (mAHD)	Top of Casing (mAHD)
	Easting	Northing		
PK1	383685	6417763	5.88	6.53
PK2	383599	6418208	5.81	6.42
PK3	383538	6418639	6.37	6.97
PK4	384144	6418033	5.80	6.41
PK5	384157	6418461	5.32	5.92
PK6	384163	6418645	5.63	6.23
PK7	384604	6418276	6.98	7.68
PK8	384570	6418638	8.00	8.64
T480	383643	6413859	-	8.62
T430 (OBS)	385714	6416781	-	7.18

3 Monitoring Data

3.1 Groundwater Levels

Recorded monthly groundwater levels are shown in Figure 3, with a summary of recorded annual maximum and minimum groundwater levels shown in Table2.

Winter maximum groundwater levels ranged from 2.64 mAHD (PK7) to 4.25 mAHD (PK3) across the Study Area. Depth to the maximum groundwater level below natural surface varied from 1.72 to 4.25 m across the Study Area. Summer minimum groundwater levels ranged from 1.72 mAHD (PK7) to 2.93mAHD (PK3) across the Study Area. Observed seasonal groundwater variations were in the range of 0.3m to 0.62 m across the site, which is typical of the Swan Coastal Plain.

The AAMGL investigation undertaken in October 2009 (figure 2) is consistent with the pre development groundwater monitoring program undertaken by JDA between 2009 and 2011.

Table 2: Groundwater Level Data

Bore	Natural Surface (mAHD)	Summer Feb 2010 minimum		Winter Oct 2009 maximum		Seasonal Groundwater Variation (m)
		mBNS	mAHD	mBNS	mAHD	
PK1	5.88	2.89	2.99	2.41	3.47	0.48
PK2	5.81	2.48	3.33	1.91	3.90	0.57
PK3	6.37	2.74	3.63	2.12	4.25	0.62
PK4	5.80	2.91	2.89	2.51	3.29	0.4
PK5	5.32	2.22	3.10	1.70	3.62	0.52
PK6	5.63	2.44	3.19	1.89	3.74	0.55
PK7	6.98	4.64	2.34	4.34	2.64	0.3
PK8	8.00	5.7	2.30	5.12	2.88	0.58

3.2 Groundwater Quality

All groundwater bores were monitored quarterly for nutrients. The monitoring results are shown in Table 3. Rubbish located close to many of the bores at the site may alter the groundwater quality of the samples obtained from the Study Area over time.

3.2.1 pH & Electrical Conductivity

pH and EC were recorded insitu at each of the 8 monitoring bores. pH ranged between a minimum of 6.61 at PK4 in January 2010 and a maximum of 8.32 at PK1 in July 2010. Mean pH is between 7.16 and 7.63 across all bores for the monitoring period.

pH results indicate groundwater is generally neutral with all bores within the Study Area showing pH values above 6.60, and mean values within the ANZECC guideline range of 6.5-8.0 pH units (ANZECC 2000).

Electrical conductivity (EC) was generally consistent at all bores over the monitoring period ranging from a minimum of 0.27 mS/cm (PK5, October 2010) to a maximum of 0.85 mS/cm (PK5, July 2010). Mean EC values were between 0.47 and 0.79 mS/cm. These mean EC values are within the expected range of 0.3-1.5 mS/cm for slightly disturbed ecosystems in south-west Australia (ANZECC 2000).

3.2.2 Nutrients

In general, all parameters for the sampled bores remained generally consistent for all monitoring events with the exception of Nitrogen Oxide (NOx) and Total Nitrogen (TN) parameters. Nutrient levels did not follow expected seasonal variation of elevated recordings during winter peaks and the initial flush of nutrients at the beginning of the monitoring period. The predevelopment monitoring levels for the nutrient parameters are shown in figure 4 and figure 5.

Ammonia (NH_4N) results were consistent and remained above 0.05mg/L, until October 2010 when all bore results decreased below 0.005mg/L, and remained low for the rest of the monitoring period. The mean values for NH_4H ranged between 0.28-0.44mg/L, above the ANZECC guideline value of 0.08mg/L (ANZECC 2000).

Bores PK3, PK5 and PK7 were consistent throughout the monitoring period for Nitrogen Oxide (NOx_N) with values below 5.3mg/L. PK1 and PK8 had much higher readings for NOxN ranging from 5.9-16mg/L with the exception of July 2010.

This was consistent with results for Total Nitrogen (TN), with PK1 and PK8 values above the mean for the monitoring period of 6.31mg/L, except in July 2010. July 2010 results were consistent for PK3, PK5 and PK7 bore results for both NOxN and TN.

Total Nitrogen (TN), TN varied from a minimum of 0.93 mg/L (PK1, July 2010 and PK3, April 2011) to a maximum of 22 mg/L (PK1 April 2010). Mean TN concentrations for individual bores ranged from 2.78 mg/L to 10.72 mg/L. These mean values exceed the ANZECC predevelopment value of 1.2 mg/L (ANZECC 2000).

Total Phosphorus (TP) varied from below the detectable limit (0.01 mg/L) to a maximum of 0.33 mg/L. Mean TP concentrations for individual bores ranged from 0.08 mg/L to 0.09 mg/L, which is above the ANZECC guideline value of 0.065mg/L (ANZECC 2000).

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Table 3: Groundwater Water Quality Data: pH, EC, TDS & Nutrients

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
pH	PK1	7.14	7.57	8.32	7.39	7.66	7.68	7.63
	PK2	7.15	7.36	7.50				7.34
	PK3	7.17	7.59	7.89	7.38	7.87	7.80	7.62
	PK4	6.61	7.39	7.53				7.18
	PK5	7.14	7.43	7.58	7.24	7.62	7.52	7.42
	PK6	6.92	7.24	7.33				7.16
	PK7	7.19	7.76	7.59	7.57	7.97	7.64	7.62
	PK8	7.12	7.48	7.56	7.48	7.68	7.42	7.46
EC (mS/cm)	PK1	0.62	0.65	0.30	0.27	0.53	0.55	0.49
	PK2	0.62	0.62	0.52				0.59
	PK3	0.52	0.50	0.55	0.43	0.40	0.4	0.47
	PK4	0.62	0.68	0.64				0.65
	PK5	0.62	0.65	0.85	0.57	0.56	0.64	0.65
	PK6	0.82	0.77	0.78				0.79
	PK7	0.80	0.64	0.57	0.66	0.56	0.57	0.63
	PK8	0.66	0.63	0.61	0.56	0.60	0.65	0.62
NH_4_N (mg/L)	PK1	0.33	2.30	0.024	<0.005	<0.005	<0.005	0.44
	PK2							
	PK3	0.29	1.50	0.019	<0.005	<0.005	<0.005	0.30
	PK4							
	PK5	0.13	1.50	0.028	<0.005	<0.005	<0.005	0.28
	PK6							
	PK7	0.18	1.70	0.087	<0.005	<0.005	0.009	0.33
	PK8	0.22	1.80	0.050	<0.005	<0.005	<0.005	0.35
NOx_N (mg/L)	PK1	9.40	16.00	0.12	6.40	11.00	9.60	8.75
	PK2							
	PK3	2.20	4.30	0.52	5.30	2.60	0.56	2.58
	PK4							
	PK5	1.80	2.00	0.32	3.50	2.60	3.10	2.22
	PK6							
	PK7	0.84	1.80	0.25	1.30	1.50	1.80	1.25
	PK8	16.00	5.90	0.91	9.70	6.70	6.10	7.55

Parameter & Location		Monitoring Date						Mean
		14/1/2010	13/4/2010	13/7/2010	14/10/2010	1/1/2011	12/04/2011	
Tot N (mg/L)	PK1	10.00	22.00	0.93	6.70	6.70	18.00	10.72
	PK2							
	PK3	3.90	5.50	4.00	5.40	5.40	0.93	4.19
	PK4							
	PK5	3.20	7.50	3.90	3.50	3.50	3.70	4.22
	PK6							
	PK7	2.10	6.50	2.60	1.50	2.00	2.00	2.78
	PK8	17.00	8.80	7.00	9.90	7.40	7.70	9.63
TKN (mg/L)	PK1	0.60	6.00	0.81	0.25	0.19	8.80	2.78
	PK2							
	PK3	1.70	1.20	3.50	0.13	0.70	0.34	1.26
	PK4							
	PK5	1.40	5.50	3.60	0.04	0.98	0.68	2.03
	PK6							
	PK7	1.30	4.70	2.30	0.21	0.49	0.21	1.54
	PK8	1.50	2.90	6.10	0.15	0.69	1.60	2.16
Tot P (mg/L)	PK1	0.06	0.33	0.06	0.01	0.02	0.02	0.08
	PK2							
	PK3	0.06	0.33	0.05	0.02	0.02	0.03	0.09
	PK4							
	PK5	0.06	0.33	0.05	0.02	0.04	0.04	0.09
	PK6							
	PK7	0.06	0.33	0.05	0.01	0.01	0.02	0.08
	PK8	0.06	0.33	0.06	0.02	0.01	0.03	0.09
PO4_P (mg/L)	PK1	0.008	<0.005	<0.005	0.009	0.006	0.01	0.01
	PK2							
	PK3	0.012	<0.005	<0.005	0.02	0.01	0.02	0.01
	PK4							
	PK5	0.013	<0.005	0.006	0.02	0.01	0.03	0.01
	PK6							
	PK7	0.01	<0.005	<0.005	0.006	0.007	0.02	0.01
	PK8	0.01	<0.005	0.007	0.02	0.01	0.02	0.01

4 Conclusions

Analysis of depth to groundwater at each of the 8 bores indicates a separation for natural surface to groundwater of greater than 1.7m at all bores. Typical building design requires clearance of at least 1.2m for soakwells. Groundwater levels at the site do not appear to pose any constraints to this requirement.

The results obtained during the 18 month monitoring period at Port Kennedy are considerably higher than the Groundwater Quality ANZECC guideline values for Fresh and Marine Water Quality (2000a). This is common for predevelopment monitoring within the superficial aquifer on the Swan Coastal Plain. Results obtained for predevelopment monitoring should be considered as baseline and for the basis upon which water quality reduction targets are formed. Rubbish located close to many of the bores at the site may also have influenced the groundwater quality of the samples obtained from the Study Area over time.

These conclusions and recommendations are supported by results collected over the 18 month monitoring period, and should be considered as the baseline for which water quality reduction targets are formed.

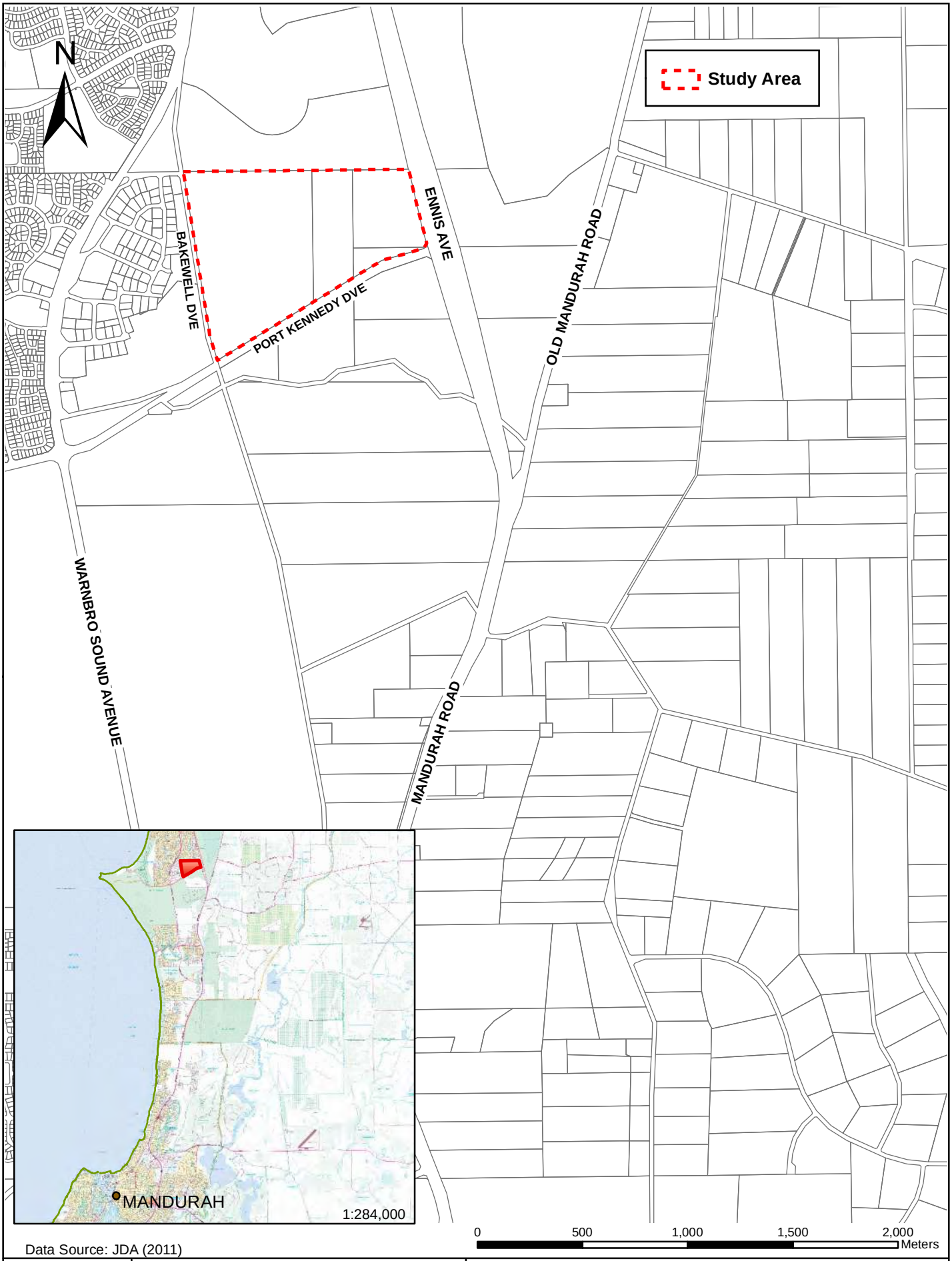
5 References

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, October 2000

JDA (2009) Lot 4 & 17 Port Kennedy Drive, Port Kennedy AAMGL Investigation, November 2009

Should you have any queries regarding the above report, please contact Matthew Yan or Kate Smith of this office.

JDA CONSULTANT HYDROLOGISTS



Data Source: JDA (2011)

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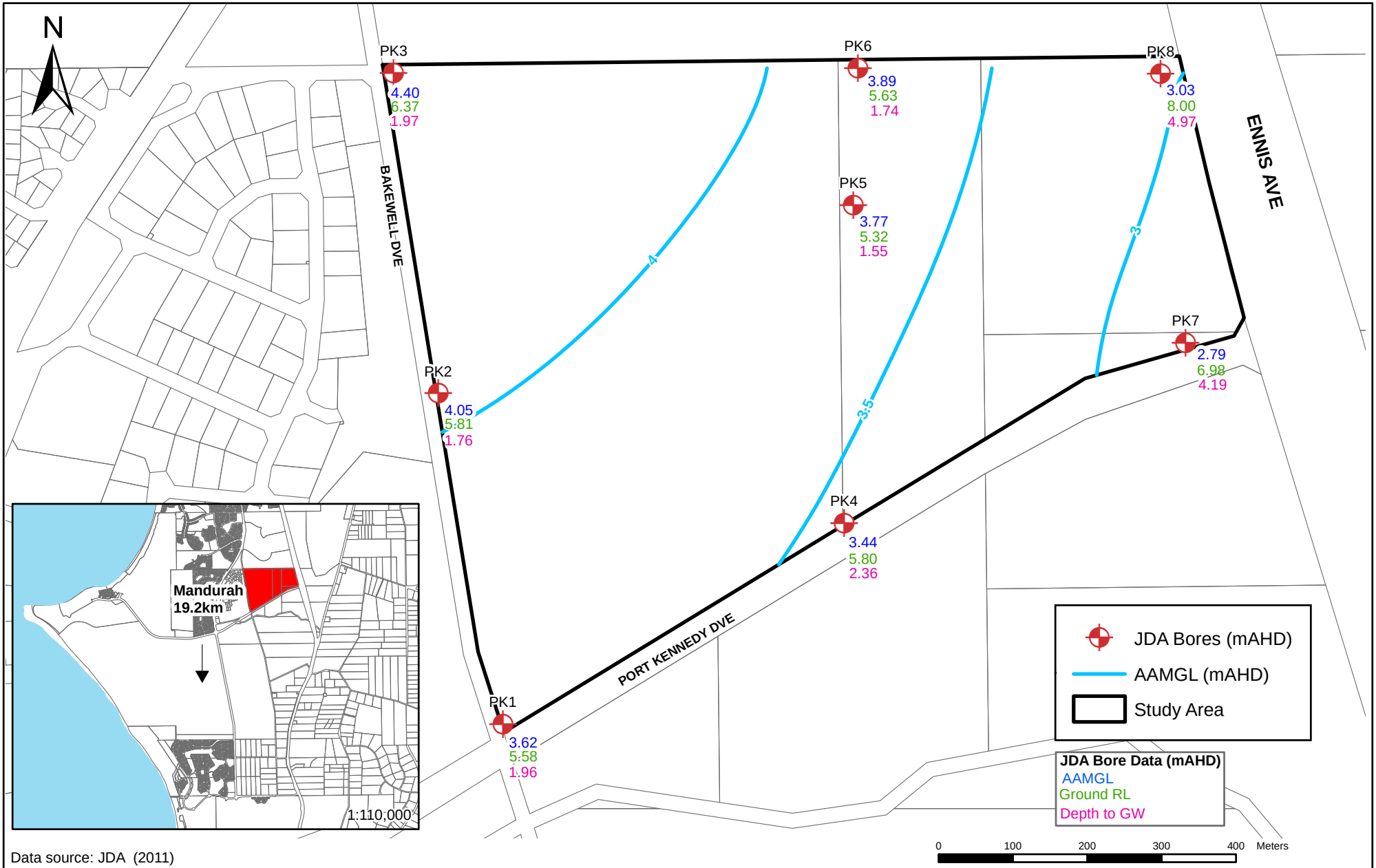
Landcorp
Lots 4 & 17 Port Kennedy Drive: Predevelopment Gorundwater Investigation
Figure 1: Location Plan



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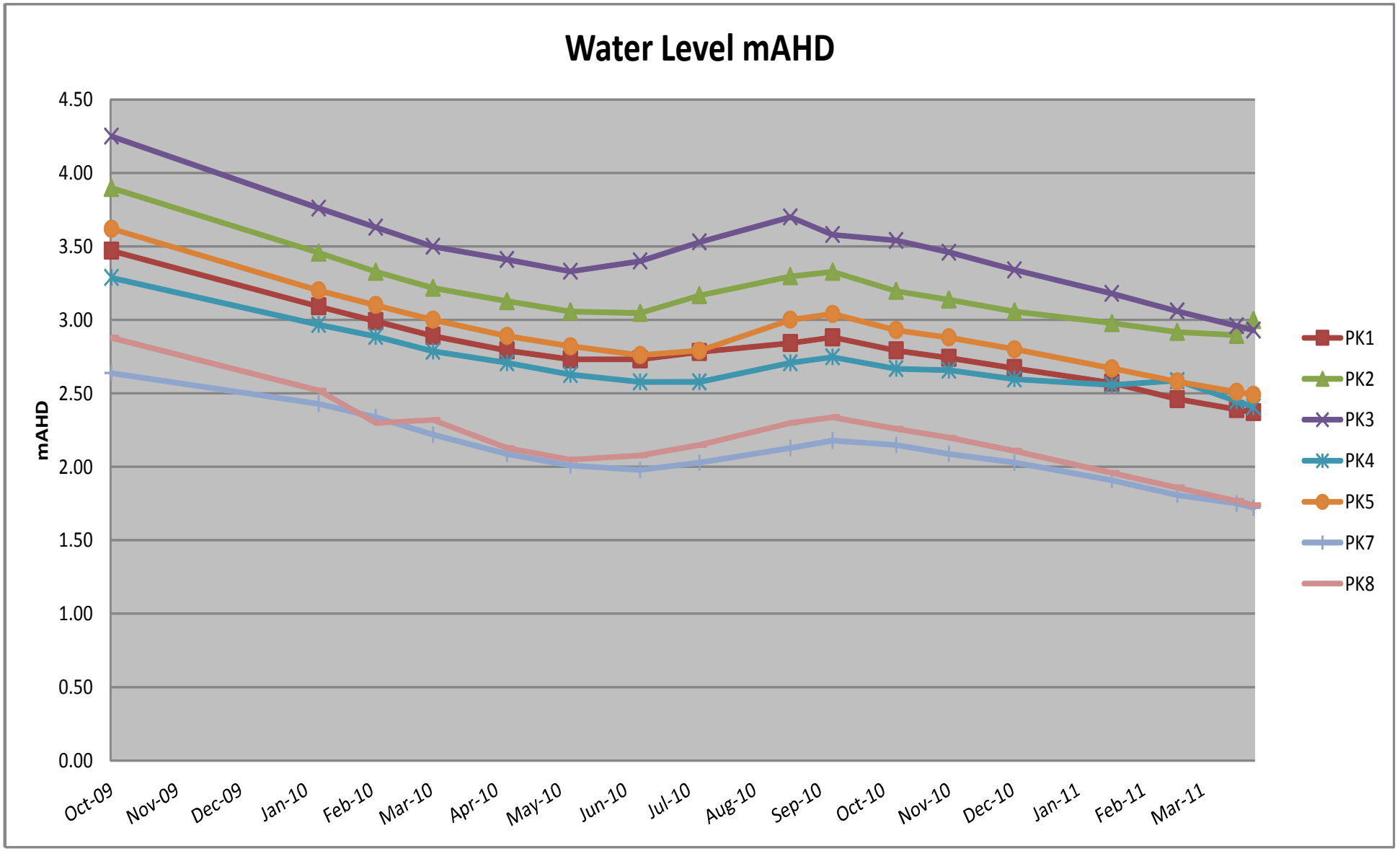
Job No. J4511
Scale:1:7,000

Landcorp

Lots 4 & 17 Port Kennedy Drive: PredevelopmentGroundwater Investigation

Figure 2: Groundwater Plan



Data Source: JDA (2011)

Job No. J4511

0 100 200 300 400 Meters

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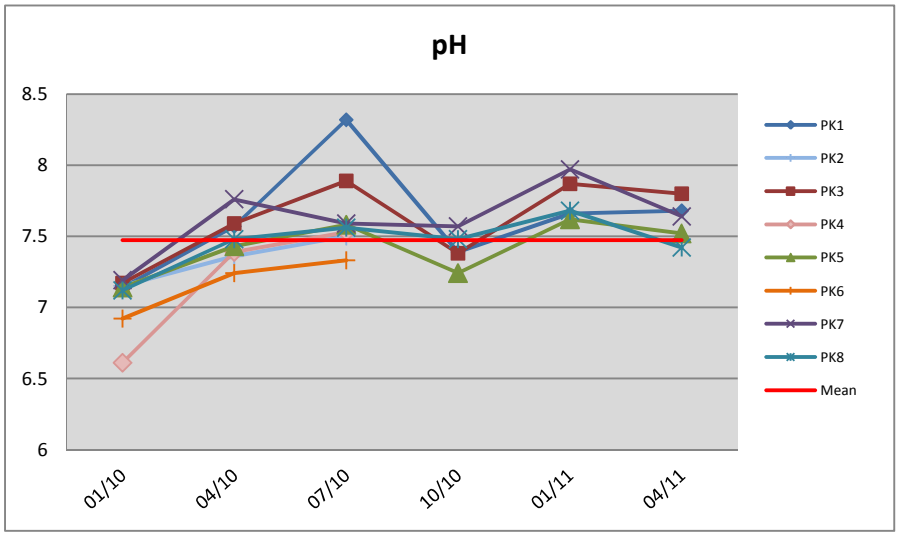
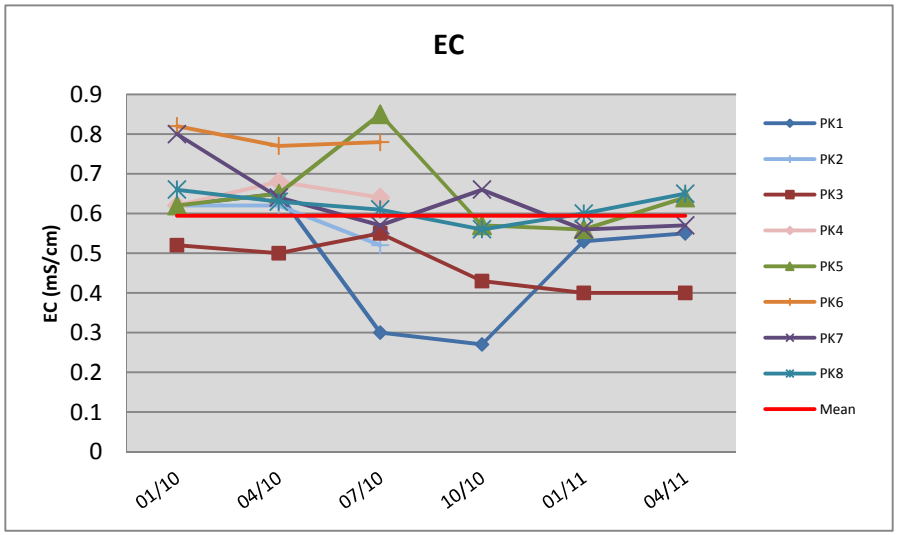
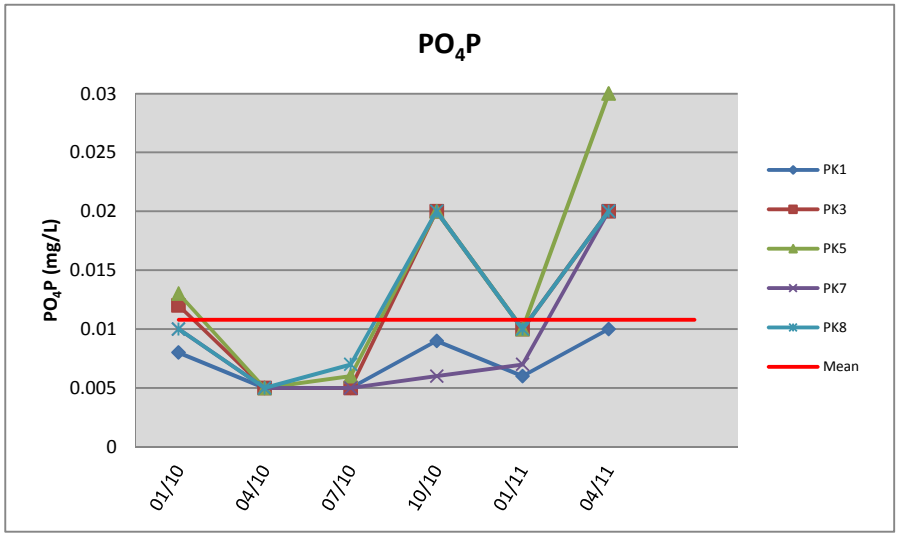
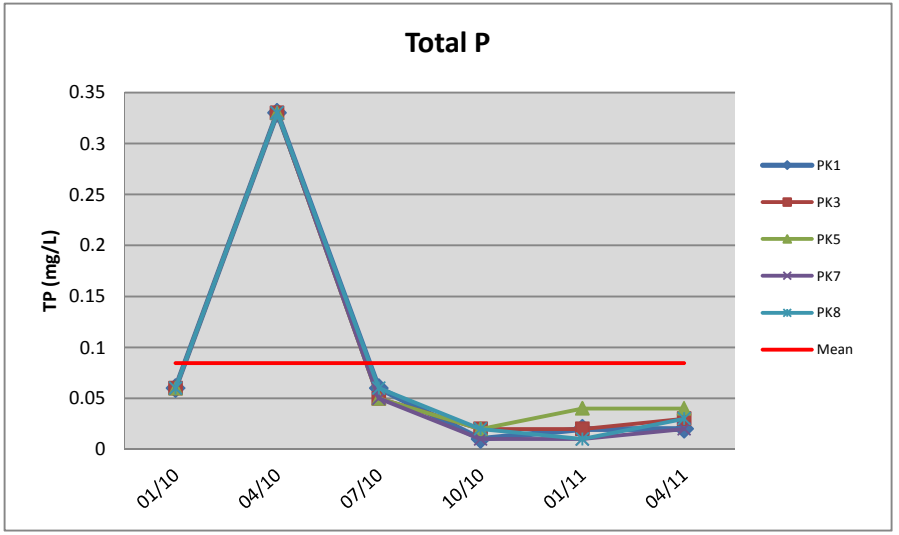
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 3: Groundwater Levels 2010-2011









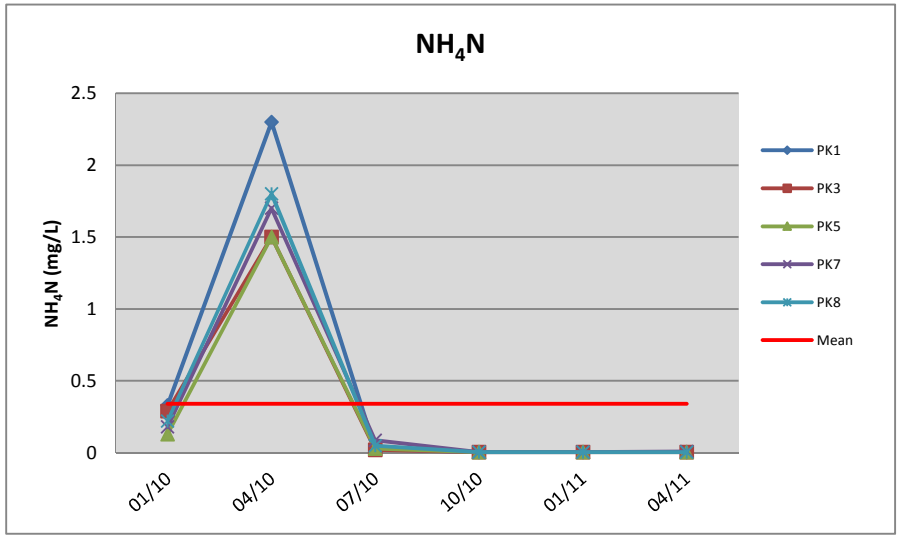
Data Source: JDA (2011)

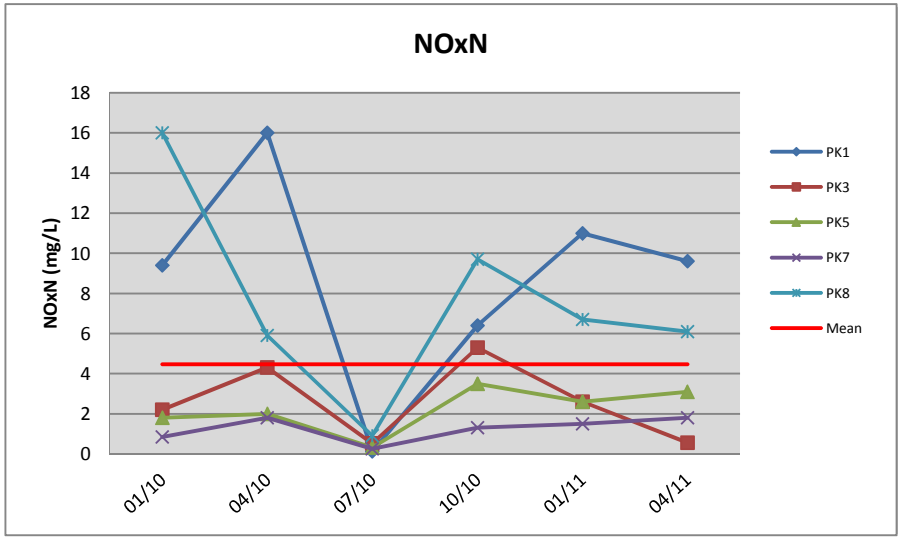
Job No: J4511

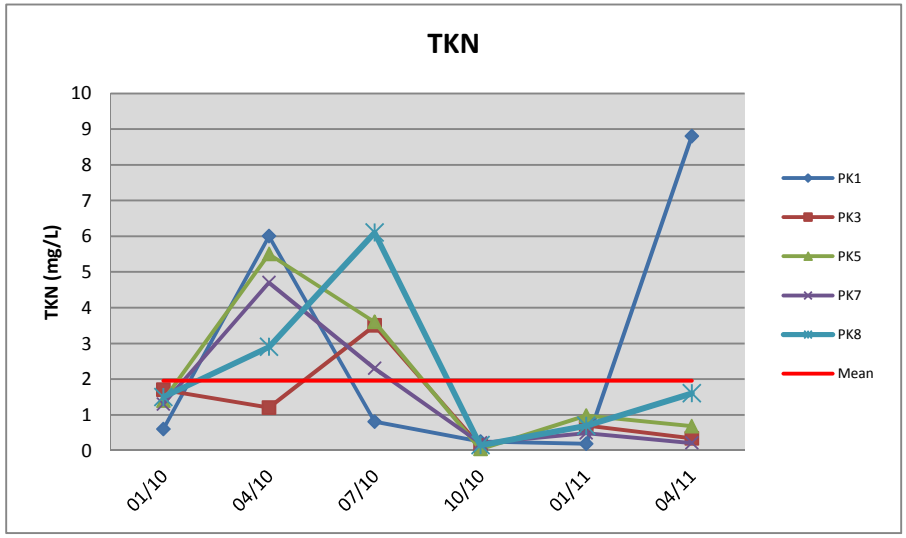
Landcorp

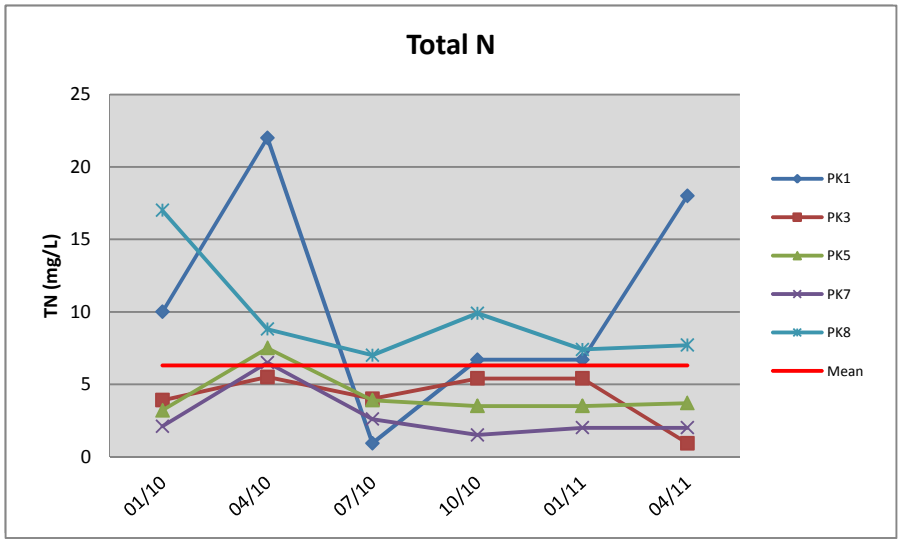
Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 4: Monitoring Results 2010- 2011









Data Source: JDA (2011)

Job No: J4511

Landcorp

Lot 4 & 17 Port Kennedy Drive: Predevelopment Groundwater Investigation

Figure 5: Monitoring Results 2010- 2011

APPENDIX A

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383685 N6417762	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK1	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med round	sand well sorted	nil	nil	
				1.0m						
				1.5m	yellow/white	fine round	Safety Bay Sand well sorted			
				2.0m						
		▽		2.5m						
				3.0m						
				3.5m	yellow / white	fine	Safety Bay Sand some shells		moist	
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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Subiaco WA 6008
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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E383606 N6418210	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK2	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)					Brown	fine	well sorted sand		nil	
				0.5m	light brown / white	fine	well sorted sand		nil	
				1.0m						
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m	light brown / white	fine	well sorted sand		moist	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	2.00pm
Bore location:	E383537 N6418639	Hole completed:	2.34pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK3	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	well sorted sand	some	dry	
				1.0m	yellow / white	fine	Safety Bay Sand well sorted	nil	dry	
		▽		1.5m						
				2.0m	white	fine	Ssfetly Bay sand	nil	moist	
				2.5m						
				3.0m						
				3.5m	yellow / white	med	gravelly sand	nil	moist	
				4.0m	yellow / white	fine	sand well sorted		saturated	
				4.5m			end of bore			
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	
Bore location:	E384143 N6418034	Hole completed:	
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK4	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Brown	med	sand	nil	nil	
				1.0m	light brown / white	fine	sand well sorted		nil	
				1.5m						
				2.0m						
				2.5m						
		▽		3.0m						
				3.5m	light brown / white	fine	sand well sorted		moist	
				4.0m						
				4.5m			end of bore		saturated	
				5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Lig Brown, Red, Orange, Yellow, Grey, Blue

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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	12.20pm
Bore location:	E384161 N6418456	Hole completed:	12.55pm
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK5	Total Depth:	4.2m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	Dark brown	med	sand well sorted	some	dry	
				1.0m	light brown	fine	sand well sorted	nil	dry	
				1.5m						
		▽		2.0m	yellow / white	med	sand sorted some shells		moist	
				2.5m					saturated	
				3.0m						
				3.5m						
				4.0m			end of bore			
				4.5m						
				5.0m						

NOTES ON BORELOG

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Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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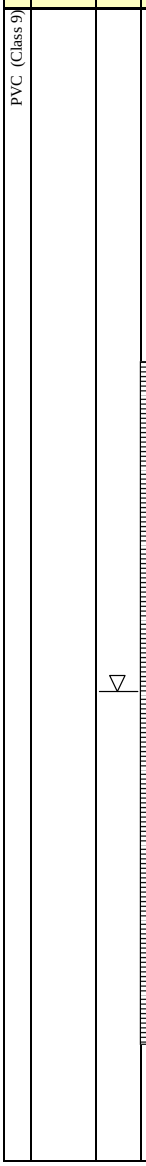
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	1:05
Bore location:	E384164 N6418647	Hole completed:	1:40
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK6	Total Depth:	4.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	



support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
					Dark brown	fine	sand	some	dry	
				0.5m	yellow / white	fine	sand well sorted	nil	dry	
				1.0m						
				1.5m						
									moist	
				2.0m						
				2.5m						
		▽		3.0m						
					yellow / white	fine	sand	nil	saturated	
				3.5m						
				4.0m						
				4.5m			end of bore			
				5.0m						

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SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	10:30
Bore location:	E384607 N6418273	Hole completed:	11:.05
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK7	Total Depth:	6.0m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown	fine / med	round sand	nil	dry	
				1.5m						
				2.0m	white	fine	Safetly Bay Sand well sorted		dry	
				2.5m						
				3.0m						
				3.5m						
				4.0m					moist	
		▽		4.5m	white	fine	poorly sorted sand large rocks + shells		saturated	
				6.0m						

NOTES ON BORELOG

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SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……..…m

Stickup above NS: ……m

WL …….. m below NS

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Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Landcorp	Job No:	J4511
Project:	Port Kennedy Drive	Hole commenced:	11:20
Bore location:	E384571 N6418642	Hole completed:	11:55
Datum:	MGA94/AHD	Logged by:	DK
Bore Name:	PK8	Total Depth:	7.5m
Drill type:	Push Probe	R.L. TOC:	
Hole diameter:	75mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				0.5m	dark brown	fine	sand well sorted	some	dry	
				1.0m	light brown white	fine	sand well sorted	none	dry	
				1.5m						
				2.0m	yellow / white	fine	sand well sorted	none	dry	
				4.0m						
		▽		5.0m	white	fine	sand some rocks fragments	none	moist	
				6.0m						
					white	fine	sand well sorted		saturated	
				7.0m	white	fine	clayey sand large rocks	end of bore	saturated	
				8.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark Brown, Red, Orange, Yellow, Grey, Blue
Medium Brown, Red, Orange, Yellow, Grey, Blue
Light Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

STATIC WATER LEVEL

Date: ……

WL below TOC ……m

Stickup above NS: ……m

WL …….. m below NS

APPENDIX 5

RPS-BBG AND STRATEGEN WETLAND MAPPING

APPENDIX 6

RPS-BBG VEGETATION AND FLORA REPORT

APPENDIX B

Process for the Review of Wetland Management Categories

Review of Wetland Management Categories

As described previously in Section 2.5 the Environmental Protection Authority and the Water and Rivers Commission (WRC) have developed three evaluation/management categories for wetlands (Conservation, Resource Enhancement and Multiple use) as shown in Table 2.

The WRC considers that if a wetland is recognised in existing expert evaluations at the international, national and regional level in the following publications then it is automatically assigned to the Conservation category:

1. Ramsar Convention;
2. A Directory of Important Wetlands in Australia;
3. Register of the National Estate;
4. System 6 Conservation through Reserves;
5. The Perth-Bunbury Study; and
6. Bush Forever.

As discussed in the previous section Becher Suite wetlands and the Port Kennedy area have been recognised in all of the above documents, although not necessarily within the study area specifically.

The WRC however does recognise that over time the values of certain wetlands can change. If a proponent feels that the evaluation category of a wetland is incorrect and wishes the Commission to re-assess, the proponent can submit a request for the wetland management category to be changed. There are at least four Conservation category wetlands within the Port Kennedy site which have been heavily impacted by clearing which would warrant reassessment.

There is a standard protocol to be used when submitting requests for wetland management categories to be changed. The four steps in the wetland re-evaluation process are:

Step 1

The proponent requests the Commission to reassess the wetland evaluation category. This request must be supported by:

- A clear and recent aerial photograph of the area at an adequate scale to clearly delineate wetland vegetation;

- On ground photographs from all angles of the wetland showing each habitat, section, direction and distinguishable areas of the wetland clearly indicating the condition of the wetland;
- A map showing the location and direction of the photograph points; and
- A report outlining why the proponent considers that the values listed in the previous studies no longer exist.

Step 2

When the proponent has submitted the information required in Step 1 the Commission has three options available:

- The Commission may decide that there is enough evidence from the photos provided to reassess the evaluation and make a decision on the evaluation category. No further action is required and the Commission will advise the proponent of the new evaluation; or
- The Commission may decide that the photographs do not show the need for re-evaluation and refuse to re-assess the evaluation category; or
- The Commission may decide that further justification is needed and request that an EPA Bulletin 686 is completed.

Step 3

If the Commission decides that further justification is needed, the Commission usually requests the proponent to undertake an assessment of the wetland using the methodology set down in the EPA's Bulletin 686.

Bulletin 686 provides a questionnaire used to determine management categories for wetlands through a series of questions regarding natural and human use attributes. The questionnaire consists of four sections:

Part I	Presence of Gazetted Rare Species
Part II	Natural Attributes
Part III	Human-use Attributes
Part IV	Supplementary questions

Part I is a filtering question, whilst Parts II and III are made up of a series of questions that relate to specific wetland attributes. The answers to each question are given a score, which are tallied to give a total score for each part. The scores enable the wetland to be classified into a management category by plotting the results within a graph shown in Appendix 2 of Bulletin 686. The supplementary questions in Part IV are only completed

if the wetland is placed between two wetland categories when plotted on the graph, or if the wetland is located on private land with high private human-use values.

If after the submission of the 686 report, the Commission feels that there is adequate justification to show that the wetland management category may need to re-evaluated, then a site visit shall be undertaken by a Commission staff member to check the evaluation.

Step 4

Agreements to alter the management category are to be signed off by a Manager or Director of the Commission.

APPENDIX B

RPS 2006 Botanical Report

FLORA AND VEGETATION REPORT
LOT 4 MANDURAH ROAD & LOT 17
PORT KENNEDY DRIVE, PORT KENNEDY

Prepared for:

Landcorp

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40 The Esplanade

PERTH WA 6000

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Report No: L06215-B

Rev 0, December 2006

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1.0 BACKGROUND

In the following text, Lot 17 refers to 17 Warnbro Sound Avenue Port Kennedy 6172 and Lot 4 refers to 4 Mandurah Road Port Kennedy 6172.

A Level 2 survey (Environmental Protection Authority, 2004) was commissioned by Landcorp to quantitatively assess flora and vegetation on both Lots 17 and 4, for the purposes of assessing environmental constraints as part of a Due Diligence.

Partial studies of the survey area have previously been carried out. Val English of the Species and Communities Branch of the Department of Conservation and Environment (DEC) supervised a quantitative vegetation assessment of wetlands at the western end of Lot 17. These wetlands are known as the Bakewell Drive wetlands (English *et al.*, 2002). A preliminary assessment of wetland vegetation across both Lots 17 and 4 was done by RPSBBG botanists (RPSBBG, 2002).

The following is a Level 2 Vegetation and Flora survey (Environmental Protection Authority, 2004) of Lots 17 and 4. It is a comprehensive assessment of conservation significance of the flora and vegetation at the site.

2.0 METHODS

2.1 Field Survey

Survey methodology was based on a Level 2 Flora and Vegetation Survey as outlined in Guidance Statement 51 (Environmental Protection Authority, 2004) and is consistent with methodology established in Keighery *et al.*,(1994) for the Swan Coastal Plain.

Sixteen 10m by 10m plots were established by botanists A. Mercier, A. Weston, K. McCreery, M. Henson and V. Yeomans between 31 August and 1 September 2006 and 17 and 23 November 2006.

The information recorded at each 10m by 10m plot included:

- A GPS location at the NW corner (WGS84, accuracy <5m);
- Photographs;
- Vegetation structure (Table B1)(Western Australian Planning Commission, 2000);
- Species present (including height and density);
- Soil description;
- Landform description;
- Aspect;
- Condition (Western Australian Planning Commission, 2000)(Table B2); and
- Bare ground and litter cover estimates.

Table B1: Vegetation Structure Classes (Western Australian Planning Commission, 2000)

Life Form/ Height Class	Canopy Cover (percentage)			
	100% - 70%	70% - 30%	30% - 10%	10% - 2%
Trees 10-30m Trees < 10m	Closed Forest Low Closed Forest	Open Forest Low Open Forest	Woodland Low Woodland	Open Woodland Low Open Woodland
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs > 2m Shrubs 1-2m Shrubs <1m	Closed Tall Scrub Closed Heath Closed Low Heath	Tall Open Scrub Open Heath Open Low Heath	Tall Shrubland Shrubland Low Shrubland	Tall Open Shrubland Open 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

Table B2: Vegetation Condition Scale (Western Australian Planning Commission, 2000)

Condition		Definition
P	Pristine	No obvious signs of disturbance.
E	Excellent	Vegetation structure intact, disturbance affecting individual species ; weeds are non-aggressive species
V	Very Good	Vegetation structure altered; obvious signs of disturbance
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained
D	Degraded	Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good (sic) condition without intensive management
C	Completely Degraded	Vegetation structure not intact; the area completely or almost completely without native species ('parkland cleared').

The flora inventory was developed from all collections made from plots and releves and included opportunistic records. Flora specimens were identified using the resources of the Western Australian Herbarium. Taxonomy is based on the DEC's flora database, Florabase (www.florabase.calm.wa.gov.au). Atkins (2006) was used as the reference list of DRF and Priority flora.

Condition assessment mapping was conducted using 1:5000 aerial photo-interpretation and site confirmation.

Vegetation community mapping was conducted using a combination of ground truthing, aerial photo-interpretation, floristics and structure of vegetation as well as nearest neighbour PATN analysis (Appendix B4).

A PATN analysis was conducted by E.A. Griffin and Associates. This is a multi-variate analysis which enabled a comparison of 10m by 10m plot data with equivalent data in Gibson *et al.*, (1994). This report established Floristic Community Types (FCT's) across the southern Swan Coastal Plain (SCP). From this analysis, the vegetation could be assessed for Threatened Ecological Communities (TEC's). This is currently the most accurate quantitative method of determining FCT's and TEC's available.

In addition to Gibson *et al.*, (1994), data was obtained courtesy of DEC's Species and Communities branch from three sites within known TEC's at the western end of Lot 17. These sites are known as the Bakewell Drive wetlands. In total, the data from the current survey was compared to six known TEC19 sites: three from Gibson *et al.*, (1994) and three from the TEC Branch.

2.2 Assessing Conservation Significance

2.2.1 Flora

Declared Rare Flora (DRF) are flora that have been adequately surveyed and are considered to be in danger of extinction, rare or otherwise in need of special protection within Western Australia. DRF are protected under the *Wildlife Conservation Act 1950* (as amended).

Additionally in Western Australia there are four categories of Priority flora, which are not DRF, but their conservation status warrants some protection. Three categories of Priority Flora are allocated to species that are poorly known (Priority 1 to 3). These require more information to be assessed for inclusion as DRF. The categories are arranged to give an indication of the priority for undertaking further surveys based on the number of known sites, and the degree of threat to those populations. A fourth category of priority flora (Priority 4) is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened.

Guidance Statement 51 (Environmental Protection Authority, 2004) lists species other than DRF and Priority Flora as of conservation significance where a species has:

- a keystone role;
- relictual status;
- anomalous features indicating a potential new discovery;
- a representation of a species range (range extensions, extremes or an outlier population);
- status as a restricted subspecies, variety, or naturally occurring hybrid;
- poor reservation; and
- status as a local endemic or has a restricted distribution.

This document states that conservation significance includes these criteria, but is not limited to them. In this instance, it includes flora that are poorly represented in the Western Australian Herbarium (WAH) and flora with few known populations.

Some flora species have additional protection under the *Environment Protection and Biodiversity Conservation Act (EPBC) 1999.* In Western Australia, this predominantly consists of DRF flora. These are defined as Threatened Flora Species under the *EPBC Act.* Penalties apply for any damage to individuals, populations or habitats of species protected.

2.2.2 Vegetation

Within Western Australia, Threatened Ecological Communities (TECs) are defined by CALM as those which are found to fit into one of the categories in Table B3. The categories "Data Deficient" and "Lower Risk" can be used to provide a list of communities not classified as threatened, but that require more information. Within Western Australia, TEC's have limited protection under the *Wildlife Conservation Act, 1950* and the *Environmental Protection Act, 1986* (as amended). TEC's will be protected by the proposed Biodiversity Conservation Act (in prep.)

Table B3: CALM Threatened Ecological Communities Category of Threat (English and Blyth, 1997)

Category	Definition
Presumed Totally Destroyed (PD)	An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies: A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats or B) All occurrences recorded within the last 50 years have since been destroyed.
Critically Endangered (CR)	An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria: A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and **either or both** of the following apply: • geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years) • modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capoable of being substantially rehabilitated. B) Current distribution is limited, and **one or more** of the following apply (i, ii or iii): • geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years) • there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes • there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years).

Category	Definition
Endangered (EN)	An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The estimated geographic range, and.or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii) • geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years) • modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is uynlikely to be capoable of being substantially restored or rehabilitated. B) Current distribution is limited, and one or more of the following apply (i, ii or iii): • geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years) • there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes • there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).
Vulnerable (VU)	An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated. B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.
Data Deficient (DD)	An ecological community which has not been adequately evaluated with respect to status or where there is currently insufficient information to assign it to a particular category. (An ecological community with poorly known distribution or biology that is suspected to belong to any of the above categories. These ecological communities have a high priority for survey and/or research.)
Lower Risk (LR)	An ecological community that has been adequately surveyed and does not qualify for any of the above categories of threat and appears unlikely to be under threat of significant modification or destruction in the short to medium term future.

The *EPBC Act* provides protection for TECs, which are defined as those communities which are:

- **Critically Endangered** (if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future);

- **Endangered** (if, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future); and

- **Vulnerable** (if, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future).

3.0 RESULTS

3.1 Flora

A total of 118 species were recorded from Lots 17 and 4. This is an estimated >80% of the flora species likely to exist at the site. Sixty four of the total 118 species were local flora and 54 were introduced.

3.1.1 Flora of Conservation Significance

No DRF or Priority flora were recorded from Lots 17 or 4. No species of conservation significance as defined by Guidance Statement 51 (Environmental Protection Authority, 2004) were recorded.

3.1.2 Introduced Flora

Sixty four introduced flora were recorded from Lots 17 and 4, which was 46% of the total flora recorded for the site.

The site has seven of the 34 weed species rated as High in the Environmental Weed Strategy for Western Australia (CALM, 1999). A high rating is given to those species which are known to have *'an ability to invade undisturbed bushland, have a wide current or potential distribution and have an ability to change the structure composition and function of ecosystems.'*

Table B4: Introduced Flora from Lots 17 and 4 in Environmental Weeds Strategy (High rating)

Species	Common Name	Survey Area Distribution
**Brassica tournefortii*	Mediterranean Turnip	Lot 17 & 4. Low density, occasional.
**Bromus diandrus*	Great Brome	Lot 17. One record at low density in wetland 2 (site PK02).
**Ehrharta calycinus*	Perennial Veldt Grass	Lot 17 & 4. Occasional at low density. Mainly near tracks and firebreaks.
**Eragrostis curvula*	African Lovegrass	Lot 17 & 4. Occasional in vegetation (adjacent to housing on north boundary).
**Euphorbia terracina*	Geraldton Carnation Weed	Lot 17 & 4. Widespread and naturalised. Densities from <1% to 35% total cover.

Species	Common Name	Survey Area Distribution
**Lagurus ovatus*	Hare's Tail Grass	Lot 17 & 4. Widespread and naturalised. Densities from <1% to 35% total cover.
**Pelargonium capitatum*	Rose Pelargonium	Lot 17 & 4. Scattered individuals from eastern boundary of Lot 17 eastwards.

A number of garden escapes have become weeds due to the dumping of garden waste at the site. Couch **Cynodon dactylon* was seen in several rubbish piles. **Yucca aloifolia* was on the western firebreak of Lot 17. The Olive **Olea europaea* is becoming naturalised across the eastern boundary of Lot 17 and Lot 7. **Gaura lindheimeri*, a recent garden escape was recorded from the wetland containing site PK01.

3.2 Vegetation

3.2.1 Vegetation Communities

The primary division in the vegetation communities was between 1: Dune System and 2: Wetlands, Damplands and Depressions in Dune Swales. The PATN analysis indicated that this division coincides with FCT29B: *Acacia* Shrublands on Taller Dunes and FCT19: Sedgelands in Holocene Dune Swales (Gibson *et al.*, 1994).

The vegetation communities were defined as:

1. Dune System

1a Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests.

1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.

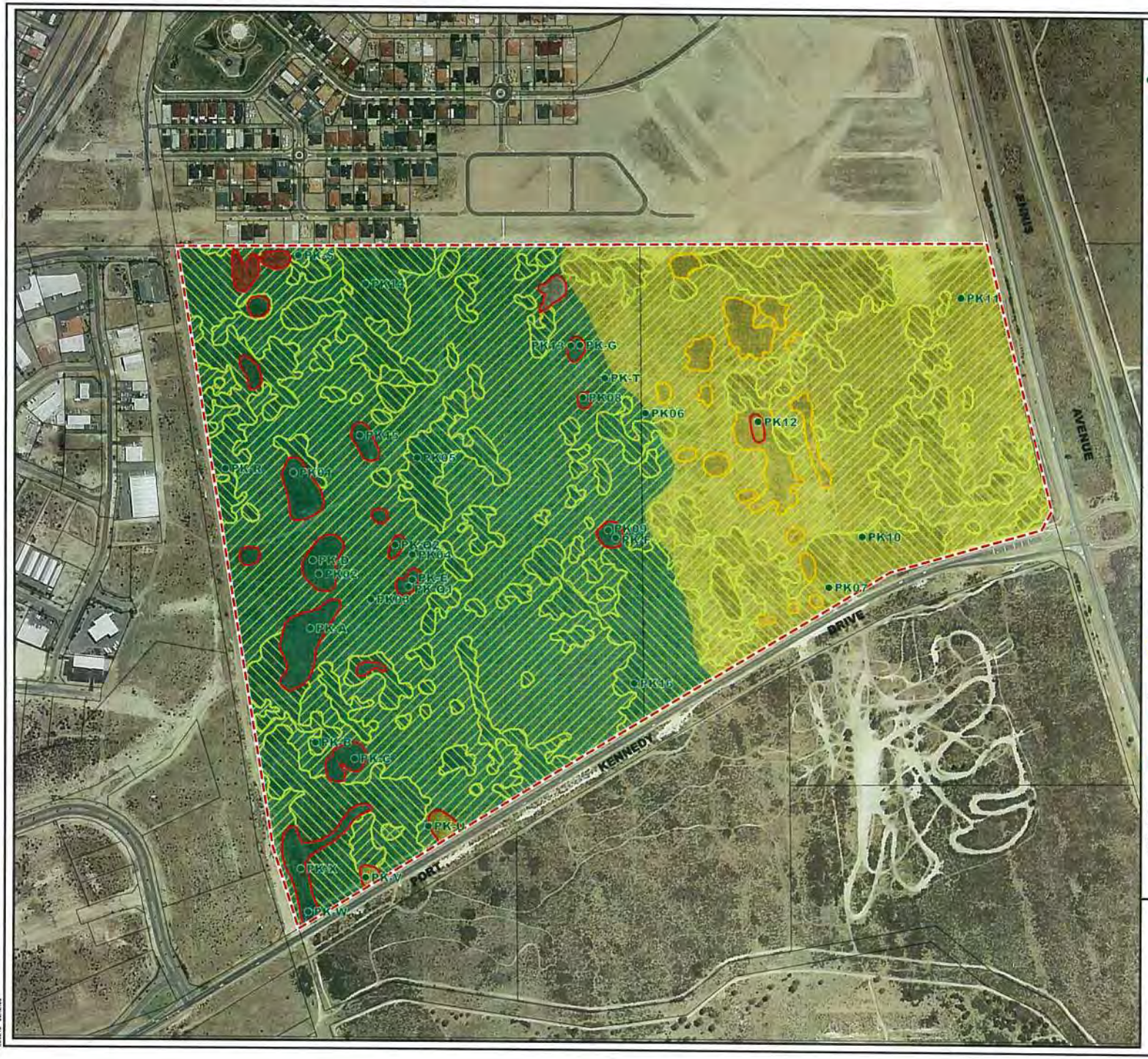
2. Wetlands, Damplands and Depressions in Dune Swales

2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.*

2b: Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa.*

2c: Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea.*

See Figure B1 for vegetation community and condition mapping.



LEGEND

- Site boundary
- Existing cadastre
- PK01 Flora site locations

N

0 50 150 250m

Scale 1: 5000

VEGETATION UNITS

DUNE SYSTEM

1a - Open Low Heath of *Acacia rostellifera*, *Melaleuca systena* on Dune Swales and Crests
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks.

1b - Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks

WETLANDS, DAMPLANDS AND DEPRESSIONS IN DUNE SWALES

2a - Closed Sedgeland of *Baumea juncea*, *B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale*.
Condition: Excellent to Very Good with Degraded areas within 10m of tracks and firebreaks

2b - Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks

2c - Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.
Condition: Very Good to Good with Degraded areas within 10m of tracks and firebreaks
(is equivalent to FCT 19: Sedgelands in Holocene Dune Swales)

Transitional vegetation between Community Units 1 and 2

VEGETATION CONDITION

- Very Good
- Good to Very Good
- Good
- Good to Degraded

NOTE:
Boundaries determined from 1: 5000 aerial photography and selective ground truthing.
Boundaries are indicative only.

Figure B1

Vegetation Units and Condition

RPS BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

L00215 09.12.08

Dune System

This is a mosaic of Open Low Heath (coastal) and *Acacia rostellifera* Open Heath to Closed Tall Scrub. The PATN analysis indicated that the sites within this community had the closest neighbours of FCT29b: *Acacia* Shrublands on Taller Dunes, and also FCT24: Northern Spearwood Shrublands and Woodlands. While the PATN analysis did not differentiate between the sites in communities 1a and 1b (as PATN is based on a floristic presence-absence analysis), these were split here on the basis of structure and density.

1a Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests

This community occurs on calcareous sands (Quindalup or Safety Bay Sands) in a parallel dune system. It is a Low Open Heath dominated by *Acacia rostellifera* and *Melaleuca systena*, with other typical low shrubs including *Adriana quadripartita* and *Acanthocarpus preissii.* There are occasional emergents *Hakea prostrata, Acacia saligna* and *Jacksonia furcellata*, up to three metres. In the ground layer there is typically an Open Herbland dominated by **Euphorbia terracina, Opercularia vaginata, Lomandra maritima* and *Conostylis aculeata* var. *preissii.* There is an Open to Very Open Sedgeland of *Lepidosperma squamatum* and *Desmocladus asper*, with occasional dense patches of *Lepidosperma gladiatum* and scattered *Schoenus grandiflorus*. There is an Open to Very Open Grassland typically of *Austrostipa flavescens, Bromus arenarius, *Avena barbata* and **Lagurus ovatus*.

This community formed a mosaic with community 1b.

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT29B: *Acacia* shrublands on Taller Dunes; and FCT24: Northern Spearwood Shrublands and Woodlands.

There were five detailed flora sites (PK03, PK04, PK06, PK10, PK11) and one releve PK-T within this community. The detailed flora sites had a mean species richness of 23 ± 4 (FCT29B has a mean species richness of 35.6 and FCT24 has 41.8). There was a mean weed frequency of seven species per site (FCT29B has 3.4 and FCT24 has 14.2). The condition varied from Good in Lot 4 to Very Good in Lot 17. There were Degraded areas which were generally limited to within 20m of tracks and firebreaks. The main

impacts have been from weed invasion, which may have been exacerbated by too frequent fires and fragmentation. There was also soil disturbance from trail bikes and dumping of household, industrial and garden rubbish.

See Figure B1 and Plate B1.

1b Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes

This association was on calcareous sand (Quindalup or Safety Bay Sands), both in swales and dune slopes. *Acacia rostellifera* formed an Open Heath to Closed Tall Scrub over Very Open Sedgeland to Sedgeland of *Lepidosperma squamatum*. Within lower lying areas there were occasional tall shrubs to four metres of *Hakea prostrata* or *Acacia saligna*. The understorey was often sparse where there were unburnt *Acacia rostellifera* thickets. There was a Low Open to Open Shrubland which typically included *Melaleuca systena, Rhagodia baccata* subsp. *baccata, Acacia lasiocarpa* var. *bracteolata* and *Adriana quadripartita*. There was a Very Open to Open Grassland typically including *Poa porphyroclados, Austrostipa flavescens, *Lagurus ovatus* and **Avena barbata*. In lower lying areas there was occasionally the sedge *Ficinia nodosa* present and in the lee of dunes there was occasionally dense but localised patches of sedge *Lepidosperma gladiatum*.

This community forms a mosaic and intergrades with community 1a.

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT29B: *Acacia* shrublands on taller dunes and FCT24: Northern Spearwood shrublands and woodlands.

There were four detailed flora sites within this community, PK05, PK07, PK14 and PK16, with an average of 20 ± 3 species per site. (FCT29B has a mean species richness of 35.6 and FCT24 has 41.8). There was a mean weed frequency of 5.5 species per site (FCT29B has 3.4 and FCT24 has 14.2).

The condition of this community varied from Very Good to Good with some Degraded areas near tracks and firebreaks. The main impacts have been from weed invasion, which may have been exacerbated by too frequent fires and fragmentation.

See Figure B1 and Plates B2 to B4.

Plate B1:: Community 1a: Open Low Heath of *Acacia rostellifera, Melaleuca systena* Site PK03. Lot 17.

Plate B2: Community 1b: Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes. Mature, not recently burnt. Lot 4.

Plate B3: Community 1b: Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes. Regrowth after fire (ca. 2 years ago). Site PK16. Lot 17.

Plate B4: Community 1b: Patches of *Lepidosperma gladiatum.* SW of Site PK16. Lot 4.

Wetlands, Damplands and Depressions in Dune Swales

This 'community' is equivalent to FCT19 and therefore TEC19: Sedgelands in Holocene Dune Swales, however it actually has a number of different communities within it. According to English *et al.,* (2002), the floristic composition of TEC19 appears to *'vary according to the age of the dunes and the depth to the water table'.* In the study area, there were four series of wetlands, each series running north to south along the dune swales of approximately five dune ridges. The wetlands got 'drier' progressively to the east. The most eastern site (PK12) intergraded with the surrounding dune swale vegetation, with only a couple of typical wetland species present to indicate that it was

still a wetland. These drier wetlands had *Xanthorrhoea preissii* as a dominant species within the wetland itself, while the wetter ones often had it as a fringing species.
These communities are all mapped as one unit but are described separately below. This is because the changes are fine scale, often change numerous times within each wetland and are unable to be accurately determined using aerial photography.

2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.*

This community occurred in wetlands with discrete boundaries in depressions in dune swales. The soil was a damp, dark brown peaty calcareous sand. The wetlands were often surrounded by a dense ring of *Xanthorrhoea preissii* (Plates A.7 and A.8) or *Acacia rostellifera.*

The wetlands themselves were a Closed Sedgeland, with *Baumea juncea* being the densest and most widespread sedge species. *Lepidosperma longitudinale* and *Ficinia nodosa* were also typical. Other sedges included *Lepidosperma gladiatum, Juncus pallidus, Baumea articulata, Isolepis cernua* var. *cernua* and *Gahnia trifida.* The shrubs *Logania vaginalis* and *Adriana quadripartita* were present as scattered individuals to Open Low Heath. There was a Very Open to Open Herbland typically dominated by the creeping herb *Centella asiatica* and often with *Lobelia alata.* Herb weeds were typically **Euphorbia terracina, *Conyza sumatrensis, *Carduus pycnocephalus* and **Sonchus oleraceus.*

Occasional emergent or overstorey species included *Xanthorrhoea preissii, Melaleuca teretifolia, M. rhaphiophylla, Acacia rostellifera* and *A. saligna.*

The PATN analysis indicated that the closest neighbour for the sites and releves in this community was FCT19, which is equivalent to TEC19: Sedgelands in Holocene Dune Swales. Site PK13, a very small wetland, had affiliations with FCT19 as well as FCT24 (Community 1a) which it is surrounded by. One of the of the DEC's Species and Community Branch sites (Wetland 103) came out as FCT19, while the remaining two (Wetlands 98 and 162) came out as close to both FCT17 and FCT19.

There were four detailed flora plots within this community: PK01, PK02, PK13 and PK15. These sites had a mean species richness of 25 species ± 7 (FCT19 has 22.6) with a mean weed frequency of 10 (FCT19 has 6.9). Additionally, there were four releves within this community PK-C, PK-D, PK-E and PK-U.

The condition within the wetlands was generally Very Good to Excellent. While there were weeds present, they were often in low densities. The exception to this were the wetlands in Lot 17 along the edge of Port Kennedy Drive on the southern boundary and the housing development on the northern boundary. These were in Good to Degraded condition as they had been impacted by clearing, drainage modification, exposure and weed invasion. Some wetlands had also been affected by a very patchy fire within the last two years that had enabled weeds to colonise and spread throughout the wetlands.

See Figure B1 and Plates B5 to B8.

2b: Scattered to Low Open Forest of *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*.

This community was in depressions in dune swales. The soil was a dark brown peaty sand. It appeared to be slightly drier than community 2a.

Melaleuca rhaphiophylla occured erratically in this community, as a Low Open Forest to scattered individuals or was occasionally absent. There was a Low Open to Open Shrubland of *Xanthorrhoea preissii* and/or *Adriana quadripartita*. The Open Sedgeland was most typically dominated by *Ficinia nodosa*, but also included *Baumea juncea* and *Gahnia trifida*. As a consequence there was often an Open Grassland dominated by weeds Couch **Cynodon dactylon* or Buffalo Grass **Stenotaphrum secundatum* and a Very Open Herbland of **Euphorbia terracina*. In areas that were in better condition, there were the native grasses *Sporobolus virginicus* and *Bromus arenarius*, and creeping herb *Centella asiatica*.

The PATN analysis indicated that this community is the closest to FCT19: Sedgelands in Holocene Dune Swales and FCT17: *Melaleuca rhaphiophylla – Gahnia trifida* Wetlands.

There was one detailed flora site in this community, PK09 and four releve's PK-A, PK-F, PK-V and PK-W. PK09 had a mean species richness of 20 (FCT19 has 22.6, FCT17 has 13.6) of which five were weeds (FCT19 has 6.9 and FCT17 has 1.7 weeds).

The condition of these wetlands was Very Good to Good. The examples along Port Kennedy Drive had been heavily impacted by weeds and more than likely drainage modification. The wetland indicated by site PK09 was affected by weeds due to kangaroos using it for protection. The Olive **Olea europaea* was establishing itself in some of the wetlands in this community.

See Figure B1 and Plate B9.

2c: Shrubland to Tall Open Scrub of *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

This community occurred in the east of the survey area in Lot 4 and in two wetlands at the west boundary of Lot 17. They were drier than wetlands in communities 2a and 2b. This community was also present in dune swales but on broader, shallower depressions. The soil was calcareous sand but more consolidated than the surrounding sand dunes and was probably sand with some clay or organic matter.

This community typically had mature *Xanthorrhoea preissii* up to three metres that formed a Shrubland to Tall Open Scrub. Other occasional tall shrubs included *Hakea prostrata* and *Acacia saligna.* Scattered shrubs under one metre included *Logania vaginalis* and *Adriana quadripartita* and the creeper *Kennedia prostrata.* The understorey was very sparse. There are scattered sedges to Open Sedgelands of *Ficinia nodosa. Baumea juncea* occurred at low density, indicating that they were still wetlands. There was a Very Open Grassland of *Poa porphyroclados* and *Austrostipa flavescens* and a Very Open Herbland of **Euphorbia terracina.* As the wetlands were smaller and drier, they were influenced by the floristics of Communities 1a and 1b, which surrounded them.

The PATN analysis indicated that the closest neighbour for the detailed flora sites in this community was both FCT19: Sedgelands in Holocene Dune Swales and FCT24: Northern Spearwood Shrublands and Woodlands.

There were two detailed flora sites in this community, PK08 and PK12. These sites had a mean species richness of 22.5 species ± 2 (FCT19 has 22.6 and 41.8 for FCT24) with a mean weed frequency of five species (FCT19 has 6.9 and FCT24 has 14.2).

The condition of this community was Good. Kangaroos used these areas for the shade provided by *X. preissii*, and the understorey was dominated by weed species, particularly **Lagurus ovatus* and **Euphorbia terracina.*

See Figure B1 and Plate B10.

Plate B5: **Community 2a: Closed Sedgeland of *Baumea juncea, B. articulata* and/or *Ficinia nodosa* and *Lepidosperma longitudinale.* Near Site PK01. Lot 17.**

Plate B6: **Community 2a: Closed Sedgeland of Baumea juncea, B. articulata and/or Ficinia nodosa and Lepidosperma longitudinale. Site PK15. Lot 17.**

Plate B7: **Community 2a: Closed Sedgeland surrounded by *Xanthorrhoea preissii.* Site PK13. Lot 17.**

Plate B8: **Community 2a: Closed Sedgeland surrounded by *Xanthorrhoea preissii.* Lot 17.**

Plate B9: **Community 2b: Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland. Site PK09. Lot 17.**

Plate B10: **Community 2c: Shrubland to Tall Open Scrub *Xanthorrhoea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea.* Near Site PK12. Lot 4.**

3.2.2 PATN Analysis

The following text was taken from the PATN analysis results completed by E.A. Griffin and Associates (see Appendix B4 for full report).

It is common for the nearest neighbour analysis to be less conclusive than the dendrogram classification. This is more a product of the classification process than any inconsistency of the analyses. The message from the nearest neighbour is probably clearer in this instance. Table B5 is the product of the attempt to reconcile these differences. Some uncertainty exists in this assignment as indicated.

The conclusions were very difficult to derive in some cases given the low level of similarities between the Port Kennedy sites and the SCP or TEC sites. Why there is a low level of similarity is unknown. From the species richness point of view (a common reason for low similarities) there is a mixed picture. The richness of sites apparently related to FCT19, values are similar. However, of the others values (largely related to 29b) are low. The latter may be suggestive that these sites are partly transitional.

In the conclusion, it was considered that few sites would be related to FCT 24 as Port Kennedy is Quindalup rather than Spearwood landscapes.

Table B5: Summary of FCT Assignment

Site Number	Dendrogram	Nearest Neighbour	Conclusion
TEC98	19	17/19	?19
TEC103	19	19	19
TEC162	19	19/17	19
PK01	19	19(T)	19
PK02	19	19(T)	19
PK03	?19	29b/24	29b
PK04	?19	24/29b	29b
PK05	?19	29b	29b
PK06	?19	29b/24	29b
PK07	?19	24	?24?19
PK08	19	24	?24
PK09	19	?19/?24	?19
PK10	?19	29b/24	29b

Site Number	Dendrogram	Nearest Neighbour	Conclusion
PK11	?19	29b/29a/24	29b
PK12	?19	19/24/29a	19/24/29a
PK13	19	24/19(T)	24/19(T)
PK14	?19	24/29b	?29b
PK15	19	19(T)	19
PK16	?19	24/29b	?29b
PKA	19	19(T)/?17	19
PKB	?19	29b	29b
PKC	?19	?19	?19
PKD	19	19(T)/17	?19
PKE	?19	?19	?19
PKF	?19	?19/?17	?19/?17
PKG	?19	?29b/?19	?29b/?19
PKQ	?19	?19/?29b	?19/?29b
PKR	?19	29b	29b
PKS	?19	?24?29b	?29b
PKT	?19	29b	29b
PKU	?19	?19	?19
PKV	?19	?17/?19	?17/?19
PKW	?19	?17	?17
PKX	?19	?24/?19	?19

(T) is by reference to a TEC site rather than a SCP site.

3.3 Wetlands

Using vegetation as an indicator, the wetlands were mapped in Figure B1 (Community 2). The mapping was based on field observations, detailed flora and releve sites and the results of the PATN analysis. Previous mapping of the wetlands at the site was also taken into consideration.

4.0 DISCUSSION

4.1 Flora

No Declared Rare (DRF) as defined by the Wildlife Conservation Act, 1950 (as amended) or Priority Flora were recorded for either Lot 17 or Lot 4.

No Threatened Species as defined by the *Environmental Protection Biodiversity Conservation Act, 1999* (EPBC Act, 1999) were recorded for either Lot 17 or Lot 4.

No flora species was recorded for either Lot 17 or Lot 4 that was deemed to be conservation significant under Guidance Statement 51.

It is estimated that the flora inventory of the site (Appendix B1) represents an estimated greater than 80% of the potential flora for the survey area.

A search of the EPBC protected matters database identified the presence of suitable habitat for three flora species listed under the EPBC Act, orchid *Drakaea micrantha* ms (Vulnerable) and *Lasiopetalum pterocarpum* ms and the sedge *Lepidosperma rostratum* (Endangered), however none of these species were recorded from either Lot 17 or 4.

A search of the Department of Conservation and Land Management (CALM) Declared Rare (DRF) and Priority flora databases showed three records of Priority 4 species, *Jacksonia sericea* and one record of Priority 2 species *Acacia benthamii*. This search covered an area within a 10km radius from the site. None of these existing records were from within in the study area. Neither species was recorded from either Lot 17 or 4.

4.2 Vegetation

At a very broad scale, the site is in Quindalup Vegetation Complex (Heddle *et al.*, 1980) of which there is 48% remaining in the metropolitan region of the Swan Coastal Plain, of which 20% is protected or proposed for protection (Western Australian Planning Commission, 2000).

The two dominant Floristic Community Types (FCT's)(Keighery *et al.*, 1994) in the survey area according to the PATN analysis were FCT19: Sedgelands in Holocene Dune Swales (Unreserved, Endangered) and FCT29b: *Acacia* Shrublands on Taller Dunes (Poorly Reserved, Susceptible). Some sites, particularly the drier wetlands, were transitional. The floristics appeared to be secondarily influenced by FCT17: *Melaleuca rhaphiophylla – Gahnia trifida* Seasonal Wetlands (Well Reserved, Low Risk) and FCT24: Northern Spearwood Shrublands and Woodlands (Well Reserved, Susceptible).

FCT19: Sedgelands in Holocene Dune Swales (TEC19) was found to be present on both Lot 17 and in a single wetland on Lot 4. This is listed as a Threatened Ecological Community (TEC)(Critically Endangered) by the Department of Conservation and Land Management. It is listed under the *EPBC Act, 1999* as an Endangered Ecological Community. The Critical Habitat for this community is the *'system of dunes and swales in which they occur, the fresh superficial groundwater that provides water to the swale wetlands and the catchment for this groundwater'* (English *et al.*, 2002).

A Critically Endangered TEC (DEC) is a community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. An Endangered Ecological Community (EPBC Act, 1999) is a community that is facing a very high risk of extinction in the wild in the near future.

TEC19 includes not a single plant community but an association of communities. The structure, densities and floristics vary and *'sub-groupings appear to relate to variations in depth to groundwater and in age of the dunes'* (English *et al.*, 2002). It was found that the smaller, drier wetlands, which were mainly in the eastern portion of Lot 17 and the single wetland in Lot 4, were influenced by the FCT surrounding them. Under the precautionary principal (Environmental Protection Authority, 2004), all these communities were included within TEC19 (Figure B1).

The map of the current known distribution of TEC 19 (deh.gov.au/biodiversity/threatened/communities/maps/pubs/southern-swan-sedgelands-map.pdf) covers an area from Point Becher eastwards, covering the study area and then north in a ring surrounding Rockingham. It indicates that the Rockingham – Point Becher site represents the largest remnant of this community and its critical habitat. It is also known from Yanchep and three small wetlands at Preston Beach.

Lots 17 and 4 are both listed as an Environmentally Sensitive Area, under the Environmental Protection Act, 1996 (Vegetation Clearing Regulations, 2004).

4.3 Site Condition

Lot 17 was in Excellent to Very Good condition, with Degraded to Completely Degraded areas along tracks and firebreaks. Lot 4 was in Good condition with Degraded to Completely Degraded areas along tracks and firebreaks (Figure B1)

Both lots are undergoing rapid decline from trail bike users and rubbish dumping, particularly garden waste which is introducing serious weeds. There was a marked increase of both activities between September and November 2006, with new tracks and more waste appearing in the intervening period.

4.4 EPBC Act, 1999

A search of the Department of Environment and Heritage (DEH) protected matters database identified the following issues under the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act).

The study area is within the boundaries of Site 17282: Lakes Cooloongup and Walyungup and Surrounds, (listed on the Register of the National Estate 30.06.1992). These sites have protection under the EPBC Act, however it states that *'although some places may be legally registered because they are within a larger registered area they may not necessarily possess intrinsic significance'*. In terms of the vegetation, Site 17282 is listed as being significant because:

> *'The surrounding heathlands, shrublands, woodlands and forests are important as a representation of the now restricted communities which covered the Swan Coastal Plain prior to urban development'.*
>
> *'It has considerable animal and plant association diversity, with thirteen vegetation associations being found within the area'*

Discussion with DEC (December 2006) indicates that the boundary of Site 17282: Lakes Cooloongup and Walyungup and Surrounds will be added to RAMSAR Site 54: Becher Point Wetlands, within an estimated timeframe of a year. RAMSAR sites are internationally significant wetland sites and are protected under the *EPBC Act.* The wetlands currently protected within RAMSAR site 54 are a few hundred to 4500 years old. One of the reasons given for the extension of the site is to include sections of the Becher Plain that support older wetlands. The wetlands within Lots 17 and 4 occur within a section of the plain that was formed between 4500 and 7500 years ago. (English *et al.,* 2002).

Endangered Ecological Community: Sedgelands in Holocene Dune Swales occurs on both Lots 17 and the western end of Lot 4, and these are protected under the *EPBC Act.*

The dune and swale community within which the Endangered Ecological Community occurs is considered critical habitat (English *et al.,* 2002). There is potential in the future for this to be listed as Critical Habitat under the *EPBC Act,* which would give it specific protection. Even as the legislation currently stands, habitat critical to the survival of an Endangered Ecological Community is considered to be covered under the *EPBC Act.*

4.5 Survey Limitations

2006 was an extremely dry year and this may have affected the flora inventory. Additionally, winter rains were late and the growing season very short.

5.0 REFERENCES

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APPENDIX B1

Species List

020 **TYPHACEAE**
Typha domingensis

031 **POACEAE**
Austrodanthonia occidentalis
Austrostipa elegantissima
Austrostipa flavescens
**Avena barbata*
**Avena fatua*
**Briza maxima*
**Briza minor*
Bromus arenarius
**Bromus diandrus*
**Cynodon dactylon*
**Desmazeria rigida*
**Ehrharta calycina*
**Ehrharta longiflora*
* *Eragrostis curvula*
**Holcus lanatus*
Lachnagrostis filiformis
* *Lagurus ovatus*
**Lolium perenne*
**Lolium rigidum*
Poa porphyroclados
* *Polypogon monspeliensis*
**Stenotaphrum secundatum*
* *Vulpia bromoides*
Sporobolus virginicus

032 **CYPERACEAE**
Baumea articulata
Baumea juncea
Carex preissii
Cyperus polystachyos
**Cyperus tenuiflorus*
Ficinia nodosa
Gahnia trifida
Isolepis cernua var. *cernua*
Isolepis cernua var. *setiformis*
Lepidosperma gladiatum
Lepidosperma longitudinale
Lepidosperma squamatum
Schoenus grandiflorus

039 **RESTIONACEAE**
Desmocladus asper

052 **JUNCACEAE**
Juncus kraussii

054C **DASYPOGONACEAE**
Acanthocarpus preissii
Lomandra maritima

054D **XANTHORRHOEACEAE**
Xanthorrhoea preissii

054E **PHORMIACEAE**
Dianella revoluta var. *divaricata*

054F **ANTHERICACEAE**
Thysanotus dichotomus
Tricoryne elatior

054G **ASPHODELACEAE**
**Asphodelus fistulosus*
**Trachyandra divaricata*

056B **AGAVACEAE**
**Yucca aloifolia*

055 **HAEMODORACEAE**
Conostylis aculeata subsp. *preissii*

060 **IRIDACEAE**
**Romulea rosea* var. *australis*

090 **PROTEACEAE**
**Grevillea* sp. Hybrid Ornamental
Hakea prostrata

092 **SANTALACEAE**
Exocarpos sparteus

103 **POLYGONACEAE**
**Acetosella vulgaris*
* *Rumex crispus*

105 **CHENOPODIACEAE**
**Atriplex prostrata*
Rhagodia baccata subsp. *baccata*

113 **CARYOPHYLLACEAE**
**Cerastium glomeratum*
Petrorhagia dubia
**Silene gallica* var?

119 **RANUNCULACEAE**
Clematis linearifolia

131 **LAURACEAE**
Cassytha racemosa forma. *racemosa*

138 **BRASSICACEAE**
**Brassica tournefortii*

149 **CRASSULACEAE**
**Crassula glomerata*

163 **MIMOSACEAE**
Acacia lasiocarpa var. *lasiocarpa*
Acacia rostellifera
Acacia saligna

165 **PAPILLIONACEAE**
Gompholobium tomentosum
Hardenbergia comptoniana
Jacksonia furcellata
Kennedia prostrata
**Medicago polymorpha*
**Melilotus indicus*
**Trifolium campestre* var. *campestre*
**Trifolium repens* var. *repens*

167 **GERANIACEAE**
**Erodium botrys*
**Pelargonium capitatum*
**Pelargonium littorale* subsp. *littorale*

185 **EUPHORBIACEAE**
Adriana quadripartita
**Euphorbia terracina*
Phyllanthus calycinus

194 **ANACARDIACEAE**
**Schinus terebinthifolius*

223 **STERCULIACEAE**
Thomasia cognata

273 **MYRTACEAE**
**Melaleuca huegelii (planted)*
Melaleuca rhaphiophylla
Melaleuca systena
Melaleuca teretifolia

275 **ONAGRACEAE**
**Gaura lindheimeri*
Epilobium billardiereanum subsp. *billardiereanum*

281 **APIACEAE**
Apium prostratum var. *prostratum*
Centella asiatica

288 **EPACRIDACEAE**
Leucopogon parviflorus

293 **PRIMULACEAE**
**Anagallis arvensis* var. *arvensis*
**Anagallis arvensis* var. *caerulea*

301 **OLEACEAE**
**Olea europaea* subsp. *europaea*

302 **LOGANIACEAE**
Logania vaginalis

303 **GENTIANACEAE**
**Centaurium pulchellum*

311 **VERBENACEAE**
**Phyla nodiflora* var.*nodiflora*

313 **LAMIACEAE**
Hemiandra glabra subsp. *glabra*

315 **SOLANACEAE**
Anthocercis littorea
**Solanum nigrum*

316 **SCROPHULARIACEAE**
**Dischisma arenarium*
**Verbascum virgatum*

320 **OROBANCHACEAE**
Orobanche minor

326 **MYOPORACEAE**
Eremophila glabra subsp. *albicans*

331 **RUBIACEAE**
Opercularia vaginata

336 **DIPSACACEAE**
**Scabiosa atropurpurea*

340 **LOBELIACEAE**
Lobelia alata

341 **GOODENIACEAE**
Scaevola anchusifolia

345 **ASTERACEAE**
**Carduus pycnocephalus*
**Conyza bonariensis*
**Conyza sumatrensis*
*?*Hedypnois rhagadioloides* subsp. *cretica*
**Hypochaeris glabra*
Olearia axillaris
Senecio pinnatifolius var.*latilobus*
**Sonchus oleraceus*
**Symphyotrichum squamatum*

APPENDIX B2

Species by Site Table

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
*Acetosella vulgaris				<0.1																													
*Anagallis arvensis var. arvensis												<0.1		<0.1	<0.1					< 0.1		0.1		0.5		0.5		<.1	0.3				
*Anagallis arvensis var. caerulea																																	
*Asphodelus fistulosus	PK11																												0.2				
*Atriplex prostrata																																	
*Avena barbata				15		5		1				5		2		10	2	30		3		1		1		<0.1	3		1		2		
*Avena fatua																																	
*Brassica tournefortii						<0.1		<0.1						<0.1														<.1					
*Briza maxima															<0.1														0.1				
*Briza minor																<0.1										<0.1							
*Bromus diandrus				15																													
*Carduus pycnocephalus		<0.1		1																									1			1	
*Centaurium pulchellum															<0.1											<0.1							
*Cerastium glomeratum																																	
*Conyza bonariensis																																	
*Conyza sumatrensis				<0.1											0.2		<0.1								3	0.5	0.2		1			<0.1	
*Crassula glomerata						<0.1		<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1					0.2		<0.1		<0.1						<0.1			
*Cynodon dactylon																																	
*Cyperus tenuiflorus																													2				
*Desmazeria rigida																<0.1																	
*Dischisma arenarium										1																							
*Ehrharta calycina																	1				0.3												
*Ehrharta longiflora								<0.1																			<.1						
*Eragrostis curvula	PK11																									2							
*Erodium botrys						<0.1		<0.1	<0.1																								
*Euphorbia terracina	PK01			2		2		5		<0.1		35		35		###		2		4		3		4		0.2		0.5		3		2		3	
*Gaura lindheimeri																																	
*Grevillea sp. Hybrid Ornamental	PK11																																
?*Hedypnois rhagadioloides subsp. cretica																										0.1							
*Holcus lanatus		<0.1		<0.1																													
*Hypochaeris glabra		<0.1										<0.1	<0.1	<0.1		0.1						<0.1				<0.1							
*Lagurus ovatus								17				5	5	10--35			5				3		10		12		0.1		1		0.1	0.5		
*Lolium perenne						<0.1		<0.1	<0.1			<0.1			<0.1		<0.1			< 0.1			<0.1			<0.1			0.1	0.1				
*Lolium rigidum		<0.1																						<0.1									

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
**Medicago polymorpha*		<0.1										<0.1																							
**Melaleuca huegelii* (planted)	PK11																																		
**Melilotus indicus*				<0.1													<0.1							<0.1											
**Olea europaea* subsp. *europaea*																		2		1 plant															
**Orobanche minor*																														<0.1					
**Pelargonium capitatum*																0.1						0.5													
**Pelargonium littorale* subsp. *littorale*																																			
**Phyla nodiflora var nodiflora*																																			
**Polypogon monspeliensis*																																			
**Romulea rosea var. australis*	PK01					1		1				1	1	3	3		<0.1				< 0.1		0.1		0.5		<0.1			0.1			1		
**Rumex crispus*																																			
**Scabiosa atropurpurea*	PK10 PK11													<0.1																					
**Schinus terebinthifolius*																																		<0.1	
**Silene gallica* var?																0.5																			
**Solanum nigrum*																																			
**Sonchus oleraceus*		<0.1				<0.1								<0.1	<0.1									<0.1		<0.1		0.2		<0.1				<0.1	
**Stenotaphrum secundatum*																																			
**Symphyotrichum squamatum*				<0.1																															
**Trachyandra divaricata*						1		5																											
**Trifolium campestre* var. *campestre*																									0.1	0.3									
**Trifolium repens* var. *repens*				70									<0.1	<0.1	<0.1														2				50		
**Verbascum virgatum*	PK11																												<0.1						
**Vulpia bromoides*																				< 0.1															
**Yucca aloifolia*																																			
Acacia lasiocarpa var. *lasiocarpa*										4												0.2						0.2							
Acacia rostellifera	PK15					40				60		10--1	2	1						45		4	2	<0.1				40	30			35	8		
Acacia saligna	PK01, 02, 04, 11, 16			<0.1				<0.1								5		0.1								4				4					
Acanthocarpus preissii	PK16					5														4		5													
Adriana quadripartita	PK01			<0.1				<0.1		0.1		1		<0.1				0.5		0.5		1		<0.1		60		1		1		1		1	
Anthocercis littorea				2																															
Apium prostratum var. *prostratum*				2																														1	
Austrodanthonia occidentalis	PK03, PK14						0.5																									<0.1			
Austrostipa elegantissima				<0.1																															
Austrostipa flavescens						4		5--12		0.3		5--10		<0.1	<0.1			<0.1		4		4		<0.1		<0.1		1				5			

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Baumea articulata		7	5																														
Baumea juncea		20-30		15												0.5		0.3						<0.1	80			40				1	
Bromus arenarius	PK03 PK04			<0.1	<.1		0.1	0.1			0.1		2		<0.1		<0.1	0.2	2	2			<0.1	0.5			<0.1	1		<0.1		2	<0.1	
Carex preissii	PK13															0.1																	
Cassytha racemosa forma *racemosa*				20																													
Centella asiatica		2		50																					10			25				60	
Clematis linearifolia	PK14, PK10																														0.1		
Conostylis aculeata subsp. *preissii*	PK04					2		0.1		0.1										0.1		4									1		
Cyperus polystachyos																																	
Desmocladus asper						<0.1		1				1								0.5		0.1			0.3						1		
Dianella revoluta var. *divaricata*	RV01											<0.1		0.5				<0.1		0.1		0.3						0.2			0.1		
Epilobium billardiereanum subsp. *billardiereanum*				<0.1																												<0.1	
Eremophila glabra subsp. *albicans*	RV04																																
Exocarpos sparteus	PK11 PK15			0.5														<0.1										0.2					
Ficinia nodosa				2						2						3		1						2		1		1		50			<0.1	
Gahnia trifida	PK13			1														3															
Gompholobium tomentosum																0.1												<0.1					
Hakea prostrata	PK12 PK15									1		2	1							1								1						
Hardenbergia comptoniana	RV02 PK16					1																											
Hemiandra glabra subsp. *glabra*														2						0.5													
Isolepis cernua var. *cernua*				<0.1																													
Isolepis cernua var *setiformis*						<0.1	<.1			1	1																						
Jacksonia furcellata	RV01, PK11 PK16					<0.1														< 0.1													
Juncus kraussii	ADJ01																															60	
Kennedia prostrata	PK13							<0.1		1						0.5		<0.1													0.3		
Lachnagrostis filiformis																																	
Lepidosperma gladiatum		1	1	15										8						1													
Lepidosperma longitudinale		30-60	10	15-30																													
Lepidosperma squamatum						5		5--8		85		12--15		30		0.5				5		12		8				3				8		
Leucopogon parviflorus																		0.5		1		1				0.5							
Lobelia alata	PK13	<0.1																												<0.1			
Logania vaginalis	RV01			1												0.2										3				0.2			
Lomandra maritima						0.1		5				0.5		1						2		3		1				0.5					
Melaleuca rhaphiophylla																		15	5														

Species	Opportunistic	PK01		PK02		PK03		PK04		PK05		PK06		PK07		PK08		PK09		PK10		PK11		PK12		PK13		PK14		PK15		PK16		PKA	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Melaleuca systena						5		<0.1		3		3																1				4			
Melaleuca teretifolia				25																												<0.1	
Olearia axillaris																																	
Opercularia vaginata						<0.1		<0.1	<0.1	<0.1		<0.1								1		2								<0.1			
Petrorhagia dubia														<0.1										0.3									
Phyllanthus calycinus						0.3																											
Poa porphyroclados	PK15					<0.1	<0.1			2				0.3		0.2						1		2	1	<0.1						1			
Rhagodia baccata subsp. *baccata*	PK11 PK14			5		1				2								2															
Scaevola anchusifolia								<0.1	<0.1													0.2										<0.1	
Schoenus grandiflorus	PK03					0.1						1	1							0.3												1			
Senecio pinnatifolius var. *latilobus*																						<0.1		0.2								<0.1		<0.1	
Sporobolus virginicus	PK11																	1								0.2				2					
Thomasia cognata																																	
Thysanotus dichotomus						0.1																											
Tricoryne elatior						0.5																		<0.1									
Typha domingensis																																	
Xanthorrhoea preissii	RV01, PK09													5		55								40		2								

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		© PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
*Acetosella vulgaris												<0.1																							
*Anagallis arvensis var. arvensis																																			
*Anagallis arvensis var. caerulea																																			
*Asphodelus fistulosus	PK11																																		
*Atriplex prostrata																																			
*Avena barbata		<0.1																																	
*Avena fatua																						<0.1		5		35		3		<0.1		1		<0.1		2	
*Brassica tournefortii																																			
*Briza maxima																																			
*Briza minor																																			
*Bromus diandrus																																			
*Carduus pycnocephalus																																			
*Centaurium pulchellum																																			
*Cerastium glomeratum																																			
*Conyza bonariensis																																			
*Conyza sumatrensis														<0.1																					
*Crassula glomerata																														<0.1					
*Cynodon dactylon																																			
*Cyperus tenuiflorus																																			
*Desmazeria rigida																																			
*Dischisma arenarium																																			
*Ehrharta calycina																																			
*Ehrharta longiflora																										5									
*Eragrostis curvula	PK11																																		
*Erodium botrys																																			
*Euphorbia terracina	PK01	1				7		10						20		<0.1		5		3		2		15		15		5		10		5				3	
*Gaura lindheimeri																																			
*Grevillea sp. Hybrid Ornamental	PK11																																		
?*Hedypnois rhagadioloides subsp. cretica																																			
*Holcus lanatus				60		60		20																											
*Hypochaeris glabra																																			
*Lagurus ovatus																																			
*Lolium perenne																										15		8						10	
*Lolium rigidum																																			

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		© PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
**Medicago polymorpha*																		<0.1																	
**Melaleuca huegelii* (planted)	PK11																																		
**Melilotus indicus*																																			
**Olea europaea* subsp. *europaea*																		10																	
**Orobanche minor*																																			
**Pelargonium capitatum*																<0.1																			
**Pelargonium littorale* subsp. *littorale*																				<0.1															
**Phyla nodiflora var nodiflora*												20																							
**Polypogon monspeliensis*																																			
**Romulea rosea var. australis*	PK01																	<0.1				<0.1						<0.1							
**Rumex crispus*																																			
**Scabiosa atropurpurea*	PK10 PK11																																		
**Schinus terebinthifolius*																																			
**Silene gallica* var?																																			
**Solanum nigrum*												<0.1																							
**Sonchus oleraceus*																																			
**Stenotaphrum secundatum*																																85			
**Symphyotrichum squamatum*												<0.1						<0.1																	
**Trachyandra divaricata*																																			
**Trifolium campestre* var. *campestre*																																			
**Trifolium repens* var. *repens*												<0.1																							
**Verbascum virgatum*	PK11																																		
**Vulpia bromoides*																																			
**Yucca aloifolia*																																		<0.1	
Acacia lasiocarpa var. *lasiocarpa*																						<0.1				<0.1								<0.1	
Acacia rostellifera	PK15	70								60								3						50		<0.1		15		30				5	
Acacia saligna	PK01, 02, 04, 11, 16																			1		<0.1		1				3		<0.1		1		5	
Acanthocarpus preissii	PK16																											0.5							
Adriana quadripartita	PK01							10		1						40		3		5		3						<0.1		5		1			<0.1	
Anthocercis littorea										20																									
Apium prostratum var. *prostratum*												20																		1		0.5			
Austrodanthonia occidentalis	PK03, PK14																											<0.1							
Austrostipa elegantissima																																			
Austrostipa flavescens																				<0.1				1				2				<0.1		2	

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		® PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Baumea articulata																																			
Baumea juncea																																			
Bromus arenarius	PK03 PK04															2		5				5								15				<0.1	
Carex preissii	PK13																					5						<0.1			10	45		<0.1		2
Cassytha racemosa forma *racemosa*																		<0.1																	
Centella asiatica												50																							
Clematis linearifolia	PK14, PK10	<0.1		60		60		20				50										20													
Conostylis aculeata subsp. *preissii*	PK04																											<0.1							
Cyperus polystachyos																																			
Desmocladus asper																																			
Dianella revoluta var. *divaricata*	RV01																																		
Epilobium billardiereanum subsp. *billardiereanum*												<0.1																<0.1							
Eremophila glabra subsp. *albicans*	RV04																																		
Exocarpos sparteus	PK11 PK15																											<0.1							
Ficinia nodosa						7		10								50		5				70								30		20			
Gahnia trifida	PK13											5						10																	
Gompholobium tomentosum																																			
Hakea prostrata	PK12 PK15	10								10												1	15	1						2				<0.1	
Hardenbergia comptoniana	RV02 PK16																																	<0.1	
Hemiandra glabra subsp. *glabra*																																			
Isolepis cernua var. *cernua*																																			
Isolepis cernua var *setiformis*																																			
Jacksonia furcellata	RV01, PK11 PK16																																		
Juncus kraussii	ADJ01																											<0.1							
Kennedia prostrata	PK13	<0.1																<0.1		1		<0.1													
Lachnagrostis filiformis												<0.1																		<0.1		<0.1		1	
Lepidosperma gladiatum												80												<0.1											
Lepidosperma longitudinale												5																							
Lepidosperma squamatum		5																		8				<0.1				10						20	
Leucopogon parviflorus																				1								<0.1							
Lobelia alata	PK13																																		
Logania vaginalis	RV01							10								5						3								5					
Lomandra maritima																																			
Melaleuca rhaphiophylla																		30	70													3		5	30

Species	Opportunistic	PKB		# PKC1		PKC2		PKC3		Δ PKC4		PKD		€ PKE1		® PKE2		PKF		PKG		PKQ		PKR		PKS		PKT		PKU		PKV		PKW		PKX	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
Melaleuca systena																								2		<0.1		5							<0.1	
Melaleuca teretifolia												60																							
Olearia axillaris																												<0.1		<0.1					
Opercularia vaginata																												<0.1							
Petrorhagia dubia																																			
Phyllanthus calycinus																												0.5							
Poa porphyroclados	PK15	<0.1																		<0.1		<0.1		0.5						<0.1				1	
Rhagodia baccata subsp. *baccata*	PK11 PK14	<0.1								1								3				<0.1								1					
Scaevola anchusifolia																												<0.1							
Schoenus grandiflorus	PK03																											<0.1							
Senecio pinnatifolius var. *latilobus*																																			
Sporobolus virginicus	PK11											1														15					5		5		
Thomasia cognata																																		<0.1	
Thysanotus dichotomus																																			
Tricoryne elatior																																			
Typha domingensis																																			
Xanthorrhoea preissii	RV01, PK09																			90				<0.1							1		2		20	

APPENDIX B3

Vegetation Site Descriptions

Detailed Flora Site: PK01
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383678 **Northing**: 6418353 **Accuracy:** 5m
Photo: KM031
Topography: damp land in coastal swale.
Soil: Dark brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years (Surrounding dunes to the east have been recently burnt).
Litter: 80% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Excellent. **Disturbance:** Level low - weeds and rubbish.
Vegetation Description:
Lepidosperma longitudinale, Baumea juncea and *Baumea articulata* Sedgeland over *Centella asiatica* Very Open Herbland.
Species List:
**Carduus pycnocephalus, *Holcus lanatus, *Hypochaeris glabra, *Lolium rigidum, *Medicago polymorpha, *Sonchus oleraceus, Baumea articulata, Baumea juncea, Centella asiatica, Lepidosperma gladiatum, Lepidosperma longitudinale, Lobelia alata.*
Notes: An existing Threatened Ecological Community plot (TEC98) mapped by The Department of Environment and Conservation (DEC) is present within this site.

Detailed Flora Site: PK02
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383712 **Northing**: 6418220 **Accuracy:** 5m
Photo: KM 038 & 039.
Topography: dampland.
Soil: Dark brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** approx 2 years (50% of plot is unburnt)
Litter: 50% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Good. **Disturbance:** Level medium – weeds (>70% cover in herb layer).
Vegetation Description:
Melaleuca teretifolia Tall Shrubland over *Lepidosperma longitudinale, Lepidosperma gladiatum* and *Baumea juncea* Open Sedgeland over **Trifolium repens* var. *repens, Centella asiatica* Herbland and **Avena barbata* Open Grassland.
Species List:
**Avena barbata, *Bromus diandrus, *Carduus pycnocephalus, *Conyza sumatrensis, *Euphorbia terracina, *Holcus lanatus, *Melilotus indicus, *Symphyotrichum squamatum, *Trifolium repens* var. *repens, *Acetosella vulgaris, Acacia saligna, Adriana quadripartite, Anthocercis littorea, Apium prostratum* var. *prostratum, Austrostipa elegantissima, Baumea juncea, Bromus arenarius, Cassytha racemosa* forma. *racemosa, Centella asiatica, Epilobium billardiereanum* subsp. *billardiereanum, Exocarpos sparteus, Ficinia nodosa, Gahnia trifida, Isolepis cernua* var.*cernua, Lepidosperma gladiatum, Lepidosperma longitudinale, Logania vaginalis, Melaleuca teretifolia, Rhagodia baccata* subsp.*baccata* and sterile herb.

Notes: An existing Threatened Ecological Community plot (TEC Pm35) mapped by The Department of Environment and Conservation (DEC) is present within this site.

Detailed Flora Site: PK03
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383781 **Northing**: 6418187 **Accuracy:** 5m
Photo: KM41.
Topography: dune crest.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: crest slightly NE. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 20%.
Condition: Very Good. **Disturbance:** Level medium - weeds (approx 25% cover).
Vegetation Description:
Acacia rostellifera, Melaleuca systena and *Acanthocarpus preissii* Open Low Heath to Low Shrubland over **Trachyandra divaricata* and *Conostylis aculeata* subsp.*preissii* Very Open Herbland and *Lepidosperma squamatum* Very Open Sedgeland.
Species List:
**Avena barbata, *Brassica tournefortii, *Crassula glomerata, *Erodium botrys, *Euphorbia terracina, *Lolium perenne, *Romulea rosea* var. *australis, *Sonchus oleraceus, *Trachyandra divaricata, Acacia rostellifera, Acanthocarpus preissii, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp.*preissii, Desmocladus asper, Hardenbergia comptoniana, Isolepis cernua* var.*setiformis, Jacksonia furcellata, Lepidosperma squamatum, Lomandra maritima, Melaleuca systena, Opercularia vaginata, Phyllanthus calycinus, Poa porphyroclados, Rhagodia baccata* subsp.*baccata, Schoenus grandiflorus, Thysanotus dichotomus, Tricoryne elatior* and sterile herb

Detailed Flora Site: PK04
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383836 **Northing**: 6418246 **Accuracy:** 5m
Photo: KM 43 & 43.
Topography: on flat in a swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly NE. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 20%.
Condition: Degraded. **Disturbance:** Level High - weeds and fire.
Vegetation Description:
**Euphorbia terracina, *Trachyandra divaricata* and *Lomandra maritima* Open Herbland over *Austrostipa flavescens* and weedy sterile grasses over *Lepidosperma squamatum* Very Open Sedgeland
Species List:
**Avena barbata, *Brassica tournefortii, *Crassula glomerata, *Ehrharta longiflora, *Erodium botrys, *Euphorbia terracina, *Lagurus ovatus, *Lolium perenne, *Romulea rosea* var. *australis, *Trachyandra divaricata, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp. *preissii, Desmocladus asper, Kennedia prostrata, Lepidosperma sqaamatum, Lomondra maritima, Melaleuca systena, Opercularia vaginata, Scaevola anchusifolia* and sterile herb & weedy grasses.

Detailed Flora Site: PK05
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383842 **Northing**: 6418374 **Accuracy:** 5m
Photo: KM 44 & 45.
Topography: dampland.
Soil: grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Very Good. **Disturbance:** Level medium - weeds.
Vegetation Description:
Acacia rostellifera and *Hakea prostrata* Open Low Heath over *Lepidosperma squamatum* Closed Sedgeland and *Austrostipa flavescens* and sterile weedy grasses Very Open Grassland.
Species List:
**Crassula glomerata, *Dischisma arenarium, *Euphorbia terracina, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conastylis aculeata* subsp. *preissii, Ficinia nodosa, Hakea prostrata, Isalepis cernua* var. *setiformis, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Opercularia vaginata, Poa porphyroclados, Rhagodia baccata* subsp. *baccata* and sterile weedy grasses.
Notes: The *Acacia rostellifera* and *Hakea prostrata* were both less than 1m, if the site had not been burnt they may have been >3m.

Detailed Flora Site: PK06
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384144 **Northing**: 6418435 **Accuracy:** 5m
Photo: KM 46.
Topography: dune swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly NE. **Age Since Fire:** more than 2 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level High - weeds.
Vegetation Description:
Acacia rostellifera Shrubland (with scattered *Hakea prostrata*) over *Acacia rostellifera* (regrowth) and *Melaleuca systena* Low Shrubland over *Lepidosperma squamatum* Open to Very Open Sedgeland, *Austrostipa flavescens* Very Open Grassland and **Euphorbia terracina* Herbland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Hypochaeris glabra, *Lagurus ovatus, *Lolium perenne, *Medicago polymorpha, *Romulea rosea* var. *australis, *Trifolium repens* var. *repens, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Desmocladus asper, Dianella revoluta* var. *divaricata, Hakea prostrata, Lepidosperma squamatum, Lomandra maritima, Melaleuca systena, Opercularia vaginata* and *Schoenus grandiflorus.*

Detailed Flora Site: PK07
Date: 01.09.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384387 **Northing**: 6418207 **Accuracy:** 5m
Photo: KM 47, 48 & 49.
Topography: dune swale.
Soil: Light brown sandy. **Rock Type:** limestone.
Aspect: flat, slightly SW. **Age Since Fire:** more than 2 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** 5%.
Condition: Degraded. **Disturbance:** Level High - weeds (80%).
Vegetation Description:
Xanthorrhoea preissii Open Shrubland over *Lepidosperma gladiatum* and *Lepidosperma squamatum* Open Sedgeland over **Euphorbia terracina* Herbland and mixed annual weedy Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis*, **Avena barbata*, **Brassico tournefortii*, **Briza maxima*, **Crassula glomerata*, **Euphorbia terracina*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Romulea rosea* var. *australis*, **Scabiosa atropurpurea*, **Sonchus oleraceus*, **Trifolium repens* var. *repens*, *Acacia rostellifera*, *Adriana quadripartita*, *Austrostipa flavescens*, *Bromus arenarius*, *Dianella revoluta* var. *divaricata*, *Hemiandra glabra subsp. glabra*, *Lepidosperma gladiatum*, *Lepidasperma squamatum*, *Lomandra maritima*, *Petrorhagia dubia*, *Poa porphyroclados*, *Xanthorrhoea preissii* and sterile herb

Detailed Flora Site: PK08
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384061 **Northing**: 6418455 **Accuracy:** 4.1m
Photo: RPS 1039-1041.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: W-SW. **Age Since Fire:** more than 5 years.
Litter: 3% dead grasses and weeds. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level medium to high – graffiti, weeds and fire.
Vegetation Description:
Xanthorrhoea preissii and *Acacia saligna* Tall Shrubland/ Shrubland over *Ficinia nodosa* Open Sedgeland over **Avena barbata* and **Lagurus ovatus* Very Open Grassland.
Species List:
**Avena barbata*, **Briza minor*, **Centaurium pulchellum*, **Conyza sumatrensis*, **Desmazeria rigida*, **Euphorbia terracina*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Melilotus indicus*, **Pelargonium capitatum*, **Romulea rosea* var. *australis*, **Silene gallica* var?, *Acacia saligna*, *Baumea juncea*, *Carex preissii*, *Ficinia nodosa*, *Gompholobium tamentosum*, *Kennedia prostrata*, *Lepidosperma squamatum*, *Logania vaginalis*, *Poa porphyroclados* and *Xanthorrhoea preissii*.

Detailed Flora Site: PK09
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384095 **Northing**: 6418280 **Accuracy:** 6.3m
Photo: RPS 1043-1046.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 10% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Degraded - Good. **Disturbance:** Level medium - weeds.
Vegetation Description:
Melaleuca rhaphiophylla Low Woodland over *Gahnia trifida*, *Ficinia nodosa* Open Sedgeland and **Olea europaea* subsp. *europaea* Low Open Shrubland over **Avena barbata* and *Bromus arenarius* Grassland.
Species List:
**Avena barbata*, **Conyza sumatrensis*, **Ehrharta calycina*, **Euphorbia terracina*, **Olea europaea* subsp. *europaea*, *Acacia saligna*, *Adriana quadripartita*, *Austrostipa flavescens*, *Baumea juncea*, *Bromus arenarius*, *Dianella revoluta* var. *divaricata*, *Exocarpos sparteus*, *Ficinia nodosa*, *Gahnia trifida*, *Kennedia prostrata*, *Leucopogon parviflorus*, *Melaleuca rhaphiophylla*, *Rhagodia baccata* subsp. *baccata* and *Sporobolus virginicus*

Detailed Flora Site: PK10
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384431 **Northing**: 6418274 **Accuracy:** 4m
Photo: RPS 989-992.
Topography: upper slope of dune.
Soil: Light brown sand. **Rock Type:** limestone.

Aspect: NW. **Age Since Fire:** more than 5 years.
Litter: 80% dead grasses. **Bare Ground:** 5%.
Condition: Good. **Disturbance:** Level High – weeds, rubbish and vehicle tracks.
Vegetation Description:
Acacia rostellifera Open Heath over *Acanthocarpus preissii* and **Euphorbia terracina* Low Open Shrubland and *Lepidosperma squamatum* Very Open Sedgeland over *Lomandra maritima* Very Open Herbland and *Austrostipa flavescens, Bromus arenarius* and **Lagurus ovatus* Very Open Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Lolium perenne, *Olea europaea* subsp. *europaea, *Romulea rosea* var. *australis, *Vulpia bromoides, Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Canostylis aculeata* subsp. *preissii, Desmocladus asper, Dianella revaluta* var. *divaricata, Hakea prostrata, Hemiandra glabra* subsp. *glabra, Jacksonia furcellata, Lepidasperma gladiatum, Lepidosperma squamatum, Leucopogon parviflorus, Lomandra maritima, Opercularia vaginata* and *Schoenus grandiflorus,*

Detailed Flora Site: PK11
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384561 **Northing**: 6418590 **Accuracy:** 5m
Photo: RPS 993 & 994.
Topography: hill top on a coastal dune crest.
Soil: Light brown sand. **Rock Type:** limestone.
Aspect: E. **Age Since Fire:** < 2 years.
Litter: 80% dead weeds and grass. **Bare Ground:** 10%.
Condition: Good – Very Good. **Disturbance:** Level medium - weeds and fire.
Vegetation Description:
Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita and *Leucopogon parviflorus* Low Open Shrubland over *Lepidosperma squamatum* Open Sedgeland over *Lomandra maritima, Conostylis aculeata* subsp.*preissii* and **Euphorbia terracina* Very Open Herbland and **Lagurus ovatus* and *Austrostipa flavescens* Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis, *Avena barbata, *Crassula glomerata, *Ehrharta calycina, *Euphorbia terracina, *Hypochaeris glabra, *Lagurus ovatus, *Lolium perenne, *Pelargonium capitatum, *Romulea rosea* var. *australis, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Acanthocarpus preissii, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp. *preissii, Desmocladus asper, Dianella revoluta* var. *divaricata, Lepidosperma squamatum, Leucopogon parviflorus, Lomandra maritima, Opercularia vaginata, Poa porphyroclados, Scaevola anchusifolia* and *Senecio pinnatifolius* var.*latilobus,*

Detailed Flora Site: PK12
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384293 **Northing**: 6418425 **Accuracy:** 4.3m
Photo: RPS 995-998.
Topography: Prominent dip in dune swale
Soil: Light brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 80% dead weeds and grasses. **Bare Ground:** 10%.
Condition: Good. **Disturbance:** Level medium - weeds and rubbish.
Vegetation Description:
Xanthorrhaea preissii Open Heath over *Ficinia nodosa* and *Lepidosperma squamatum* Open Sedgeland over **Lagurus ovatus* Open Grassland.
Species List:
**Anagallis arvensis L.* var. *arvensis, *Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Lolium rigidum, *Melilotus indicus, *Romulea rosea* var. *australis, *Sonchus oleraceus, *Trifolium campestre* var. *campestre, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Desmocladus asper, Ficinia nodosa, Lepidosperma squamatum, Lomandra maritima, Petrorhagia dubia, Poa porphyroclados, Senecio pinnatifolius* var.*latilobus, Tricoryne elatior, Xanthorrhoea preissii* and sterile herb.

Detailed Flora Site: PK13
Date: 17.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384045 **Northing**: 6418523 **Accuracy:** 3.8m
Photo: RPS 999-1001.
Topography: damp land in a prominent dip.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance:** Level medium - weeds.

Vegetation Description:
Adriana quadripartita, Acacia saligna, Logania vaginalis and *Xanthorrhoea preissii* Open Heath over *Baumea juncea* Closed Sedgeland over *Centello asiatica* and **Conyza sumatrensis* Open Herbland and **Eragrostis curvula* Very Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Avena barbata*, **Briza minor*, **Centaurium pulchellum*, **Conyza sumatrensis*, **Eragrostis curvula*, **Euphorbia terracina*, *?*Hedypnois rhagadioloides ssp. Cretica*, **Hypochaeris glabra*, **Lagurus ovatus*, **Lolium perenne*, **Romulea rosea* var. *australis*, **Sonchus oleraceus*, **Trifolium campestre* var. *campestre*, *Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Leucopogon parviflorus, Logania vaginalis, Poa porphyrocladas, Sporobolus virginicus* and *Xanthorrhoea preissii*
Notes: Around the wetland is a dense ring of *Xanthorrhoea preissii* up to 3m tall with a density of approx 85%.

Detailed Flora Site: PK14
Date: 21.11.06
Botanists: A. Mercier, K. McCreery and Vanessa Yeomans
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383773 **Northing**: 6418602 **Accuracy:** 5.3m
Photo: RPS 1047 & 1048.
Topography: Flat.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 80% dead grasses and weeds. **Bare Ground:** <1%.
Condition: Good – Very Good. **Disturbance:** Level Low- weeds.
Vegetation Description:
Acacia rostellifera Closed Heath over *Lepidosperma squamatum* Very Open Sedgeland and **Avena barbata* Very Open Grassland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Avena barbata*, **Brassica tournefortii*, **Briza maxima*, **Conyza sumatrensis*, **Ehrharta longiflora*, **Euphorbia terracina*, **Lagurus ovatus*, **Lolium perenne*, **Sonchus oleraceus*, *Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Adriana quadripartita, Austrostipa flavescens, Bromus arenarius, Dianella revoluta* var. *divaricata, Exocarpos sparteus, Ficinia nodosa, Gompholobium tomentosum, Hakea prostrata, Lepidosperma squamatum, Lomandra maritima* and *Melaleuca systena.*

DETAILED FLORA SITE: PK15
Date: 23.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0383766 **Northing**: 6418403 **Accuracy:** 4.8m
Photo: RPS 1095 - 1097.
Topography: wetland.
Soil: Dark brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years.
Litter: 10% humus layer over wetland. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance:** Level medium – trampled vegetation, weeds and rubbish.
Vegetation Description:
*Adriana quadripartita, *Carduus pycnocephalus* and **Euphorbia terracina* Low Open Shrubland over *Ficinia nodosa, Baumea juncea* and *Juncus pallidus* Closed Sedgeland and *Centella asiatica* Herbland.
Species List:
**Anagallis arvensis* var. *arvensis*, **Asphodelus fistulosus*, **Avena barbata*, **Carduus pycnocephalus*, **Conyza sumatrensis*, **Cyperus tenuiflorus*, **Euphorbia terracina*, **Lagurus ovatus*, **Lolium perenne*, **Orobanche minor*, **Romulea rosea* var. *australis*, **Sonchus oleraceus*, **Trifolium repens* var. *repens*, **Verbascum virgatum*, *Acacia saligna, Adriana quadripartita, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Juncus pallidus, Lobelia alata, Logania vaginalis* and *Sporobolus virginicus.*

Notes: *Acacia rostellifera* and *Acacia saligna* Low Woodland surrounds the edge of the wetland

Detailed Flora Site: PK16
Date: 23.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)(NW corner of plot)
Zone: 50H **Easting**: 0384130 **Northing**: 6418078 **Accuracy:** 4.5m
Photo: RPS 1098 - 1100.
Topography: flat
Soil: Light brown sandy peat. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** less than 2 years.
Litter: 20% dead grasses and weeds. **Bare Ground:** 3%.
Condition: Good – Very Good. **Disturbance:** Level medium - weeds and fire.

Vegetation Description:
Acacia rostellifera Melaleuca systena Open Shrubland to Low Open Shrubland over *Lepidosperma squamatum* Very Open Sedgeland and *Austrostipa flavescens, *Avena barbata* and *Bromus arenarius* Very Open Grassland
Species List:
**Avena barbata, *Crassula glomerata, *Euphorbia terracina, *Lagurus ovatus, *Romulea rosea* var. *australis, Acacia rostellifera, Adriana quadripartita, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Clematis linearifolia, Conostylis aculeata, Desmocladus asper, Dianella revoluta* var. *divaricata, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Opercularia vaginata, Poa porphyroclados, Scaevola anchusifolia, Schoenus grandiflorus* and *Senecio pinnatifolius* var.*latilobus*

Notes: Large *Acacia rostellifera* trees (1.8m tall) are dead due to fire, live *Acacia rostellifera* shrubs are 60cm in height.

RELEVE: PKA
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383701 **Northing**: 6418148 **Accuracy:** 5m
Photo: KM032
Topography: Dampland.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 5 years
Litter: 2%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Juncus pallidus and *Baumea juncea* Sedgeland, over *Centella asiatica* and **Trifolium repens* var. *repens* Herbland.
Species List:
**Carduus pycnocephalus, *Conyza sumatrensis, *Euphorbia terracina, *Schinus terebinthifolius, *Sonchus oleraceus, *Trifolium repens* var. *repens, Adriana quadripartita, Apium prostratum* var. *prostratum, Baumea juncea, Bromus arenarius, Centella asiatica, Epilobium billardiereanum* subsp. *billardiereanum, Ficinia nodosa, Juncus pallidus, Melaleuca teretifolia* and *Senecio pinnatifolius* var.*latilobus.*

Notes: A Department Environment and Conservation (DEC) Threatened Ecological Community (TEC 103) is located in this area.

RELEVE: PKB
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383708 **Northing**: 6417997 **Accuracy:** 5m
Photo: KM033
Topography: Depression in a swale
Soil: brown sandy. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 30%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Acacia rostellifera and *Hakea prostrata* Tall Open Scrub, over *Lepidosperma squamatum* Very Open Sedgeland and Grassland of annual sterile weed.
Species List:
**Avena barbata, *Euphorbia terracina, Acacia rostellifera, Clematis linearifolia, Hakea prostrata, Kennedia prostrata, Lepidosperma squamatum, Poa porphyroclados, Rhagodia baccata* subsp. *baccata* and annual sterile grass.

RELEVE: PKC1-PKC4
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383760 **Northing**: 6417976 **Accuracy:** 6m
Photo: KM034
Topography: Depression
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 30%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium/ High- weeds
Vegetation Description:
Anthocercis littorea and *Hakea prostrata* Shrubland, with *Acacia rostellifera* and *Adriana quadripartita* Low Open Heath, over *Ficinia nodosa* Very Open Sedgeland, with *Holcus lanatus* and *Centella asiatica* Herbland.
PKC1 Species List:
**Holcus lanatus* and *Centella asiatica,*

PKC2 Species List:
**Euphorbia terracina, *Holcus lanatus, Centella asiatica* and *Ficinia nodosa,*
PKC3 Species List:
**Euphorbia terracina, *Holcus lanatus, Adriana quadripartita, Centella asiatica, Ficinia nodosa* and *Logania vaginalis*
PKC4 Species List:
Acacia rostellifera, Adriana quadripartita, Anthacercis littorea, Hakea prostrata, Rhagodia baccata subsp. *baccata* and annual sterile grass.
Notes: PKC1 is the lowest part of the depression followed by PKC2, PKC3, and the high point of the depression is PKC4.

RELEVE: PKD
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383704 **Northing**: 6418238 **Accuracy:** 5m
Photo: KM036 & 037 (KM035 is from dune looking into the wetland)
Topography: Wetland/ Dampland.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 80%. **Bare Ground:** <1%.
Condition: Very Good. **Disturbance Level:** Low- weeds
Vegetation Description:
Melaleuca teretifolia Tall Open Scrub, over *Lepidosperma gladiatum* Closed Sedgeland, with *Cassytha racemosa Nees forma racemosa, Centella asiatica, Apium prostratum* and **Phyla nodiflora* var.*nodiflora* Herbland
Species List:
**Acetasella vulgaris, *Phyla nodiflora* var.*nodiflora, *Solanum nigrum, *Symphyotrichum squamatum, *Trifolium repens* var. *repens, Apium prostratum Vent.* var. *prostratum, Cassytha racemosa Nees forma racemosa, Centella asiatica, Epilobium billardiereanum* Ser. subsp. *billardiereanum, Gahnia trifida, Lachnagrostis filiformis, Lepidosperma gladiatum, Lepidosperma langitudinale, Melaleuca teretifolia* and *Sporobolus virginicus*
Notes: A Department Environment and Conservation (DEC) Threatened Ecological Community (TEC PM35) is located in this area. Vegetation was too thick to put a plot in. Borehole 62-3 is also present.

RELEVE: PKE1 AND PKE2
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383836 **Northing**: 6418213 **Accuracy:** 5m
Photo: KM040
Topography: Dampland in dune swale.
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 50%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** Medium- > 70% weeds in herb layer
Vegetation Description:
Adriana quadripartita Low Shrubland, over *Ficinia nodosa* Sedgeland and *Baumea juncea* Very Open Sedgeland, with annual sterile grass Closed Grassland
PKE1 Species List:
**Conyza sumatrensis, *Eupharbia terracina* and sterile annual grass.
PKE2 Species List:
**Euphorbia terracina, *Pelargonium capitatum, Adriana quadripartita, Baumea juncea, Ficinia nodosa, Logania vaginalis* and annual sterile grass.
Notes: PKE1 is the lowest, and PKE2 is the highest section of the dampland.

RELEVE: PKF
Date: 31.8.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384105 **Northing**: 6418270 **Accuracy:** 5m
Photo: no photo
Topography: flat
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Melaleuca rhaphiophylla Low Open Forest, over **Olea europaea* subsp. *europaea, Acacia rostellifera, Rhagodia baccata* subsp.*baccata* and *Adriana quadripartita* Open– Low Open Shrubland, over *Gahnia trifida, Ficinia nodosa* and *Baumea juncea* Very Open Sedgeland, with annual sterile grass Grassland

Species List:
**Euphorbia terracina, *Medicago polymorpha, *Olea europaea* subsp. *europaea, *Romulea rosea* var. *australis, *Symphyotrichum squamatum, Acacia rostellifera, Adriana quadripartita, Baumea juncea, Carex preissii, Ficinia nodosa, Gahnia trifida, Kennedia prostrata, Melaleuca rhaphiophylla, Rhagodia baccata* subsp. *baccata* and annual sterile grass.

RELEVE: PKG
Date: 18.11.06
Botanist: K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384057 **Northing**: 6418524 **Accuracy:** 5.8m
Photo: KM023
Topography: Depression on dune swale
Soil: Dark brown peaty sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 85%. **Bare Ground:** 10%.
Condition: Very Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Xanthorrhoea preissii Closed Tall Scrub, with *Adriana quadripartita* and **Eupharbia terracina* Low Open Shrubland, over *Lepidosperma squamatum* Very Open Sedgeland.
Species List:
**Euphorbia terracina, *Pelargonium littorale* subsp. *littorale, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Kennedia prostrata, Lepidosperma squamatum, Leucopogan parviflorus, Poa porphyroclados* and *Xanthorrhoea preissii*
Notes: Area mapped surrounds PK13.

RELEVE: PKQ
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383831 **Northing**: 6418204 **Accuracy:** 5m
Photo: RPS 1054- 1056
Topography: Wetland basin in dune swale
Soil: Dark brown sandy loam. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 90%. **Bare Ground:** 5%.
Condition: Very Good. **Disturbance Level:** Low- 20% weeds
Vegetation Description:
Hakea prostrata (mostly burnt) Tall Shrubland, with *Adriana quadripartita, Logania vaginalis* and **Euphorbia terracina* Low Open Shrubland, over *Ficinia nodosa* and *Baumea juncea* Sedgeland, with *Centella asiatica* Open Herbland.
Species List:
**Avena barbata, *Euphorbia terracina, *Romulea rosea* var. *australis, Acacia lasiocarpa* var. *lasiocarpa, Acacia saligna, Adriana quadripartita, Baumea juncea, Bromus arenarius, Centella asiatica, Ficinia nodosa, Hakea prostrata* (mostly burnt), *Kennedia prostrata, Lagania vaginalis, Poa porphyroclados* and *Rhagodia baccata* subsp.*baccata.*

RELEVE: PKR
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383588 **Northing**: 6418358 **Accuracy:** 5m
Photo: RPS 1068
Topography: Dunes.
Soil: Grey sandy. **Rock Type:** limestone.
Aspect: West. **Age Since Fire:** < 2 years
Litter: 85%. **Bare Ground:** 3%.
Condition: Good-Very Good. **Disturbance Level:** High- weeds
Vegetation Description:
Acacia rostellifera Open Heath, over a Closed Grassland of dead grasses.
Species List:
**Avena barbata, *Euphorbia terracina, Acacia rostellifera, Acacia saligna, Austrostipa flavescens, Hakea prostrata, Lepidosperma gladiatum, Lepidosperma squamatum, Melaleuca systena, Poa porphyroclados* and *Xanthorrhoea preissii.*

RELEVE: PKS
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383684 **Northing**: 6418639 **Accuracy:** 5m
Photo: RPS 1069
Topography: Flat

Soil: Grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 90%- weedy hay. **Bare Ground:** 5%.
Condition: Degraded- Completely Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
**Euphorbia terracina* Low Shrubland, over **Avena barbata, *Lagurus ovatus, Sparobolus virginicus* and **Ehrharta calycina* Open Grassland
Species List:
**Avena barbata, *Ehrharta calycina, *Euphorbia terracina, *Lagurus ovatus, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Melaleuca systena* and *Sporobolus virginicus.*

RELEVE: PKT
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0384090 **Northing**: 6418481 **Accuracy:** 5m
Photo: RPS 1070
Topography: Dune crest
Soil: Light grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 80%- dead grasses. **Bare Ground:** 10%.
Condition: Good-Very Good. **Disturbance Level:** Medium- weeds (5-15%)
Vegetation Description:
Acacia rostellifera and *Melaleuca systena* Low Shrubland, over *Lepidosperma squamatum* Very Open Sedgeland, with **Lagurus ovatus, *Avena barbata* and *Austrostipa flavescens* Very Open Grassland.
Species List:
**Avena barbata, *Euphorbia terracina, *Lagurus ovatus, *Romulea rosea* var. *australis, Acacia rostellifera, Acacia saligna, Acanthocarpus preissii, Adriana quadripartita, Austrodanthonia occidentalis, Austrostipa flavescens, Bromus arenarius, Conostylis aculeata* subsp.*preissii, Dianella revoluta* var. *divaricata, Exocarpos sparteus, Jacksonia furcellata,, Lepidosperma squamatum, Leucopogon parviflorus, Melaleuca systena, Olearia axillaris, Opercularia vaginata, Phyllanthus calycinus, Scaevola anchusifolia* and *Schoenus grandiflorus.*

RELEVE: PKU
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383858 **Northing**: 6417888 **Accuracy:** 5m
Photo: RPS 1082 & 1083
Topography: Depression on dampland
Soil: Light grey sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** < 2 years
Litter: 10%. **Bare Ground:** 5%.
Condition: Good. **Disturbance Level:** Medium
Vegetation Description:
Acacia rostellifera Tall Shrubland, with **Euphorbia terracina, Adriana quadripartita* and *Logania vaginalis* Low Open Shrubland, over *Ficinia nodosa* and *Baumea juncea* Open Sedgeland.
Species List:
**Avena barbata, *Conyza sumatrensis, *Euphorbia terracina, Acacia rostellifera, Acacia saligna, Adriana quadripartita, Anthocercis littorea, Baumea juncea, Bromus arenarius, Ficinia nodosa, Hakea prostrata, Kennedia prostrata, Lagania vaginalis, Olearia axillaris, Poa porphyroclados* and *Rhagodia baccata* subsp.*baccata.*

RELEVE: PKV
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383775 **Northing**: 6417820 **Accuracy:** 5m
Photo: RPS 1084
Topography: Wetland depression in dune swale.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 90%. **Bare Ground:** <1%.
Condition: Good- Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Melaleuca rhaphiophylla Tall Open Shrubland, over *Ficinia nodosa* Open Sedgeland, with *Bromus arenarius* Grassland
Species List:
**Avena barbata, *Euphorbia terracina, Acacia saligna, Adriana quadripartita, Anthocercis littorea, Bromus arenarius, Ficinia nodosa, Kennedia prostrata, Melaleuca rhaphiophylla, Sporobolus virginicus* and *Xanthorrhoea preissii.*
RELEVE: PKW
Date: 22.11.06

Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383699 **Northing**: 6417774 **Accuracy:** 5m
Photo: RPS 1085 & 1086
Topography: Depression in dune swale.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Degraded. **Disturbance Level:** High- weeds
Vegetation Description:
Melaleuca rhaphiophylla Tall Shrubland (mostly dead), over **Stenotaphrum secundatum* Closed Grassland.
Species List:
**Avena barbata, *Stenotaphrum secundatum, Acacia rostellifera, Austrostipa flavescens, Bromus arenarius, Melaleuca rhaphiophylla, Sporobolus virginicus* and *Xanthorrhoea preissii.*

RELEVE: PKX
Date: 22.11.06
Botanists: A. Mercier, K. McCreery
Location (Datum: WGS84)
Zone: 50H **Easting**: 0383689 **Northing**: 6417831 **Accuracy:** 5m
Photo: RPS 1088
Topography: Wetland.
Soil: Dark brown sand. **Rock Type:** limestone.
Aspect: flat. **Age Since Fire:** more than 2 years
Litter: 10%. **Bare Ground:** <1%.
Condition: Good. **Disturbance Level:** Medium- weeds
Vegetation Description:
Xanthorrhoea preissii Tall Shrubland, with *Acacia rostellifera* and *Acacia saligna* Open Shrubland, over *Lepidosperma squamatum* Open Sedgeland.
Species List:
**Avena barbata, *Euphorbia terracina, *Lagurus ovatus, *Yucca aloifolia, Acacia lasiocarpa* var. *lasiocarpa, Acacia rostellifera, Acacia saligna, Adriana quadripartita, Austrostipa flavescens, Baumea juncea, Bromus arenarius, Gompholobium tomentosum, Hakea prostrata, Kennedia prostrata, Lepidosperma squamatum, Melaleuca systena, Poa porphyroclados, Thomasia cognata* and *Xanthorrhoea preissii.*

APPENDIX B4

PATN Analysis Results

1.0 INTRODUCTION

1.1 Purpose of this report

The current report is intended to help clarify the assignment of Floristic Community type (FCT) designation to vegetation community (site) data. FCTs were defined by Gibson et al (1994) based on site data collected from vegetation on the Swan Coastal Plain. In particular, the potential that a Threatened Ecological Community (English and Blyth 1997) is represented by the data collected needs to be clarified.

1.2 Location of Port Kennedy Sites

The sites were in the beach ridge plain in the Port Kennedy area.

1.3 Brief background to floristic analysis of vegetation on the Swan Coastal Plain

Floristic analysis (ie., analysis of variation in vegetation based on the species present, rather than description of structural variation and dominance) as a significant component of the understanding of the variation present in the native vegetation of the Swan Coastal Plain dates to Gibson *et al* (1994 – all references to the SCP survey in the current report refer to this publication), the first publication to document the floristics of the vegetation of a large part of the Swan Coastal Plain. While the SCP survey is based on a very significant amount of work, it must be viewed as a "first pass" survey, limited, in the context of the great variety of vegetation present in the very large area surveyed, by the relatively limited number (509) of sites (quadrats) it is based on. To a limited degree, this limitation has subsequently been addressed in an "update" to the work of the SCP survey (which describes additional units). However, there is no detailed publication of the results of this update available and the additional data used are not readily available in an appropriate form (ie., one that would enable ready comparison of new data to the overall data set).

The units described by the SCP survey are a series of "floristic community types", a "unit" whose rank is defined by the use within a study. The SCP survey surveyed a very large survey area and defined a relatively small number of floristic community types. Consequently, the floristic community types they have described are of a very high order (see Trudgen 1999, volume 1, for further discussion of this point). This is an extremely important point to fully grasp in interpreting the analysis presented by the SCP survey and in understanding the meaning of analysis of other data sets when they are compared to the floristic community types of the SCP survey.

The important effects of the limited size data set used by the SCP survey and of the relatively small number of floristic community types defined by them, can be summarised by the following points:

1. the definition of all but two of the Threatened Ecological Communities for vegetation on the Swan Coastal Plain (English and Blyth 1997) has been based on the floristic community types of the SCP survey. It therefore follows, that with two exceptions, only vegetation units from one study that are different at a very high order of floristics are treated as rare by Government. No account is taken of other important differences, such as differences in structure and dominance;

2. for the definition of floristic community types to be robust, a sufficient sized database is needed to give adequate precision in their definition. About half of the floristics community types (or sub types) of the SCP survey are based on less than 10 sites. It is likely that with a larger data set there would be significant alteration in the classification of those floristic community types from the SCP survey based on small numbers of sites.

3. as noted above, many (if not most) of the floristic community types defined by the SCP survey are very broad. They contain very significant variation in floristics, structure and

dominance. Some (or in more highly cleared parts of the Swan Coastal Plain much) of this variation may be rare by any reasonable definition, but it is currently "buried" within larger groups;

4. there is likely to be significant variation not sampled by the SCP survey. This includes some variation at a high level of floristic difference (see Trudgen 1999, volume 1, for an example of this) and undoubtedly quite significant (large!) amounts of variation at "medium" and "low" levels.

5. the document, and its use by Government, has focussed attention in the environmental impact assessment process on the high level of units described, deflecting attention from the layers of variation beneath these units that also have significant conservation value.

From these points it is obvious that there is a need for a major "upgrade" to the floristic analysis of the vegetation of the Swan Coastal Plain to provide a more detailed floristic classification that considers not only more of the variation present, but explicitly recognises more of the variation present in formally described units.

Obviously, such a reworking would have some effect on what vegetation is considered rare on the Swan Coastal Plain. It needs to be stressed that it would be very unlikely to find that any of the vegetation currently considered to be rare on the basis of the SCP survey *'s* classification was not rare. On the other hand, it is likely that such a review would very probably consider to be rare some vegetation which is not currently considered rare.

1.4 Data provided

It is very important in comparing different sets of floristic data that they are comparable in the application of names, in the intensity of the survey (ie., the effort of searching resulting in similar proportion of the flora at sites being recorded) and in the size of the site recorded. If the data from different data sets is not comparable in these ways, it reduces the clarity of the results of the analyses carried out. If the discrepancy in the comparability of the data sets is large, the results may become meaningless.

Superficial scanning suggested that the quadrats appeared to have a reasonable number of species for the expected Floristic Community Type (19) but releves were low in species compared to FCTs 29b.

2.0 METHODS

2.1 Data Preparation

The data from the Port Kennedy sites were provided in a spreadsheet. These were incorporated into a standard MS Access based database designed for this type of data. One virtue of the database is that the species recorded at each site are stored against standard codes (numbers, those used by the Western Australian Herbarium) for each species. This facilitates ready comparison of data from different surveys stored in the same system.

After the data were incorporated into the database, a process of reconciliation of flora species names with those used in the SCP survey was undertaken. This step was necessary at least because of changes in nomenclature over the last ten years and the potential of survey specific variations in the application of names. The reconciliation involved:

- reducing some infra-specific names to the relevant species name, and
- combining some taxa where confusion is known to have occurred in field observations and identifications.

The reconciliation process was relatively straightforward as most of the names had already been standardised. Most reconciliation was to conform with the methods that the SCP survey used to manage confusing taxa plus some nomenclatural changes (Appendix).

2.2 Comparability of datasets

It was concluded that the quadrat datasets were probably reasonably compatible in nomenclature. The richness of sites are moderate (see extract of dendrogram in results.) The number of species from families often overlooked (eg Orchidaceae) is comparable to that of quadrats in SCP dataset for similar vegetation (see Data Provided section).

2.3 Comparisons made

The data therefore from the ten quadrats plus the 509 sites from the SCP survey of the southern part of the Swan Coastal Plain (south of Gingin) were combined. This enabled various analyses to be performed.

The main purpose was intended to assign the individual sites to the Floristic Community Types (FCTs) defined in the SCP survey. These data are provided in BBG_Port Kennedy.mdb.)

2.4 Analyses carried out

The approach was the use of numerical classification techniques (PATN) based on the similarity of the floristic composition of the Port Kennedy quadrats to sites in the SCP survey data set.

2.4.1 PATN

Several modules of the numerical classification package PATN (Belbin 1987) were used for the analyses. The parameter values were the same as used by the SCP survey to ensure consistency of analysis with that study.

The PATN modules used were ASO (calculation of similarity matrix), FUSE (classification based on the results of ASO), DEND (representation of classification) and NNB (determination of sites most similar to each site – nearest neighbours). The results of the analyses were imported into a database (BBG_ Med_Springs.mdb) so that site characteristics and previous classifications (eg., Floristic Community Types derived in earlier classifications) could be associated and various analyses based on these data could be performed.

The attempted assignment of floristic community types to the Port Kennedy quadrats was made by summarising the results of two different methods:

- the classification, and
- the ten nearest neighbours.

Experience demonstrates that the results of these are likely to vary, but that from nearest neighbours is likely to make more sense for it is not directly influenced by group membership. On the other hand the nearest neighbour analysis often is ambiquous as it provides several options.

To the classification dendrogram of the combined dataset, the FCT assigned by the SCP survey was associated with the SCP survey sites. The apparent FCTs were assigned to the Port Kennedy quadrats by interpreting the position of these sites in the dendrogram (particularly by the way they joined to the SCP sites).

The 10 sites in the combined data set that were most similar to each of the Port Kennedy quadrats were obtained from the nearest neighbour method (NNB). By associating those nearest neighbours from the SCP survey, the most likely FCTs from this method for each of the Port Kennedy quadrats were determined.

It is common for there to appear tob inconsistencies in the affinietie indicated by these methods. Classification can be strongly influenced by the membership of groups which can "draw" a site "away" from another that it appears similar to. An attempt was then made to reconcile these different assignments of a Floristic Community Type. The relevant portion of the site by species matrix was examined to seek clarity in some cases.

3.0 LIMITATIONS

It has been found in earlier projects that the addition of new sites to the SCP survey data set to produce a combined classification disrupts the original classification. The more data added, the higher the level of the disruption. This is particularly the case with wetland sites, partly because there are relatively few of these in the SCP data set and these communities are often very distinctive. This problem can make it difficult to assign Floristic Community Types to new sites using this method.

Secondly, it is common for new data to group to their cohorts. In some cases this has proven to result from common deficiencies in the data, ie. whole groups of species missing. This absence tends to draw them together. The more sites in the added batch, the tighter they draw together. This is probably what has happened more than "deficiencies" in the data.

The analyses are conducted without personal knowledge of the sites. No data was provided on the condition of the sites.

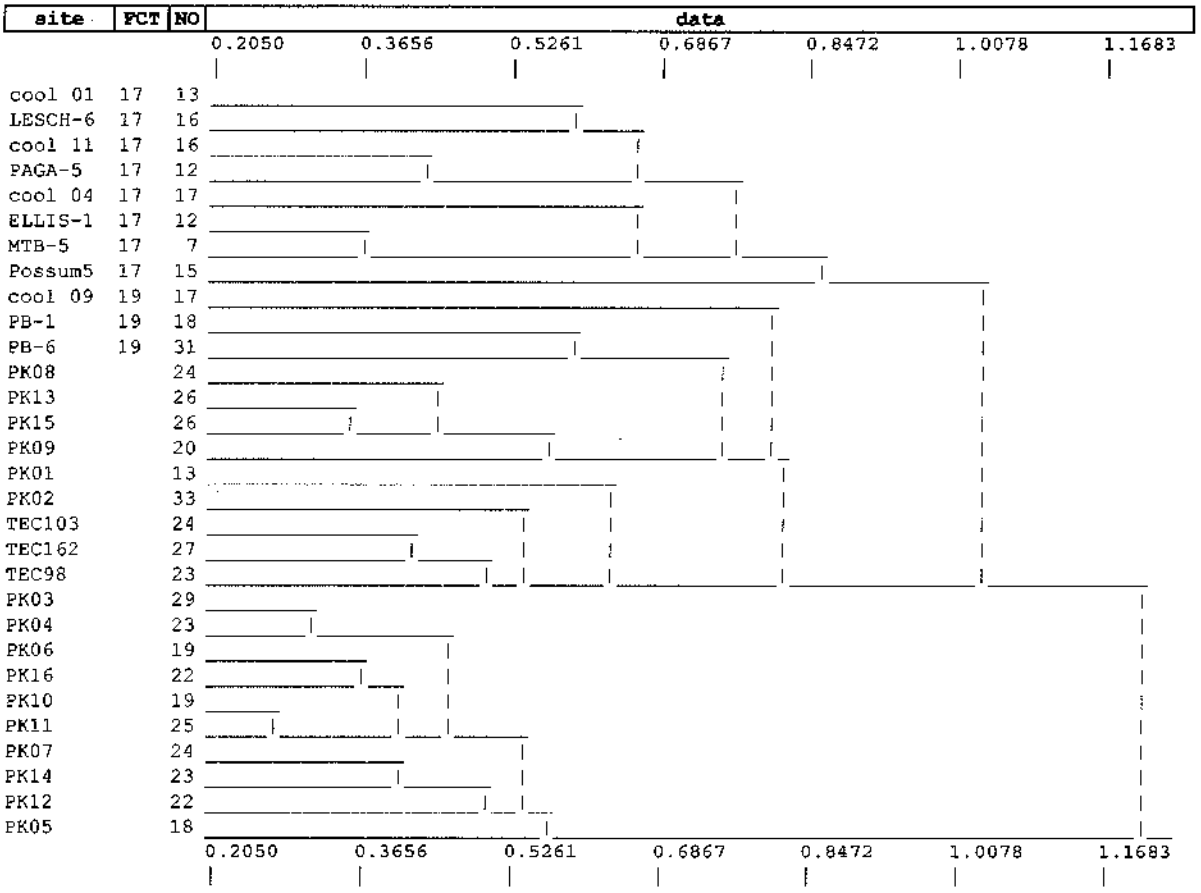
4.0 RESULTS

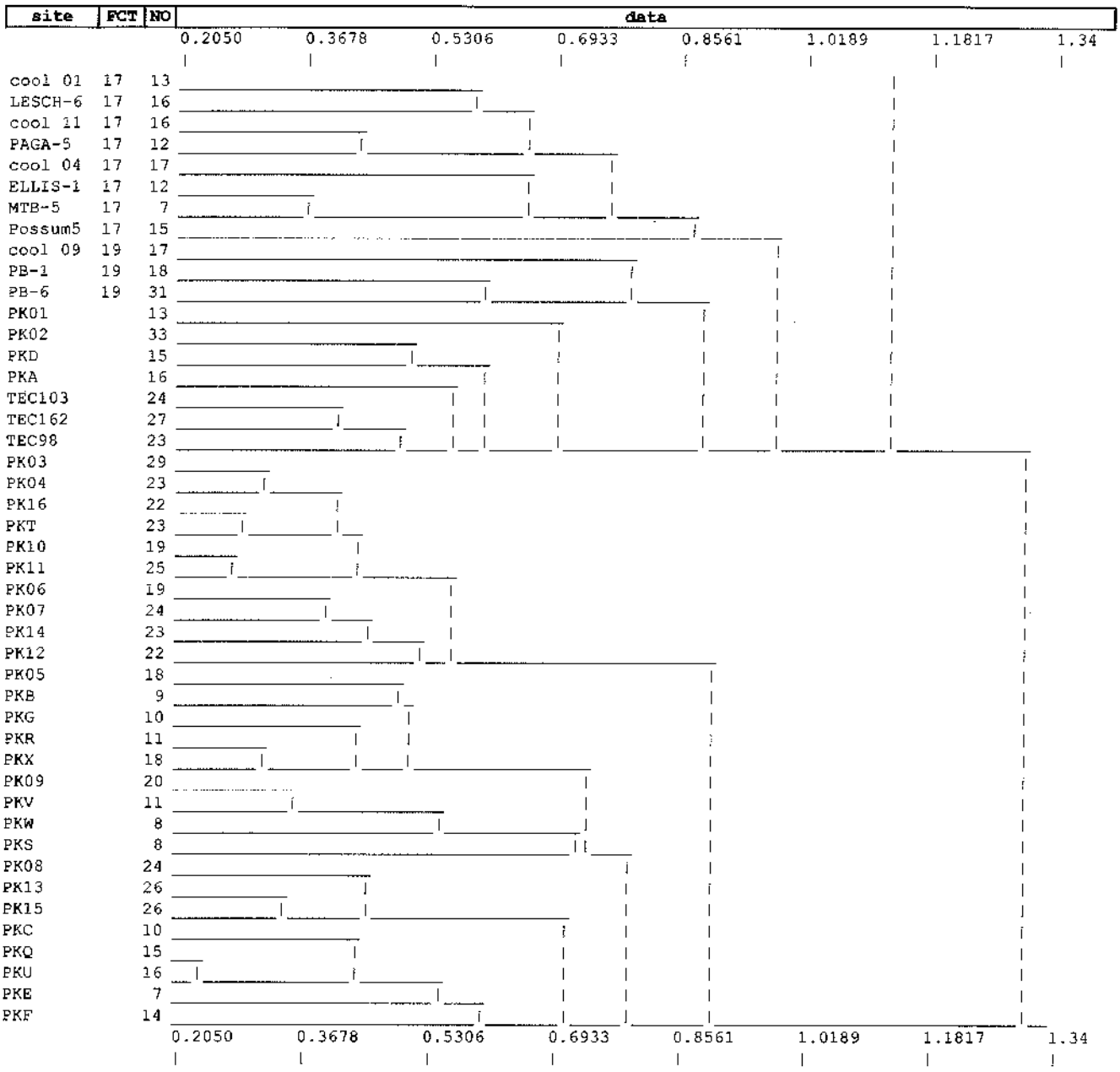
4.1 Determination of floristic community type by classification

The Port Kennedy sites were clustered in four different parts of the dendrogram. On the face of it this is encouraging in that the tendancies which sometimes occur for the new sites to aggregate with each other rather than the SCP sites has not happened. This is interpreted as an indication that, collectively, the data collected does not have significant survey dependant bias.

Most of the new sites joined with other sites from the Port Kennedy area in the SCP dataset. They were from apparently one FCT (19). The dendrograms, by their structure indicate that there are several communities.

Figure 1. Relevant portions of Dendrogram




site FCT NO data
0.2050 0.3678 0.5306 0.6933 0.8561 1.0189 1.1817 1.34
cool 01 17 13
LESCH-6 17 16
cool 11 17 16
PAGA-5 17 12
cool 04 17 17
ELLIS-1 17 12
MTB-5 17 7
Possum5 17 15
cool 09 19 17
PB-1 19 18
PB-6 19 31
PK01 13
PK02 33
PKD 15
PKA 16
TEC103 24
TEC162 27
TEC98 23
PK03 29
PK04 23
PK16 22
PKT 23
PK10 19
PK11 25
PK06 19
PK07 24
PK14 23
PK12 22
PK05 18
PKB 9
PKG 10
PKR 11
PKX 18
PK09 20
PKV 11
PKW 8
PKS 8
PK08 24
PK13 26
PK15 26
PKC 10
PKQ 15
PKU 16
PKE 7
PKF 14
0.2050 0.3678 0.5306 0.6933 0.8561 1.0189 1.1817 1.34

4.2 Determination of floristic community type using Nearest Neighbour method

The nearest neighbour analysis suggested that the quadrats have affinities with a number of different communities even though they were more similar to each other than any SCP sites by a modest amount. Some of the similarity values for sites from the SCP data sets were low enough (values less than about 0.55) to give confidence in this method being useful (Table 1).

Most Port Kennedy sites were more similar to sites in the new data set than those in the SCP sites. This indicates a reasonably strong geographic basis to the floristic composition.

By this analysis many of the new sites were related to sites from FCT 19 but also 29a, 24 and 17.

Table 1. Results of Nearest Neighbour analysis

s	s1	fct1	v1	s2	fct2	v2	s3	fct3	v3	s4	fct4	v4	s5	fct5	v5
PK01	TEC103		0.5135	TEC98		0.6111	PK15		0.641	TEC162		0.65	PK02		0.6522
PK02	TEC162		0.4333	TEC103		0.5439	PK15		0.5593	TEC98		0.6071	PK09		0.6226
PK03	PK04		0.3077	PK11		0.4074	PK16		0.4118	PK10		0.4167	cool 08	24	0.4603
PK04	PK03		0.3077	PK16		0.3333	PK11		0.375	PK10		0.4286	PK06		0.4762
PK05	PK16		0.4	PK11		0.4884	PK03		0.4894	PK14		0.5122	PK04		0.5122
PK06	PK16		0.3659	PK07		0.3953	PK11		0.4091	PK10		0.4211	PK14		0.4762
PK07	PK10		0.3953	PK06		0.3953	PK14		0.4043	PK12		0.4222	PK11		0.4286
PK08	PK13		0.36	PK12		0.5111	PK15		0.52	PK09		0.5909	PK14		0.617
PK09	PK13		0.4783	PK15		0.5652	PK14		0.5814	PK08		0.5909	PK02		0.6226
PK10	PK11		0.2727	PK07		0.3953	PK03		0.4167	PK06		0.4211	PK04		0.4286
PK11	PK10		0.2727	PK16		0.2766	PK04		0.375	PK03		0.4074	PK06		0.4091
PK12	PK07		0.4222	PK11		0.4348	PK10		0.45	PK16		0.4884	PK13		0.4894
PK13	PK15		0.3462	PK08		0.36	PK09		0.4783	PK12		0.4894	PK07		0.52
PK14	PK07		0.4043	PK11		0.4583	PK06		0.4762	PK05		0.5122	PK04		0.5217
PK15	PK13		0.3462	TEC98		0.5102	PK08		0.52	PK14		0.551	PK02		0.5593
PK16	PK11		0.2766	PK04		0.3333	PK06		0.3659	PK05		0.4	PK03		0.4118
TEC98	TEC162		0.48	TEC103		0.4894	PK15		0.5102	PK02		0.6071	PK01		0.6111
TEC103	TEC162		0.4118	TEC98		0.4894	PK01		0.5135	PK02		0.5439	PK15		0.56
TEC162	TEC103		0.4118	PK02		0.4333	TEC98		0.48	PK15		0.6226	PK01		0.65

Table 1 (cont)

s	s6	fct6	v6	s7	fct7	v7	s8	fct8	v8	s9	fct9	v9	s10	fct10	v10
PK01	PAGA-5	17	0.68	PK13		0.6923	cool 11	17	0.7241	LESCH-6	17	0.7241	PB-6	19	0.7273
PK02	PK01		0.6522	PK13		0.661	cool 09	19	0.66	PK08		0.6842	ELLIS-1	17	0.7333
PK03	PK05		0.4894	PK07		0.5094	PK12		0.52	PK14		0.5385	PK06		0.5417
PK04	PK05		0.5122	PK14		0.5217	PK07		0.5319	PB-3	29b	0.551	PK12		0.5909
PK05	PK06		0.5135	PB-3	29b	0.5909	PK07		0.619	PK10		0.6216	PK09		0.6316
PK06	PK04		0.4762	PK05		0.5135	PK03		0.5417	PK12		0.55	cool 08	24	0.6226
PK07	PK03		0.5094	PK13		0.52	PK16		0.5217	PK04		0.5319	cool 06	24	0.5862
PK08	PK04		0.617	PK07		0.625	PK11		0.6327	PB-6	19	0.6364	PK16		0.6522
PK09	PK05		0.6316	PK11		0.6444	cool 11	17	0.6667	PK16		0.6667	PK04		0.6744
PK10	PK12		0.45	PK16		0.4634	cool 08	24	0.5094	PK14		0.5238	PK13		0.6
PK11	PK07		0.4286	PK12		0.4348	cool 08	24	0.4576	PK14		0.4583	PK05		0.4884
PK12	PK08		0.5111	PK03		0.52	PK14		0.5455	PK06		0.55	PK15		0.5745
PK13	PB-6	19	0.5439	PK14		0.551	PK11		0.5686	PK10		0.6	TEC98		0.6327
PK14	PK10		0.5238	PK03		0.5385	PK12		0.5455	PK13		0.551	PK15		0.551
PK15	TEC103		0.56	PK09		0.5652	PK12		0.5745	PB-6	19	0.5789	PK07		0.6
PK16	PK10		0.4634	PK12		0.4884	PK07		0.5217	PB-3	29b	0.5417	PK14		0.5556
TEC98	PK13		0.6327	cool 11	17	0.6923	PB-6	19	0.7037	cool 01	17	0.7222	Possum2	16	0.7333
TEC103	PK13		0.64	PK12		0.6444	PB-1	19	0.6667	PB-6	19	0.6727	cool 11	17	0.7
TEC162	PK13		0.6604	PB-6	19	0.6897	PK12		0.7083	cool 11	17	0.7209	cool 09	19	0.7273

Table 1 (cont)

s	S11	Fct1 1	V11	S12	Fct1 2	V12	S13	Fct1 3	V13	S14	Fct1 4	V14	S15	Fct1 5	V15
PK01	cool 04	17	0.7333	ELLIS-1	17	0.76	PK12		0.7647	McLART-1	13	0.7692	PK07		0.7838
PK02	cool 01	17	0.7391	PK12		0.7407	PK14		0.75	PB-6	19	0.75	cool 11	17	0.7551
PK03	TRIG-1	29b	0.5926	PB-3	29b	0.6	PB-4	29b	0.6271	NWIL-3	29b	0.6364	CHIDPT-1	24	0.6452
PK04	cool 08	24	0.614	PK08		0.617	PK13		0.6327	PK15		0.6735	PK09		0.6744
PK05	PK12		0.641	PB-4	29b	0.6667	PB-5	29b	0.6744	NWIL-1	29b	0.7037	PB-2	29b	0.7083
PK06	PB-3	29b	0.6444	cool 02	24	0.6735	PK13		0.6889	BOLD-4	24	0.6897	MTB-2	24	0.6897
PK07	PK15		0.6	PK05		0.619	PK08		0.625	CHIDPT-1	24	0.6491	cool 02	24	0.6667
PK08	PK10		0.6744	PK02		0.6842	cool 08	24	0.6897	PK03		0.6981	TRIG-6	24	0.7097
PK09	cool 09	19	0.6757	PB-6	19	0.6863	cool 08	24	0.7037	PK12		0.7073	PK07		0.7273
PK10	PK05		0.6216	PB-3	29b	0.6444	PB-4	29b	0.6735	cool 02	24	0.6735	PB-2	29b	0.6735
PK11	PB-3	29b	0.5294	PK13		0.5686	PK08		0.6327	PB-4	29b	0.6364	BURN-1	29a	0.6364
PK12	PB-1	19	0.5897	PK04		0.5909	cool 08	24	0.6	NAVB-2	29a	0.6056	PB-6	19	0.6154
PK13	PK04		0.6327	cool 08	24	0.6333	TEC103		0.64	TEC162		0.6604	PK02		0.661
PK14	PK16		0.5556	cool 08	24	0.5789	PK09		0.5814	PK08		0.617	TRIG-1	29b	0.625
PK15	TEC162		0.6226	PK01		0.641	PK11		0.6471	PK04		0.6735	PK10		0.6889
PK16	cool 08	24	0.6429	PK08		0.6522	TRIG-1	29b	0.6596	PK09		0.6667	PK13		0.6667
TEC98	cool 04	17	0.75	PK09		0.7674	PK12		0.7727	PK08		0.7872	PK07		0.7872
TEC103	LESCH-6	17	0.7	cool 09	19	0.7073	cool 04	17	0.7073	low10b	11	0.7083	ELLIS-1	17	0.7222
TEC162	PB-1	19	0.7333	NAVB-2	29a	0.7403	PK09		0.7447	cool 01	17	0.75	Possum2	16	0.7551

Table 1 (cont)

s	S16	Fct1 6	V16	S17	Fct1	V17	S18	Fct1 8	V18	S1	Fct1 9	V19	S20	Fct2 0	V20
PK01	PK08		0.7838	low10b	11	0.7838	cool 09	19	0.8	brick4	9	0.8	PB-1	19	0.8065
PK02	NAVB-2	29a	0.759	cool 04	17	0.76	TRIG-6	24	0.7746	NAVB-4	24	0.7778	PAGA-5	17	0.7778
PK03	BURN-1	29a	0.6571	NWIL-1	29b	0.6615	SEAB-5	29a	0.6706	PK13		0.6727	WHILL-2	29b	0.68
PK04	NWIL-1	29b	0.7627	TRIG-6	24	0.7705	PB-2	29b	0.7736	NAVB-4	24	0.7742	MTB-2	24	0.7742
PK05	NWIL-3	29b	0.7091	PK08		0.7143	PB-6	19	0.7143	TRIG-1	29b	0.7209	PK13		0.7273
PK06	NAVB-3	24	0.7049	PB-4	29b	0.7143	TRIG-5	24	0.7188	BOLD-1	24	0.7231	NAVB-4	24	0.7241
PK07	TRIG-5	24	0.6812	BOLD-4	24	0.7143	PB-1	19	0.7143	TRIG-1	29b	0.7143	NAVB-4	24	0.7143
PK08	cool 03	24	0.7143	PK05		0.7143	TEC103		0.75	PB-1	19	0.7619	TEC162		0.7647
PK09	PB-3	29b	0.7391	PK10		0.7436	TEC162		0.7447	PAGA-5	17	0.75	cool 01	17	0.7576
PK10	PK08		0.6744	PK15		0.6889	CHIDPT-1	24	0.6923	BURN-1	29a	0.7	BOLD-3	24	0.7015
PK11	BOLD-3	24	0.6438	PK09		0.6444	PK15		0.6471	CHIDPT-1	24	0.6552	PB-2	29b	0.6727
PK12	PK05		0.641	TEC103		0.6444	CHIDPT-1	24	0.6667	BURN-1	29a	0.6774	cool 02	24	0.6863
PK13	PK16		0.6667	PK03		0.6727	PK06		0.6889	PK01		0.6923	NEER-1	24	0.6944
PK14	NEER-10	24	0.6712	TRIG-6	24	0.6721	NAVB-4	24	0.6774	CHIDPT-1	24	0.6786	BOLD-3	24	0.6901
PK15	cool 08	24	0.7	PK16		0.7083	PK03		0.7091	cool 11	17	0.7143	PB-1	19	0.7273
PK16	NWIL-1	29b	0.6897	PB-4	29b	0.6923	NWIL-3	29b	0.6949	PK15		0.7083	SEAB-3	29b	0.7313
TEC98	LESCH-6	17	0.7949	cool 09	19	0.8	PB-1	19	0.8049	PK14		0.8261	CARAB-2	7	0.8261
TEC103	Possum2	16	0.7391	PK08		0.75	PK07		0.75	NEER-1	24	0.7714	PK09		0.7727
TEC162	PK08		0.7647	PAGA-5	17	0.7949	ELLIS-1	17	0.7949	PK14		0.8	PK07		0.8039

s – the site being compared
s1 to s20 – the 1st to 20th most similar sites
f1 to f20 – the FCT of the similar sites (only for SCP sites)
v1 to v20 – the dissimilarity value between the site and the similar sites (values above 0.6 tend to indicate low similarity)

Table 2. Results of Nearest Neighbour analysis Releves (only PK sites)

s	s1	fct1	v1	s2	fct2	v2	s3	fct3	v3	s4	fct4	v4	s5	fct5	v5
PKA	TEC162		0.5349	TEC98		0.5385	TEC103		0.55	LESCH-6	17	0.75	cool 11	17	0.75
PKB	TRIG-1	29b	0.7647	WHILL-2	29b	0.8	PRES-1	29a	0.8125	PB-3	29b	0.8286	TRIG-6	24	0.8298
PKC	cool 09	19	0.7037	TEC98		0.8182	TEC162		0.8378	LESCH-4	30b	0.8667	WHILL-2	29b	0.871
PKD	TEC162		0.5238	ELLIS-1	17	0.6296	TEC98		0.6316	TEC103		0.641	cool 01	17	0.8429
PKE	TEC98		0.7333	cool 09	19	0.75	PB-1	19	0.76	TEC162		0.7647	MILT-2	13	0.7847
PKF	cool 09	19	0.6774	MTB-5	17	0.7143	Possum2	16	0.7222	cool 11	17	0.7333	TEC103		0.75
PKG	PB-3	29b	0.6667	PB-6	19	0.7073	PB-5	29b	0.7143	MTB-4	24	0.7297	cool 08	24	0.7727
PKQ	cool 09	19	0.6875	TEC103		0.6923	PB-3	29b	0.7073	PB-1	19	0.7578	TEC98		0.7895
PKR	TRIG-1	29b	0.7778	PB-5	29b	0.7778	PB-3	29b	0.7838	MTB-4	24	0.7895	TRIG-6	24	0.7959
PKS	cool 08	24	0.7619	TRIG-1	29b	0.8182	PB-4	29b	0.8421	PB-6	19	0.8462	NPRES-1	29b	0.8519
PKT	WHILL-2	29b	0.6818	PB-4	29b	0.6981	PB-2	29b	0.6981	PB-5	29b	0.7083	TRIG-1	29b	0.7083
PKU	cool 09	19	0.6364	PB-6	19	0.7021	TRIG-6	24	0.7407	MTB-4	24	0.7674	PB-2	29b	0.7826
PKV	cool 11	17	0.7037	cool 09	19	0.7143	PB-6	19	0.7619	TEC103		0.7714	TEC162		0.7895
PKW	cool 01	17	0.8095	cool 08	24	0.8095	cool 11	17	0.8333	cool 09	19	0.84	CHIDPT-1	24	0.8537
PKX	cool 08	24	0.6923	PB-6	19	0.7143	PB-5	29b	0.7209	TRIG-1	29b	0.7209	PB-3	29b	0.7273

Table 2 (cont)

s	s6	fct6	v6	s7	fct7	v7	s8	fct8	v8	s9	fct9	v9	s10	fct10	v10
PKA	cool 04	17	0.7576	PB-1	19	0.7647	PAGA-5	17	0.7857	Possum2	16	0.7895	cool 01	17	0.7931
PKB	PB-4	29b	0.8462	PB-2	29b	0.8482	cool 09	19	0.8462	GARDEN-4	30a	0.8519	CHIDPT-1	24	0.8571
PKC	PEPGRV-2	30a	0.8824	TRIG-1	29b	0.8857	PB-2	29b	0.9	PB-4	29b	0.9	PB-6	19	0.9024
PKD	cool 11	17	0.7419	FL-10	12	0.75	cool 04	17	0.75	PAGA-5	17	0.7778	ELLIS-3	18	0.8
PKE	PB-6	19	0.7895	TEC103		0.8065	cool 11	17	0.8261	MTB-5	17	0.8571	low10b	11	0.871
PKF	TEC162		0.7561	ELLIS-1	17	0.7692	PAGA-5	17	0.7692	PAGA-2	13	0.7778	cool 04	17	0.8065
PKG	cool 09	19	0.7778	yarl01	3c	0.8	PB-2	29b	0.8	cool 03	24	0.8286	ELLIS-3	18	0.8286
PKQ	cool 08	24	0.7959	PB-5	29b	0.8	cool 11	17	0.8065	TEC162		0.8095	TRIG-6	24	0.8113
PKR	PB-4	29b	0.8049	PB-2	29b	0.8049	WHILL-2	29b	0.8125	CHIDPT-1	24	0.8182	TEC103		0.8286
PKS	BOLD-1	24	0.8519	MHENRY-2	30c	0.8537	BOLD-3	24	0.8571	NEER-10	24	0.8621	WHILL-2	29b	0.8621
PKT	BOLD-4	24	0.7097	BOLD-3	24	0.7183	WHILL-1	29b	0.7231	cool 02	24	0.7358	NAVB-3	24	0.7538
PKU	WHILL-2	29b	0.7838	TEC98		0.7949	cool 08	24	0.8	TEC103		0.8	PB-5	29b	0.8049
PKV	cool 08	24	0.8222	TEC98		0.8235	PAGA-5	17	0.8261	cool 01	17	0.8333	PAGA-2	13	0.8333
PKW	KERO-1	24	0.8667	Possum2	16	0.8667	MTB-5	17	0.8667	TEC98		0.871	TEC103		0.875
PKX	PB-2	29b	0.75	TRIG-6	24	0.75	TEC103		0.7619	MTB-4	24	0.7778	NPRES-1	29b	0.7813

s – the site being compared
s1 to s20 – the 1st to 20th most similar sites from SCP or TEC
f1 to f20 – the FCT of the similar sites (only for SCP sites)
v1 to v20 – the dissimilarity value between the site and the similar sites (values above 0.6 tend to indicate low similarity)

4.3 Combining the results

It is common for the classification to indicate a simple result and the nearest neighbour analysis to be less conclusive. This is more a product of the classification process than of inconsistency of the analyses.

The different results are understandable, however, the message from the nearest neighbour is probably clearer. Table 3 is the product of the attempt to reconcile these differences. Some uncertainty exists in this assignment as indicated.

The conclusions were very difficult in some cases given the low level of similarities between the Port Kennedy sites and the SCP or TEC sites. Why there is a low level of similarity is unknown. From the species richness point of view (a common reason for low similarities) there is a mixed picture. The richness of sites apparently related to FCT19, values are similar. However, of the others values (largely related to 29b) are low. The latter may be suggestive that these sites are partly transitional.

In the conclusion, it was considered that few sites would be related to FCT 24 as Port Kennedy is Quindalup rather than Spearwood landscapes.

Table 3 Summary of FCT assignment

	Dendrogram	Nearest Neighbour	Conclusion
TEC98	19	17/19	?19
TEC103	19	19	19
TEC162	19	19/17	19
PK01	19	19(T)	19
PK02	19	19(T)	19
PK03	?19	29b/24	29b
PK04	?19	24/29b	29b
PK05	?19	29b	29b
PK06	?19	29b/24	29b
PK07	?19	24	?24?19
PK08	19	24	?24
PK09	19	?19/?24	?19
PK10	?19	29b/24	29b
PK11	?19	29b/29a/24	29b
PK12	?19	19/24/29a	19/24/29a
PK13	19	24/19(T)	24/19(T)
PK14	?19	24/29b	?29b
PK15	19	19(T)	19
PK16	?19	24/29b	?29b
PKA	19	19(T)/?17	19
PKB	?19	29b	29b
PKC	?19	?19	?19
PKD	19	19(T)/17	?19
PKE	?19	?19	?19
PKF	?19	?19/?17	?19/?17
PKG	?19	?29b/?19	?29b/?19
PKQ	?19	?19/?29b	?19/?29b
PKR	?19	29b	29b
PKS	?19	?24?29b	?29b
PKT	?19	29b	29b
PKU	?19	?19	?19
PKV	?19	?17/?19	?17/?19
PKW	?19	?17	?17
PKX	?19	?24/?19	?19

(T) is by reference to a TEC site rather than a SCP site.

5.0 REFERENCES

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APPENDIX1

Names combined for reconciliation

FCOD	Species_LUP.name	Species_LUP_1.name
031	Avena barbata	Avena barbata/fatua
031	Avena fatua	Avena barbata/fatua
031	Catapodium rigidum	Desmazeria rigida
031	Holcus lanatus	Holcus setiger
031	Poa porphyroclados	Poa poiformis/porphyroclados
032	Ficinia nodosa	Isolepis nodosa
032	Isolepis cernua	Isolepis cernua var. cernua
032	Isolepis setiformis	Isolepis cernua var. setiformis
039	Desmocladus asper	Desmocladus flexuosus
103	Rumex acetosella	Acetosella vulgaris
113	Petrorhagia dubia	Petrorhagia velutina
131	Cassytha racemosa var. racemosa	Cassytha racemosa
163	Acacia lasiocarpa var. bracteolata	Acacia lasiocarpa
165	Trifolium campestre var. campestre	Trifolium campestre
273	Melaleuca systena	Melaleuca acerosa
275	Epilobium billardiereanum subsp.	Epilobium billardierianum
281	Apium prostratum var. prostratum	Apium prostratum
281	Centella cordifolia	Centella asiatica
293	Anagallis arvensis var. avensis	Anagallis arvensis
313	Hemiandra glabra subsp. glabra	Hemiandra pungens/linearis
326	Eremophila glabra subsp. albicans	Eremophila glabra
345	Conyza albida	Conyza bonariensis
345	Conyza sumatrensis	Conyza bonariensis
345	Senecio pinnatifolius var. latilobus	Senecio lautus
345	Symphyotrichum squamatum	Aster subulatus

APPENDIX 7
PGV ENVIRONMENTAL AND RPS-BBG FLORA LIST

Port Kennedy Business Park Red = RPS only Blue = PGV Environmental only **MONOCOTYLEDONS**	**Inside Conservation Area**	**Outside Conservation Area**
ASPARAGACEAE		
Acanthocarpus preissii	✓	✓
Lomandra maritima	✓	✓
Thysanotus dichotomus	✓	
**Yucca aloifolia*	✓	
ASPHODELACEAE		
**Asphodelus fistulosus*	✓	✓
**Trachyandra divaricata*	✓	
CYPERACEAE		
Baumea articulata	✓	
Baumea juncea	✓	✓
Carex thecata		✓
**Cyperus polystachyus*	?	?
**Cyperus tenuiflorus*	✓	
Ficinia nodosa	✓	✓
Gahnia trifida	✓	✓
Isolepis cernua var. *cernua*	✓	
Isolepis cernua var. *setiformis*	✓	
Lepidosperma gladiatum	✓	✓
Lepidosperma longitudinale	✓	✓
Lepidosperma squamatum	✓	✓
Schoenus grandiflorus	✓	✓
HAEMODORACEAE		
Conostylis aculeata	✓	✓
HEMEROCALLIDACEAE		
Dianella revoluta var. *divaricata*	✓	✓
Tricoryne elatior	✓	✓
IRIDACEAE		
**Romulea rosea*	✓	✓
JUNCACEAE		
Juncus kraussii	✓	✓
Juncus pallidus	✓	
JUNCAGINACEAE		
Cycnogeton lineare	✓	
POACEAE		
Austrostipa elegantissima	✓	
Austrostipa flavescens	✓	✓

**Avena barbata*	✓	✓
**Avena fatua*	✓	✓
**Briza maxima*		✓
**Briza minor*		✓
Bromus arenarius	✓	✓
**Bromus diandrus*	✓	✓
**Catapodium rigidum*		✓
**Cynodon dactylon*		✓
**Ehrharta calycina*		✓
**Ehrharta longiflora*		✓
**Eragrostis curvula*		✓
**Holcus lanatus*	✓	
**Lachangrostis filiformis*	✓	
**Lagurus ovatus*	✓	✓
**Lolium perenne*	✓	✓
**Lolium rigidum*	✓	✓
Poa poiformis	✓	✓
**Polypogon monspeliensis*	?	?
Rhytidosperma occidentalis	✓	✓
Sporobolus virginicus	✓	
**Stenotaphrum secundatum*	?	?
**Vulpia bromoides*		✓
RESTIONACEAE		
Desmocladus flexuosus/asper	✓	✓
TYPHACEAE		
**Typha orientalis*	✓	
XANTHORRHOEACEAE		
Xanthorrhoea brunonis	✓	
Xanthorrhoea preissii	✓	✓
DICOTYLEDONS		
ANACARDIACEAE		
**Schinus terebinthifolius*	✓	
APIACEAE		
Apium prostratum var. *prostratum*	✓	
Centella asiatica	✓	✓
ASTERACEAE		
**Arctotheca calendula*	✓	
**Carduus pycnocephalus*	✓	
**Conyza bonariensis*	✓	✓
**Conyza sumartrensis*	✓	✓
**Hypochaeris glabra*	✓	✓
**?Leontodon rhagadioloides*		✓
Olearia axillaris	✓	✓

**Osteospermum ecklonis*	✓	
Senecio pinnatifolius	✓	✓
**Sonchus oleraceus*	✓	✓
**Symphyotrichum squamatum*	✓	
Asteraceae sp.	✓	✓
BRASSICACEAE		
**Brassica tournefortii*	✓	✓
**Diplotaxis muralis*	✓	
CAPRIFOLIACEAE		
**Scabiosa atropurpurea*	✓	✓
CARYOPHYLLACEAE		
**Cerastium glomeratum*	✓	
**Minuartia mediterranea*	✓	✓
**Petrorhagia dubia*	✓	✓
**Silene gallica*		✓
CHENOPODIACEAE		
**Atriplex prostrata*	✓	
Rhagodia baccata subsp. *baccata*	✓	✓
CRASSULACEAE		
**Crassula glomerata*	✓	✓
ERICACEAE		
Leucopogon parviflorus	✓	✓
EUPHORBIACEAE		
Adriana quadripartita	✓	✓
**Euphorbia terracina*	✓	✓
FABACEAE		
Acacia lasiocarpa var. *lasiocarpa*	✓	✓
Acacia rostellifera	✓	✓
Acacia saligna	✓	✓
Gompholobium tomentosum	✓	✓
Hardenbergia comptoniana	✓	✓
Jacksonia furcellata	✓	✓
Kennedia prostrata	✓	✓
**Medicago polymorpha*	✓	✓
**Melilotus indicus*	✓	✓
**Trifolium campestre* var. *campestre*	✓	✓
**Trifolium repens* var. *repens*	✓	✓
FUMARIACEAE		
**Fumaria capreolata*		✓

GENTIANACEAE		
**Centaurium pulchellum*		✓
GERANIACEAE		
**Erodium botrys*	✓	
**Pelargonium capitatum*	✓	✓
**Pelargonium littorale* subsp. *littorale*	?	?
GOODENIACEAE		
Scaevola anchusifolia	✓	✓
LAMIACEAE		
Hemiandra pungens/glabra		✓
LAURACEAE		
Cassytha racemosa	✓	
LOBELIACEAE		
Lobelia anceps	✓	
LOGANIACEAE		
Logania vaginalis	✓	✓
MALVACEAE		
**Malva parviflora*	✓	
Thomasia cognata	?	?
MORACEAE		
**Ficus carica*	✓	
MYRTACEAE		
Melaleuca huegelii Planted	?	?
Melaleuca rhaphiophylla	✓	✓
Melaeluca systena	✓	✓
Melaleuca teretifolia	✓	
OLEACEAE		
**Olea europea*		✓
ONAGRACEAE		
Epilobium billardiereanum	✓	
**Oenothera linheimeri*	✓	
OROBANCHACEAE		
**Orobanche minor*	✓	✓
PHYLLANTHACEAE		
Phyllanthus calycinus	✓	✓
POLYGONACEAE		

**Rumex acetosella*	✓	
**Rumex crispus*	✓	
PRIMULACEAE		
**Lysimachia arvensis* var. *arvensis*	✓	✓
**Lysimachia arvensis* var. *caerulea*	✓	
PROTEACEAE		
Grevillea sp. Hybrid Ornamental	?	?
Hakea prostrata	✓	✓
RANUNCULACEAE		
Clematis linearifolia	✓	✓
RHAMNACEAE		
Spyridium globulosum	✓	
RUBIACEAE		
Opercularia vaginata	✓	✓
SANTALACEAE		
Exocarpos sparteus	✓	✓
SCROPHULARIACEAE		
**Dischisma arenarium*	✓	
Eremophila glabra subsp. *albicans*	?	?
**Verbascum virgatum*	✓	✓
SOLANACEAE		
Anthocercis littorea	✓	
**Solanum nigrum*	?	?
Solanum symonii	✓	
VERBENACEAE		
**Phyla nodiflora* var. *nodiflora*	✓	

			Altogether	Known locations
Total species	**108**	**83**	**132**	**123**
native	58	44	63	60
introduced	50	39	69	63

APPENDIX 8

FAUNA REPORT

Port Kennedy Business Park Fauna Assessment – Survey Results

Prepared for: Strategen
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Prepared by: Jeff Turpin and Mike Bamford

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CONSULTING ECOLOGISTS.
23 Plover Way,
Kingsley, WA, 6026

24th June 2011

EXECUTIVE SUMMARY

The Port Kennedy Business Park is a development proposed by LandCorp at Port Kennedy, Western Australia. The proposed project is situated approximately 45 km south of the Perth Central Business District and comprises Lot 4 Mandurah Rd and Lot 17 Port Kennedy Drive.

Bamford Consulting Ecologists was commissioned by Strategen on behalf of LandCorp to undertake a Level 1 Fauna Assessment of the proposed project covering the entire 67 hectare site.

The key objectives of this fauna study are:

- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the Project Area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify and describe general vegetation ("habitats") present including:
    - descriptions of vegetation and substrate associations (VSAs);
    - observations on the presence and distribution of rare VSAs;
- identify potential impacts of a development within the Project Area upon fauna values, and
- provide management recommendations to mitigate these impacts.

The desktop survey identified 204 fauna species potentially occurring in the Port Kennedy area. A total of 34 native fauna species was recorded during the site inspection. This comprised 25 bird, two native mammals, two introduced mammals, four reptile and one frog species. Conservation significant species recorded include the Quenda (Southern Brown Bandicoot) and a number of CS3 bird species listed as declining on the Swan Coastal Plain.

Forty-seven species of conservation significance are considered likely to occur in or utilise habitat within the proposed Port Kennedy Business Park. Of these, six are of high significance (Conservation Significance Level 1), being listed under legislation, five are of moderate conservation significance (Conservation Significance Level 2), being listed as priority species by the Department of Environment and Conservation (DEC), and thirty six are of local significance (Conservation Significance Level 3), because they have restricted distributions or are listed as declining species on the Swan Coastal Plain (DEP, 2000). The project area also supports a population of the conservation significant Graceful Sunmoth and habitats known to support short-range endemic fauna such seasonal wetlands.

Impacts upon fauna due to the construction and operation of the project are discussed in a separate report.

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CONTENTS

1. INTRODUCTION

1.1 Introduction

The Port Kennedy Business Park is a development proposed by LandCorp at Port Kennedy, Western Australia (see Figure 1). The proposed project is situated approximately 45 km south of the Perth Central Business District and comprises Lot 4 Mandurah Rd and Lot 17 Port Kennedy Drive.

The project lies within an area zoned as "Port Kennedy Business Enterprise". The 67 ha proposed project site s flanked by Port Kennedy Drive to the south and Ennis Avenue to the east. Rockingham Lakes Regional Park lies immediately adjacent to the east (see Figure 2), and the Rockingham Scientific Park a short way to the west.

Bamford Consulting Ecologists was commissioned by Strategen on behalf of LandCorp to undertake a Level 1 Fauna Assessment of the proposed project covering the entire 67 ha site. A level 1 Fauna Assessment is required to identify the fauna values of a site so that impacts upon these from any proposed development can be assessed and, where possible, minimised.

Figure 1. Location of the proposed Port Kennedy Business Park.

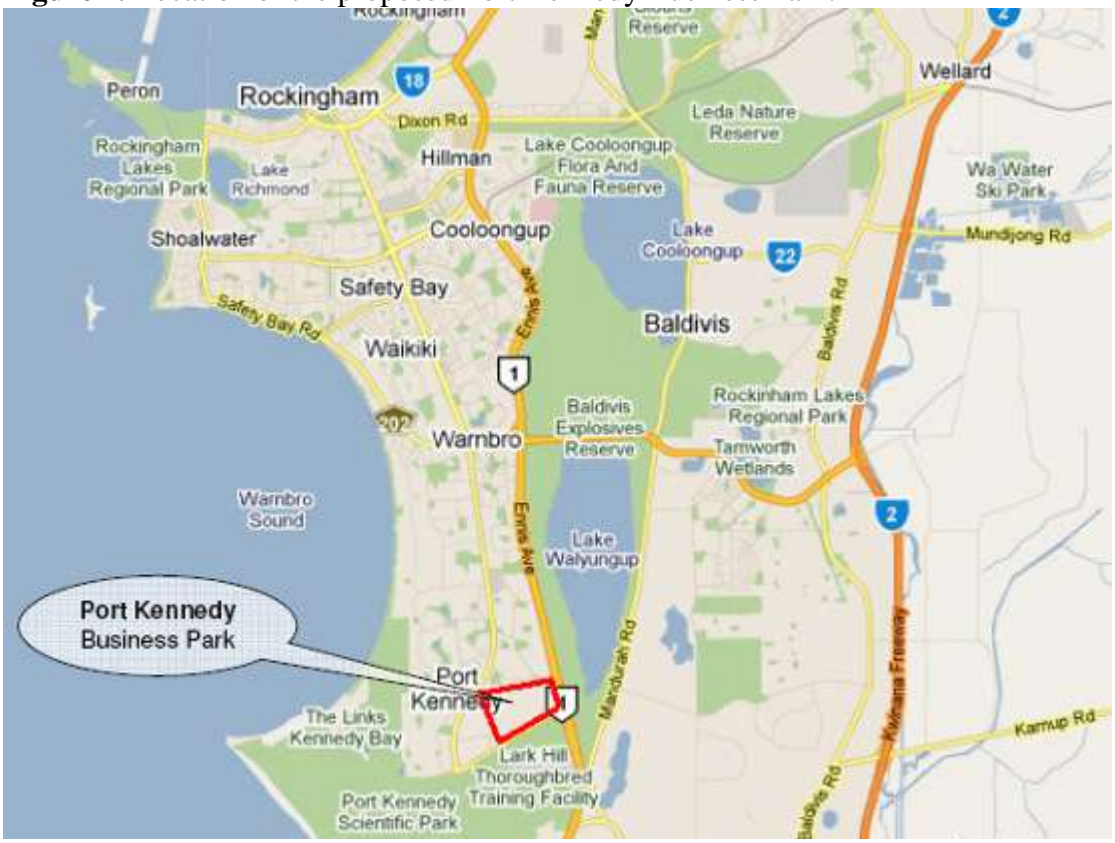


Figure 2. The location of the Proposed Project (shaded red).

1.2 Study Objectives

The objectives of fauna studies in the Environmental Impact Assessment (EIA) process are broadly to determine the fauna values of a site and the likely impacts of a proposed development. This provides government agencies with the information needed to assess the significance of impacts under state and government legislation. The key objectives of fauna studies are to:

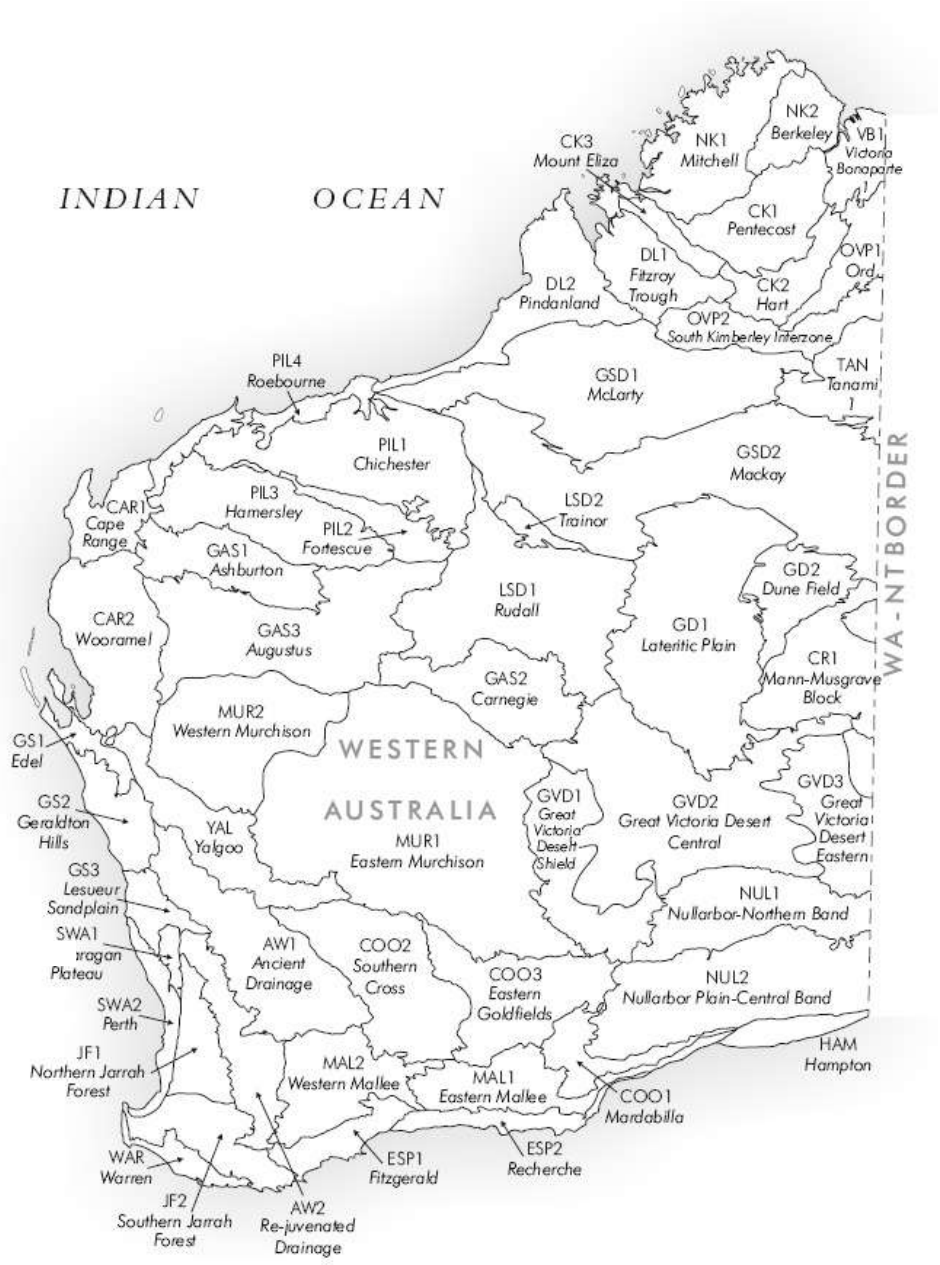
- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the Project Area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify and describe general vegetation ("habitats") present including:
  - descriptions of vegetation and substrate associations (VSAs);
  - observations on the presence and distribution of rare VSAs;
- identify potential impacts of a development within the Project Area upon fauna values, and
- provide management recommendations to mitigate these impacts.

2. BACKGROUND

2.1 Regional Description

The project area lies within the Swan Coastal Plain (SWA2) subregion of the Swan Coastal Plain Bioregion (Interim Biogeographical Regionalisation for Australia classification system, EA 2000; McKenzie *et al.* 2003, see Figure 3). The Swan Coastal Plain Bioregion falls within the Bioregion Group 1 classification of EPA (2004). Group 1 comprises the "bioregions of the South-West Botanical Province that are extensively cleared for agriculture."

Figure 3 **IBRA Subregions in Western Australia. Note the project lies in SWA2: Swan Coastal Plain.**



The general features of the Swan Coastal Plain subregion are summarised by Mitchell, Williams and Desmond (2002). The Swan Coastal Plain is a low-lying coastal plain, mainly covered with woodlands. It is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark (*Melaleuca* spp.) in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. The climate is Mediterranean with rainfall varying from 600 to 1000, depending on topography and elevation. Three phases of marine sand dune development provide relief.

The Swan Coastal Plain subregion is composed of:

"colluvial and aeolian sands, alluvial river flats and coastal limestone. Vegetation includes heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvial deposits. The subregion includes a complex series of seasonal wetlands and also includes Rottnest, Carnac and Garden Islands. The subregional area is 1,333, 901 ha. (Mitchell *et al.* 2002)."

The dominant land uses in this subregion are dry land agriculture, unallocated crown land and crown reserves, urban areas, rural residential, cultivation, forestry-plantations, conservation and grazing. There are smaller areas of mining and defence lands. The Perth Metropolitan Area makes up 20% of the entire subregion (Mitchell *et al.* 2002). The Swan Coastal Plain has undergone large scale development and as a result much of the native vegetation in the region has been cleared. The majority of the remaining remnant vegetation occurs in small and isolated remnants.

2.2 Vegetation

The vegetation of the Swan Coastal Plain has been extensively cleared and significantly altered by human activities. Native vegetation has been reduced and degraded to such an extent that much of the remaining remnant vegetation is regionally significant and in need of retention and some level of protection. The project area contains approximately 67ha of intact native vegetation comprising coastal and near-coastal heaths and shrublands generally in good condition (RPS, 2006). It falls within the Rockingham-Becher Plain that comprises a low sandplain featuring a distinctive landscape of parallel dune ridges alternating with linear swale depressions containing a series of wetlands at the lowest points in the landscape (RPS, 2006).

RPS conducted a flora and vegetation survey of the project area and mapped two major vegetation communities (RPS, 2006, see Figure 4). These comprise:

- Dune System
    a. Open Low Heath of *Acacia rostellifera, Melaleuca systena* on Dune Swales and Crests
    b. Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes
- Wetlands, Damplands and Depressions in Dune Swales
    a. Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.

b. Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
c. Shrubland to Tall Open Scrub of *Xanthorrhea preisii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

The Wetlands, Damplands and Depressions in Dune Swales vegetation community is equivalent to "FCT 19 : Sedgelands in Holocene Dune Swales of the southern Swan Coastal Plain". This community is listed under the EPBC Act as an endangered Ecological Community and listed as a threatened Ecological Community (TEC) in Western Australia. Due to large scale land clearance this vegetation community occurs in small and isolated remnants on the Swan Coastal Plain. It is restricted to the Rockingham and Yanchep areas plus a small area south of Mandurah (DEC, 2011).

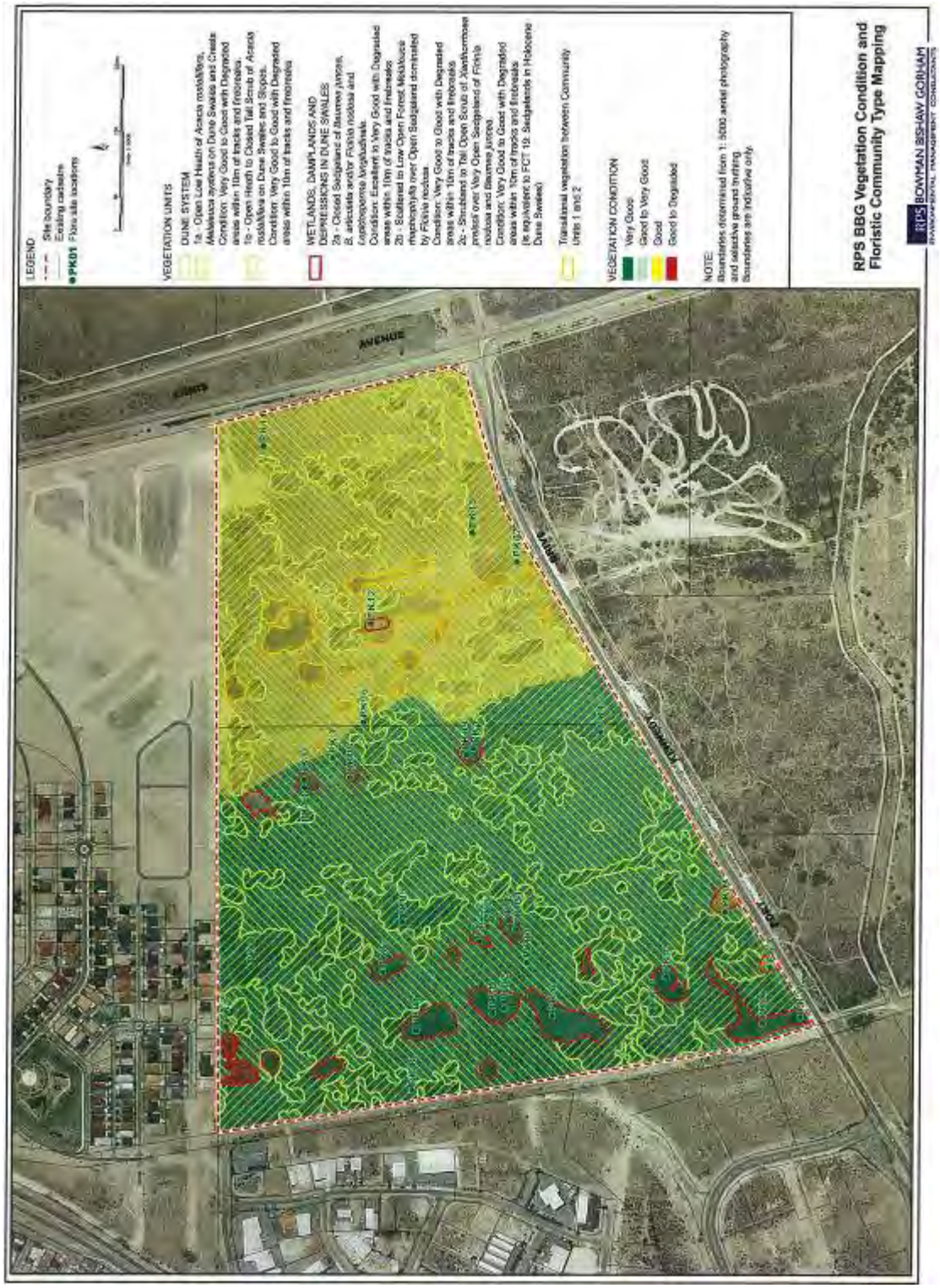


Figure 4. Vegetation of the Project Area.

2.3 Significant Wetlands

Several Wetland communities occurring within the project area have been mapped by RPS. The wetlands occur in the linear swale depressions where the ground surface approaches or meets the maximum elevation of the groundwater table during the wetter months of the year (RPS 2006). A total of 22 wetlands has been recorded from the project area comprising sumplands (seasonally inundated basin wetlands) and damplands (seasonally waterlogged basin wetlands) (see Figure 5, RPS, 2006).

Figure 5. Wetlands of the Project Area.

2.4 Previous Fauna Surveys

Bamford Consulting Ecologists has conducted several fauna assessments in the local area. This includes at Rockingham Lakes Regional Park (Site Inspection conducted in April 2011) adjacent to project area. A total of 40 species was recorded during the survey comprising 33 birds, 1 frog, 2 reptile, two native mammal and three introduced mammal species. Species of conservation significance recorded from the area include the DEC Priority Quenda and five locally significant bird species.

Species Lists are also available for the Rockingham area including fauna recorded at Point Peron (Western Australian Naturalists Club – Kwinana, Rockingham and Mandurah Branch, 1998), Port Kennedy Scientific Park (DEC, 2011) and Rockingham Lakes Regional Park (DEC, 2010). Point Peron lies approximately 10 km north-west of the project area, Port Kennedy Scientific Park lies immediately to the south-west of the project area and Rockingham Lakes Regional Park encompasses the lakes immediately to the east and also vegetation immediately to the south of the project area.

2.5 Assessment of Conservation Significance

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994). The Wildlife Conservation Act uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix One.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). In addition, the federal Department of Sustainability, Environment, Water, Population and Communities (SEWPC, formerly DEWHA and Environment Australia) has supported the publication of reports on the conservation status of most vertebrate fauna species e.g. fish (Wager and Jackson (1993), reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell et al. 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). These publications also use the IUCN categories, although those used by Cogger et al. (1993) and Wager and Jackson (1993) differ in some respects as these reports pre-date Mace and Stuart's review (1994).

In Western Australia, the Department of Environment and Conservation (DEC) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the *Wildlife Conservation Act* but for which the DEC feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN

Conservation Dependent category. Levels of Priority are described in Appendix One.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by DEC, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993) but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environmental Protection (2000, now DEC) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan.

On the basis of the above comments, three levels of conservation significance are recognised in this report:

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Conservation Significance (CS) 2: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by the DEC.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA 2002). For example, if a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3.

In addition to these conservation levels, species that have been introduced (INT) are indicated.

3. METHODS

3.1 Approach

This fauna assessment and report preparation were carried out with reference to guidance and position statements published by the WA Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (e.g. EPA 2002; EPA 2004). The level of fauna assessment required by the EPA is determined by the size and location of the proposed disturbance and the sensitivity of the surrounding environment in which the disturbance is planned.

Due to the scale and nature of the proposal, a Level 1 survey was deemed suitable (for this assessment) to satisfy the EPA guidelines, given the small area of proposed disturbance and the large extent of sampling in the region. For this assessment, a Level 1 survey involved a desktop study and reconnaissance survey (site inspection). The EPA describes a Level 1 survey as:

"Background research or 'desktop' study with the purpose to gather background information on the target area (usually at the locality scale). This involves a search of all sources for literature, data and map-based information (EPA, 2004)."

The purpose of a Reconnaissance Survey is to verify the accuracy of the background study; to further delineate and characterise the fauna and faunal assemblages present in the target area; and to identify potential impacts.

This involves:

"a target area visit by suitably qualified personnel to undertake selective, low intensity sampling of the fauna and faunal assemblages, and to provide habitat descriptions and habitat maps of the project area".

3.2 Personnel

The site inspection was conducted on 3rd June 2011 by:
Jeff Turpin: B.Sc. (Zoology)

This fauna assessment document was prepared by Mr Jeff Turpin and Dr Mike Bamford (B.Sc. Hons. Ph.D.).

3.3 Nomenclature and Taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's *Checklist of the Vertebrates of Western Australia*. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin and Smith 2001), birds (Christidis and Boles 1994; Johnstone 2001), and mammals (How *et al.* 2001).

3.4 Sources of Information for Desktop Assessment

Information for this fauna assessment was drawn primarily from the DEC NatureMap (2011), the Birds Australia Atlas Database, DEC Threatened Fauna Database and EPBC Protected Matters Search Tool. All databases were interrogated in June 2011 (see below). This information was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were: frogs (Tyler *et al.* 2000), reptiles (Storr *et al.* 1983, 1990, 1999 and 2002), birds (Blakers *et al.* 1984; Johnstone and Storr 1998; Johnstone and Storr, 2003; Storr, 1984), and mammals (Churchill 1998; Strahan 1995; Menkhorst and Knight 2001). Information was also available from some previous surveys in the region (Section 2.5 above).

Database	Type of records held on database	Area searched
NatureMap	Records of specimens held in the WA Museum. DEC records, Information and records on Threatened and Priority species in Western Australia. Includes historical data.	115.77125E, 32.36442S - plus 10km buffer
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	Species list for the 1 degree grid cell containing 115.77125E, 32.36442S
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	115.77125E, 32.36442S - plus 10km buffer

3.5 Site Inspection

The site inspection of the project area was conducted on the 3rd June 2011. During the site inspection, the project area was traversed on foot. All fauna habitats encountered were recorded as well as opportunistic fauna observations.

The aim of the site inspection was to develop an understanding of the fauna habitats occurring at the site, and to search for evidence of conservation significant species. Habitats present within the project area were assessed as to the likelihood of supporting species of conservation significance known to occur in the region. All fauna species observed during surveying were recorded.

Sampling consisted of:

- searching for evidence of significant species such as diggings and burrows, roost hollows, tracks, scats, shelters etc.;
- microhabitat searching for smaller vertebrate animals (e.g. reptiles and mammals) and invertebrates (specifically short-range endemic invertebrates e.g. land snails, millipedes);
- bird surveys;
- opportunistic observations;
- bat surveys;
- use of motion sensitive cameras;
- aural frog calls; and
- habitat assessment.

3.5.1 Searching for Significant Species

Significant species identified in the desktop assessment that may occur in the project area include several that can be found by searching for evidence of their activities. These include the Quenda or Southern Brown Bandicoot (tracks and diggings), Brush Wallaby (tracks), Carnaby's Black-Cockatoo (feeding sign), Forest Red-tailed Black-Cockatoo (feeding sign), Baudin's Black-Cockatoo (feeding sign), South-West Carpet Python (shed skin, tracks, scats), bat species (roosting hollows) and mygalomorph spiders (burrows, shelters). Searching for evidence of significant fauna was therefore undertaken by walking through habitat considered suitable for such species.

3.5.2 Micro-habitat Searching

Micro-habitat searching was carried out in any areas of interest found during the site visit. Searching involved searching through leaf-litter, looking under bark and turning over rocks, logs and rubbish.

3.5.3 Bird Surveys

Bird censusing was based on that of the Birds Australia Atlas (2 ha area search for 20 minutes). Bird surveys were conducted at least once in each habitat present within the project area. Opportunistic bird observations were recorded at all times during surveying.

3.5.4 Opportunistic Surveys

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while travelling through the site.

3.5.5 Aural Frog Calls

Frogs were active and calling in the late afternoon during the survey. Twelve wetland areas (mapped by RPS within the project area) were visited on dusk, and the presence (or absence) of calling frogs was noted.

3.5.6 Bat Surveys

An ANABAT detector was used to sample for bats for 1 hour after sunset on the 3rd June 2011. However no bats were active during this period.

3.5.7 Motion Sensitive Cameras

Three Motion Sensitive Cameras were established at three separate wetlands targeting small mammals. The cameras (Bushnell Trophy Cams) were set during the early morning, baited with universal bait (peanut butter, sardines, rolled oats) and sampled until dusk.

3.5.8 Habitat Assessment

Each habitat visited was assessed as to the suitability of supporting threatened fauna.

3.6 Limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are addressed below:

Limitation	Comment
Level of survey.	Level 1 (desktop study and reconnaissance survey). Survey intensity was deemed adequate due to the size of project and large number of fauna surveys previously conducted in the region
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and site inspections.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Birds were extensively sampled however due to the nature of the survey, low level sampling was conducted for reptiles, amphibians and mammals. Graceful Sun Moth Survey was previously conducted on site.
Proportion of fauna identified, recorded and/or collected.	No species collected, all fauna observed identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the local area (BCE database); databases (BA, DEC, WAM, EPBC); Rockingham Lakes Regional Park Management Plan (DEC, 2010).
The proportion of the task achieved and further work which might be needed.	Site Inspection completed.
Timing/weather/season/cycle.	Site Inspection conducted June 2011 which was suitable for most species but poor for recording bats and some migrants.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbances affected the survey.

Limitation	Comment
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was low (desktop study and site inspection) however was adequate to satisfy EPA guidelines.
Completeness (e.g. was relevant area fully surveyed).	Desktop study covered project area and adjacent habitats. Site inspection covered all areas of the project.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to taxon level.
Remoteness and/or access problems.	NA
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional (e.g. Swan Coastal Plain) information was available and was consulted.

4. RESULTS

4.1 Fauna Habitats / Vegetation and Substrate Associations

Two major VSAs were found within the project area. These can be further divided into sub-units reflecting a finer detail of vegetation, landform and soil:

1. Sand Dune Systems:
    a. Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes, sandplain and swales.
    b. Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.
2. Wetlands, Damplands and Seasonal Drainage Depressions in Dune swales:
    a. Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.
    b. Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*
    c. Shrubland to Tall Open Scrub of *Xanthorrhea preisii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea*.

These VSAs are depicted below.

Open Low Heath of *Acacia rostellifera, Melaleuca systena* on sand dunes and swales.

Open Heath to Closed Tall Scrub of *Acacia rostellifera* on Dune Swales and Slopes.

Scattered to Low Open Forest *Melaleuca rhaphiophylla* over Open Sedgeland dominated by *Ficinia nodosa*

Closed Sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*.

Shrubland to Tall Open Scrub of *Xanthorrhea preissii* over Very Open Sedgeland of *Ficinia nodosa* and *Baumea juncea* (above and below).

4.2 Vertebrate fauna

The desktop survey identified nearly 300 vertebrae species potentially occurring in the general region of the Port Kennedy area, but this was reviewed on the basis of available habitat (see below). A total of 34 native fauna species was recorded during the site inspection. This comprised 25 bird, two native mammals, two introduced mammals, four reptile and one frog species.

Upon completion of the site inspection a large number of species were removed from the expected species list after consideration of the limited fauna habitats present on the site. Excluded species appeared in databases but are obviously likely on the site only as vagrants, such as seabirds, or for which the site has no suitable habitat, such as marine mammals. As a result a total of 204 vertebrate fauna species are expected including 9 amphibian, 48 reptile, 122 bird and 25 mammals (Tables 1, 2, 3 and 4). Table 5 lists those species considered to be of conservation significance and details their respective conservation status.

The faunal assemblage expected is typical of a small vegetated remnant on the Swan Coastal Plain. Most fauna species occurring or expected to occur in the project area are widespread but some species may have restricted or habitat limited distributions, and some fauna species expected have declined in the region. Conservation significant fauna species occurring or likely to occur in the project area are discussed below.

The vertebrate fauna expected to occur within the project area has the following composition (see Tables 1, 2, 3 and 4 for species lists):

Taxon	Species Expected	Species Recorded (Site Inspection)	Significant Fauna Expected			
			CS1	CS2	CS3	Total
Frogs	9	1	0	0	0	0
Reptiles	48	4	1	3	6	10
Birds	122	25	10	3	34	47
Mammals	20 native 6 feral	2 2	1	4	6	11
Total	**205**	**34**	**12**	**10**	**46**	**68**

4.2.1 Freshwater Fish

There are no permanent freshwater habitats within the proposed project area. Seasonal freshwater wetlands occur although these dry out over summer.

4.2.2 Amphibians

Nine species of frogs may occur in the vicinity of the project (Table 1). Of the species expected, the *Litoria, Heleioporus, Limnodynastes* and *Pseudophryne* species rely on wetlands or damp areas for breeding but disperse widely as adults. The Turtle Frog

breeds terrestrially. All species are common in woodland on sandy soils on the northern parts of the Swan Coastal Plain. Additionally, the Motorbike Frog *Litoria moorei* and Slender Tree Frog *Litoria adelaidensis* require more or less permanent water so may be present in nearby wetlands or suburbs (in garden ponds).

One species, *Heleioporus eyrei* was recorded during the site inspection. Numerous individuals were heard calling during the late afternoon and on dusk from seasonal wetlands. During this time period of activity, 12 wetlands were visited and *H. eyrei* was calling at three of the largest and deepest wetlands. These three wetlands comprised a closed sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinal*, with thickets of *Melaleuca rhaphiophylla.* Other wetlands areas such as those containing Melaleuca or Lepidosperma appeared either too small in size or too dry (too high in the landscape) to support frogs.

No species of frog expected within the project area are of listed conservation significance. All frog species expected in the vicinity of the project area are widespread but the fact that *H. eyrei* was restricted to three of 12 wetlands suggest that some frog populations may be locally significant; ie the deeper wetlands within the project area may be locally important for frogs.

4.2.3 Reptiles

A total of 48 species of reptile may occur in the vicinity of the proposed Port Kennedy Business Park (Table 2). Due to its relative small size and homogeneity, the proposed project area is likely to support only a proportion of these species, however adjacent bushland may support a large number of additional species.

Few reptiles of conservation significance are expected to be present. These are described below and summarised in Table 5. The South-West Carpet Python is the only reptile species of high significance (CS1) recorded in the vicinity of the project.

Conservation Significance Level 1 (CS1)

Morelia spilota imbricata **South-west Carpet Python (Sch. 4)**

Listed as Schedule 4 (Specially Protected) under the WA Wildlife Conservation Act and also as Priority 4 by DEC, and is of concern because this subspecies has declined dramatically in the face of urban development and land clearing. *M. s. imbricata* occurs in the south-western of WA, south of a line that runs from approximately Geraldton in the north-west to Eyre in the south-east. It prefers undisturbed bushland and rocky outcrops and is often arboreal. It preys on birds, other reptiles and small to medium sized mammals and requires large areas of bushland to survive. Near Perth the South-west Carpet Python inhabits substantial undisturbed patches of bushland including around Neerabup, Yanchep and on Garden Island (Bush, *et al.* 1995). Large scale development on the Swan Coastal Plain has considerably reduced its numbers in the Perth area (Bush *et. al.* 1995). *Morelia spilota imbricata* is a slow-moving species and is susceptible to vehicle strikes (roadkill) and predation in an urban environment but Dogs, Cats and

Foxes. NatureMap has several records of this species within 10km of the project area, from the Point Peron and the Karnup areas. There is thus some potential for this species to persist in the project area.

Conservation Significance Level 2 (CS2)

Lerista lineata **Perth Lined Lerista (DEC Priority 3)**

Listed as Priority 3 by DEC, and is of concern because this species has a restricted distribution between Busselton and Perth and is virtually confined to the Perth area (DEP, 2000). *Lerista lineata* is found in the southern suburbs and dunes of the Swan coastal Plain, restricted to pale sands supporting heathlands and shrublands, particularly in association with Banksias (Bush, et al., 1995). *Lerista lineata* has been recorded within 5km from the project area from Point Peron and from the adjacent Port Kennedy Scientific Park (DEC, 2010). This species is likely to occur within the proposed project area.

Neelaps calonotos **Black-striped Snake (DEC Priority 3)**

The Black-striped Snake is listed as Priority 3 by the Department of Environment and Conservation. This species is restricted to the west coast region from Cataby south to Mandurah, with an apparently isolated population recorded near Dongara (Bush et al., 2007). *Neelaps calonotos* has been recorded from coastal dunes, sandplains with Heath and Banksia Woodland It is threatened by encroaching land development and appears to be uncommon on the Swan Coastal Plain.

Neelaps calonotos is fossorial and due to its patchy distribution can be difficult to find. The closely related snake *Neelaps bimaculatus* appears to be quite common in the project area with several recorded during the site inspection. *Neelaps calonotos* appears to have similar habitat requirements to more common *Neelaps bimaculatus* and as a result is also likely to occur within the project area.

Ctenotus gemmula **Jewelled Ctenotus (DEC Priority 3)**

The Swan coastal Plain population of the Jewelled Ctenotus is listed as Priority 3 by the Department of Environment and Conservation. This species is scarce on the Swan Coastal Plain, occurring in isolated populations at Cataby and from Wanneroo south to Medina (Storr *et al.,* 1999). *Ctenotus gemmula* inhabits pale soils supporting heathlands, usually in association with banksias (Bush *et al.* 1995) and has been recorded at the margins of damplands (J. Turpin, per obs). This species may occur in the Port Kennedy area and has been recorded from Medina, approximately 14km north of the project area.

Conservation Significance Level 3 (CS3)

Black-headed Tree Goanna	***Varanus tristis***
Gould's Sand Goanna	***Varanus gouldii***
Rosenberg's Goanna	***Varanus rosenbergi***

Species of *Varanus* (Varanids) and *Morelia* (Pythons) have been most severely affected by urban development in the Perth area (DEP, 2000). Varanids and Pythons are large predators that occur at low population densities and thus require large areas of intact vegetation; they are now restricted to a few larger bushland remnants in the Perth area. Perth also represents the northern limit of *Varanus rosenbergi's* distribution.

All three varanid species may occur in the vicinity of the Port Kennedy Business Park project area. *Varanus gouldi* and *V. tristis* have been recorded in the adjacent Rockingham Lakes Regional Park (DEC, 2011).

As a result there is potential for all three species to occur within the proposed project area. The Stimpson's Python (*Antaresia stimsoni*) is considered locally extinct on the Swan Coastal Plain in the Perth area (DEP, 2000).

Western Swamp Egernia	***Lissolepis luctuosa***
Beaked Blind Snake	***Ramphotyphlops waitii***
Keeled Legless-lizard	***Pletholax gracilis***

The above three species also occur in the region at the extremes of their range. The skink *Lissolepis luctuosa* is restricted to dense vegetation surrounding lakes, swamps and rivers, and has declined dramatically due to the draining and reduction of wetland habitat (DEP, 2000). Perth represents the northern limit of this species' range. *Lissolepis luctuosa* may occur within the wetland areas in the project area or may be associated with Lake Walyungup directly to the east of the proposed Port Kennedy Business Park.

Pletholax gracilis is uncommon in the Perth region, inhabiting coastal dunes and sandplain supporting heath and Banksia Woodland (Bush, *et. al.,* 1995). It has been recorded from bushland adjacent to the Rockingham Lakes Regional Park, approximately 10km north of the project area (DEC, 2010) and is likely to occur on site. *Ramphotyphlops waitii* occurs throughout the Darling Range and adjoining coastal plain south to the Armadale area (Bush, *et. al.,* 1995). This species is scarce on the Swan Coastal Plain and is unlikely to occur at Port Kennedy.

4.2.4 Birds

Twenty five bird species were recorded from the proposed project area during the site inspection (see Table 3).

A total of nearly 200 bird species are considered likely to occur in the general region, but due to the small size of the proposed project area and limited habitats present only 122 species are expected to occur as either residents, seasonal or irregular visitors (see Table 3). Several bird species listed under database searches have been excluded from the list of birds expected. Coastal species (such as the Osprey, Terns), Seabirds, Waders, Cormorants, Pelicans and birds requiring large areas of permanent water (such as many ducks, spoonbills) have been omitted from the expected species list. These birds may occasionally fly over the proposed project area but are unlikely to occur within the habitats present. Other birds such as the Emu require large areas of intact vegetation and are almost certainly locally extinct.

Waterbirds will also use seasonal wetlands and cleared areas and after flooding. However, the majority of the waterbirds expected in the area are likely to be restricted to habitats outside the proposed project area such as that associated with the adjacent Lake Walyungup.

Forty-seven of the bird species that may be present are considered to be of conservation significance. Conservation Significant species are described below, with summary information in Table 5. A suite of bird species have been identified as having declined in the Perth area (DEP 2000) and therefore listed as CS3 in this assessment. These species are not formally listed under national or state legalisation, however have been noted as conservation significant due to their local decline. This includes habitat specialists with a reduced distribution on the Swan Coastal Plain and wide-ranging species with reduced populations on the Swan coastal Plain (DEP, 2000). They are dependent upon more or less intact areas of native vegetation in the region. CS3 bird species are also discussed below.

Conservation Significance Level 1 (CS1)

Ardea alba	**Great Egret (EPBC Migratory)**
Ardea ibis	**Cattle Egret (EPBC Migratory)**
Plegadis falcinellus	**Glossy Ibis (EPBC Migratory)**

These three species are all large, Australian breeding waterbirds that are listed as Migratory under the EPBC Act. The Great and Cattle Egrets are also listed as Schedule 3 (JAMBA) under the WA Wildlife Conservation Act. The Great Egret has been recorded from Lake Walyungup and Lake Cooloongup (adjacent to the project area, Birds Australia, 2011). The Cattle Egret and Glossy Ibis may only be infrequent visitors to the

local area as they are uncommon in the South-West. None of the above three species is expected to occur regularly within the habitats present in the project area.

Botaurus poiciloptilus **Australasian Bittern (DEC Schedule 1)**

The Australasian Bittern is listed as Vulnerable under the WA Wildlife Conservation Act. This species frequents reedbeds and dense vegetation in wetlands including lignum and sedges. In Western Australia, the Australasian Bittern is confined to the far south-west. It is known from Thomsons Lake (approximately 25km north) however due to a lack of local records and suitable habitat, this species is unlikely to occur within the project area.

Falco peregrinus **Peregrine Falcon (DEC Schedule 4)**

The Peregrine Falcon is classified as "Specially Protected Fauna" under the Schedule 4 of the Wildlife Conservation Act. This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands. The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predates heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Birds Australia, 2008). The Peregrine Falcon mates for life with pairs maintaining a home range of about 20 -30 km square throughout the year. Blakers et al. (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world.

The Peregrine Falcon is a wide-ranging bird of prey that may be an occasional visitor to the project area. Due to the lack of large hollow-bearing trees this species is unlikely to breed in the proposed project area. This species has been recorded nearby from Point Peron (Birds Australia, 2011).

Calyptorhynchus banksii naso **Forest Red-tailed Black-Cockatoo (EPBC V.)**

Listed as Schedule 1 (Vulnerable) under the WA Wildlife Conservation Act and is of concern because clearing and forestry have reduced the available breeding and feeding habitat. Feral bees and Galahs also compete with *C. b. naso* for nesting hollows. *C. b. naso* occurs in the south-west of Western Australia, approximately south-west of a line between Gingin and the Green Range (near Wellstead, east of Albany). The range of this subspecies is closely tied to the distribution of Marri (*Corymbia calophylla*); the favoured nesting and food tree of *C. b. naso*. *C. b. naso* occurs occasionally on the Swan Coastal Plain, where it is associated with Marri or Pine Plantations (J. Turpin, pers. obs.). This species was recorded flying over the project area (two individuals). Due to the lack of Marri trees within the proposed project area, the Forest Red-tailed Black-Cockatoo is unlikely to breed or forage in the area.

Calyptorhynchus latirostris **Carnaby's (Short-billed) Cockatoo (EPBC E.)**

Listed as Endangered under the EPBC Act and Schedule 1 (Endangered) under the WA Wildlife Conservation Act. *C. latirostris* occurs in the south-west of Western Australia, approximately south-west of a line between the Murchison River (near Kalbarri) and Cape Arid National Park (east of Esperance). Carnaby's Cockatoo has been recorded in

the area from the Rockingham Lakes Regional Park (Birds Australia, 2011) and may be a rare visitor to the project area.

Carnaby's Cockatoo generally breeds in inland areas, moving to cooler, coastal areas for the non-breeding period (late spring to mid-winter). It has recently begun breeding on coastal areas due to loss of inland breeding habitat. Land clearing and degradation has reduced available breeding sites (tree hollows) and fragmented breeding and feeding sites. Feral bees, galahs and corellas out-compete *C. latirostris* for nesting hollows. Illegal trapping and smuggling also threaten this species.

Carnaby's Cockatoo has declined due to loss of breeding habitat in the wheatbelt and of non-breeding habitat along the west coast, partly due to urban expansion. While small areas of foraging habitat around the metropolitan area support only small numbers of birds for short periods of time, the progressive loss of such small areas is an ongoing concern for this species.

Carnaby's Cockatoo is known to feed on seeding *Banksia* and *Eucalyptus* as well as proteaceous heaths (Johnstone and Storr 1998). It will feed on scattered Proteaceae and has been observed extracting grubs from *Jacksonia* sp. (M. Bamford). Loss of feeding habitat is identified as an important contributing factor to the decline of Carnaby's Cockatoo in Garnett and Crowley (2000). Further loss of significant regional feeding habitat may constitute a trigger as a controlled action under the EPBC Act and may require assessment by the DEH. Some areas of feeding habitat (proteaceous heaths) occur including around the fringes of the wetlands however and no breeding habitat (Eucalypt trees) occurs in the project area.

Calyptorhynchus baudinii **Baudin's Cockatoo (EPBC Vulnerable)**

Listed as Vulnerable under the EPBC Act and as Schedule 1 (Endangered) under the WA Wildlife Conservation Act. *C. baudinii* occurs in the deep south-west of Western Australia, approximately south-west of a line between Morangup (near Bullsbrook, north of Perth) and Waychinicup National Park (east of Albany). Birds generally breed in the Karri, Marri and Wandoo forests in the southern parts of the species' range and move north to the Darling Range and Swan Coastal Plain during autumn and winter (non-breeding period). Clearing for agriculture and logging has removed nesting and feeding trees for this species. The species has been recorded in the region but appears to be a vagrant onto the Swan Coastal Plain in the Rockingham area. Baudin's Cockatoo is more frequently found in the Darling Range. It is unlikely to utilise the proposed project area.

Apus pacificus **Fork-tailed Swift (EPBC Migratory)**

Merops ornatus **Rainbow Bee-eater (EPBC Migratory)**

Both these species are listed as Migratory under the EPBC Act. *A. pacificus* breeds in Siberia and the Himalayas and migrates to arrive in Australia in October, returning to the breeding grounds by May or June. Movements within Australia are in response to weather patterns, with this species often following thunderstorms. It is a highly aerial

species that rarely comes to ground. The Fork-tailed Swift is not expected to utilise habitats within the proposed project area.

The Rainbow Bee-eater occurs year-around in the tropics of northern Australia, with a southward migration, to both south-eastern and south-western Australia, in early spring. Southern birds return north in autumn (Johnstone and Storr 1998). It occurs in the better watered parts of Western Australia, between the Kimberley and south-west, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr, 1998). It nests in burrows dug usually at a slight angle in flat ground, gently elevated slopes, sandy banks or cuttings, and often at the margins of roads or tracks. The Rainbow Bee-eater has a very widespread distribution over Australia, wintering in northern Australia and Indonesia, and migrating south during September and October (Johnstone & Storr, 1998).

The Rainbow Bee-eater has been previously recorded at Lake Walyungup (Birds Australia, 2011). When present, *M. ornatus* is common and prominent in natural and altered environments. Breeding is widespread on the Swan Coastal Plain and often occurs on the margins of paddocks. Although a species of high conservation significance, it is abundant and versatile in its selection of nest sites. This species is almost certainly a seasonal (late spring to late summer) breeding visitor to the proposed project area.

Conservation Significance Level 2 (CS2)

Ixobrychus minutus **Little Bittern (DEC Priority 4)**

Listed as Priority 4 by DEC and is of concern because of habitat loss due to salinisation, clearing, grazing, wetland drainage and altered fire regimes. *I. minutus* occurs in south-western Western Australia (south-west of a line between Perth and Albany), in the Kimberley, and along the eastern coast of Australia. This species does occur in the region, with records from the Rockingham Lakes Regional Park (DEC, 2010). However, It is unlikely to occur within the project area regularly because the wetlands are small are retain water for only short periods.

Ixobrychus flavicollis **Black Bittern (SW population, DEC P3)**

The south-west population of the Black Bittern is listed as Priority 3 by DEC. This species roosts and nests in trees and dense vegetation associated with wetlands. Except as a rare vagrant, the Black Bittern is unlikely to occur within the project area due to a lack of suitable habitat.

Tyto novaehollandiae novaehollandiae **Masked Owl (southern population, P3)**

Listed as Priority 3 by DEC and is of concern because the population and range of this subspecies has declined dramatically as a result of habitat clearing. *T. n. novaehollandiae* occurs in the deeper south-west of Western Australia, with recent surveys (see Garnett and Crowley 2000) recording birds only from the area between Margaret River and

Manjimup. The range of *T. n. novaehollandiae* formerly extended from Carnarvon to the Nullarbor. Three other subspecies are recognised within Australia, with only *T. n. kimberli* (listed as Vulnerable under the EPBC Act and as Priority 1 by DEC) occurring elsewhere in Western Australia (Kimberley region). There is a recent record of this species from near Mandurah (Birds Australia, 2011) and this species may be a rare visitor to the project area, but it is unlikely to be dependent on habitat within the proposed project area.

Ninox connivens connivens **Southern Barking Owl (DEC Priority 2)**

The southern population of the Barking Owl is listed as Priority 2 by DEC. The Barking Owl primarily occurs in dry sclerophyll woodland, particularly that associated with riparian vegetation in the south-west (Johnstone and Storr, 1998). The range of the Barking Owl has declined by over 50% (Garnett and Crowley, 200) as a result of land clearing. This species nests within hollows in large eucalypts (Garnett and Crowley, 2000). The Southern Barking Owl is restricted to the far south-west in Western Australia, with scattered records around the Perth region including from Pinjar, Wanneroo and Carmel (Birds Australia, 2010). This species may be a rare visitor to the project area, however is unlikely to be dependent on habitat within the proposed project area.

Conservation Significance Level 3 (CS3)

Declining Birds on the Swan Coastal Plain

A number of bird species have been identified by the WA Department of Environmental Protection (DEP, 2000) as having declined in the Perth area due to impacts associated with urban development. A few of these are birds of prey, but the majority are small birds that rely on woodlands and shrublands where they are either residents (eg. fairy-wrens and thornbills) or seasonal visitors (honeyeaters). The fairy-wrens and thornbills are particularly sensitive to habitat loss and fragmentation, whereas the honeyeaters have a greater ability to access suitable habitat even when it is fragmented by urban development. The majority of the species listed by the DEP (2000) are also noted as having declined Australia-wide by more than 20% in the New Atlas of Australian Birds (Barrett et al. 2003). The species listed as CS3 likely to occur in the project area are listed in Table A.

Seven of these CS3 species were recorded during the site inspection – Brown Goshawk, Common Bronzewing, Splendid Fairy-wren, White-browed Scrub-wren, Inland Thornbill, Western Thornbill and White-cheeked Honeyeater. The fairy-wren species, the White-browed Scrub-wren, Thornbills and the robins are all sedentary species that have poor powers of dispersal and thus rely upon continuity of habitat to persist. As a result the proposed project area may support some small but locally significant populations of these species.

Table A. Twenty-eight CS3 Bird species expected in the project area. These species are listed as declining in the Perth region by DEP (2000).

Species recorded at during the site inspection are listed with an asterisk. Species recorded in local area by Birds Australia (BA or at Rockingham Lakes Regional Park) are also listed.

Square-tailed Kite (RLRP)	Splendid Fairy-wren*	New Holland Honeyeater (RLRP)
Whistling Kite (RLRP)	Southern Emu-wren	Tawny-crowned Honeyeater (BA)
Brown Goshawk*	White-browed Scrub-wren*	Scarlet Robin (RLRP)
Collared Sparrowhawk (RLRP)	Inland Thornbill*	Hooded Robin (BA)
Wedge-tailed Eagle (RLRP)	Western Thornbill*	White-breasted Robin
Little Eagle (RLRP)	Yellow-rumped Thornbill (RLRP)	Golden Whistler (RLRP)
Brown Falcon (RLRP)	Western Wattlebird (RLRP)	Grey Shrike-thrush (RLRP)
Painted Button-quail (BA)	White-cheeked Honeyeater*	Black-faced Woodswallow (BA)
Common Bronzewing*	Western Spinebill (BA)	Dusky Woodswallow (BA)
Brush Bronzewing		

4.2.5 Mammals

A total of 26 mammal species is considered likely to occur in the general region, comprising 20 native and six introduced species. However, due to the extent of land clearance coupled with the small size of the proposed project area with limited habitats present many of these species may no longer occur in the Port Kennedy area bt have been included in the species list (see Table 4).

Several ground dwelling terrestrial mammal species found in the region have been recorded in the adjacent Rockingham Lakes Regional Park. These are:

1. Western Grey Kangaroo (*Macropus fuliginosus*);
2. Brush Wallaby (*Macropus irma*);
3. Southern Brown Bandicoot (*Isoodon obesulus*);
4. Bush Rat (*Rattus fuscipes*); and
5. Echidna (*Tachyglossus aculeatus*).

These species are expected to utilise the proposed project area. Additionally, the Common Brushtail Possum may occasionally move through the area from larger adjacent remnants of native vegetation.

Two native mammal species, the Quenda or Southern Brown Bandicoot and the Western Grey Kangaroo, were recorded during the site inspection. Three Western Grey Kangaroos were observed and Kangaroo tracks were commonly encountered throughout the project area. The Quenda was recorded from tracks, diggings and also one individual was recorded on the motion sensitive camera (see Plates 1 – 3). All evidence of the Quenda was within or on the margins of wetlands on the western side of the project area. It is likely that the local Quenda population is restricted to this area in the wetland habitats.

The Bush Rat is considered likely to occur within the project area. This species has been recorded in the adjacent Rockingham Lakes Regional Park and inhabits sedgeland of *Lepidosperma longitudinale* in dune swales on the Swan Coastal Plain (J. Turpin, pers obs.). Additionally two introduced species, the feral cat and dog were, recorded and are likely to be household pets from neighbouring residents.

Conservation significant mammal species that may be present are outlined below, with a summary of conservation status and impacts in Table 5. A number of other species are locally extinct and are not considered here (eg. Quokka, Common Ringtail Possum, Numbat).

Conservation Significance Level 1 (CS1)

Dasyurus geoffroii **Chuditch (EPBC Vulnerable)**

The Chuditch is listed as Vulnerable under the EPBC Act and Schedule 1 (Vulnerable) under the WA Wildlife Conservation Act. It currently survives only in south-western

Western Australia, in areas dominated by eucalypt forest or woodland and mallee shrubland (Strahan, 1995) and also persists amongst rocky outcrops. Habitat alteration through clearing, grazing and changed fire regimes, competition with foxes and cats for food, predation by foxes, hunting, and poisoning all threaten *D. geoffroii*. This species occupies large home ranges, is highly mobile and appears able to utilise bush remnants and corridors (DEC, 2008).

The Chuditch is effectively extinct on the Swan Costal Plain in the Perth area but vagrants occasionally occur. This species is unlikely to occur within the project area.

Conservation Significance Level 2 (CS2)

Isoodon obesulus fusciventer **Southern Brown Bandicoot/ Quenda, P5**

The Quenda is listed as Priority 5 by DEC and has declined on the Swan Coastal Plain. The Southern Brown Bandicoot occurs in the south-west of Western Australia north to Yanchep and Gingin, south to Albany and east to Esperance. This species previously occurred north to Moore River but like many mammals in the region has undergone a large range reduction (Maxwell *et al.* 1996). On the Swan Coastal Plain it is patchily distributed as a result of land clearance, habitat degradation and feral predators, and often occurs in small and fragmented populations (DEC, 2008). It is commonly associated with dense, low vegetation.

Plate 1: Quenda recorded from the proposed project area on a motion sensitive camera.

The Southern Brown Bandicoot was recorded from the project area. One individual was recorded on the motion sensitive camera (see Plate 1), from the edge of one of the larger wetland areas supporting dense sedgeland. Numerous Quenda diggings and tracks were also recorded within or on the margins of most wetlands on the western margin of the project area (see Plates 2 and 4). The Quenda may occur throughout the project area however the local population is likely to be concentrated within the wetland habitat. The Closed Sedgeland of *Baumea juncea, B. articulata* and / or *Ficinia nodosa* and

Lepidosperma longitudinale is a favoured habitat of this species and is expected to support the highest densities of Quenda in the project area.

Plate 2: Quenda diggings recorded from the proposed project area.

Plate 3: Quenda tracks recorded from the proposed project area.

Macropus irma **Brush Wallaby (DEC Priority 4)**

The Brush Wallaby is listed as Priority 4 by DEC. This species occurs in south-western Australia, from Kalbarri to Cape Arid. The Western Brush Wallaby formerly occurred over a much larger area however has suffered a large range reduction and fragmentation of populations due to clearing for agriculture and predation by introduced predators (DEC, 2008). The optimum habitat for the Western Brush Wallaby is open forest or

woodland, in which it favours open, seasonally wet flats with low grasses and open, scrubby thickets (Strahan, 1995), and areas of dense vegetation. It is also found in mallee and heathland (DEC, 2008). The Brush Wallaby occurs in native vegetation on the outskirts of Perth, including the Yanchep and Jandakot areas (BCE records). This species has also been recorded from Rockingham Lakes Regional Park, from Lake Cooloongup and the adjacent bushland (DEC, 2011) and individuals may occasionally move through the project area.

Falsistrellus mackenziei **Western False Pipistrelle (DEC P4)**

Listed as Priority 4 by DEC. *F. mackenziei* occurs in the wet sclerophyll and higher rainfall areas of dry sclerophyll forest in the south-west of Western Australia. Pipistrelle is normally associated with forest (Strahan 1995) but there is a recent record from woodland near Jandakot (Hosken and O'Shea 1994). This species is unlikely to be dependent on habitat within the project area.

Hydromys chrysogaster **Water Rat, Rakali (DEC Priority 4)**

Listed as Priority 4 by DEC and is of concern because the species' population is in decline, particularly along rivers affected by salinity or degradation. In Western Australia, *H. chrysogaster* occurs in the south-west, along parts of the Pilbara coast (including some islands) and in the Kimberley. It also occurs throughout northern and eastern Australia. The distribution of this species is very patchy on the Swan Coastal Plain with records from Kwinana, Thomsons Lake Nature Reserve, Medina and the Peel Inlet (DEC, 2008). At Port Kennedy this species may occur in and around adjacent wetlands and could be an occasional visitor to wetlands within the project area.

Conservation Significance Level 3 (CS3)

Sminthopsis griseoventer Grey-bellied Dunnart

S. griseoventer is not listed as a threatened or priority species and is moderately common in suitable habitat north of Perth, but it appears to be locally extinct on the Coastal Plain south of Perth (Bamford, 2008, unpublished), with no recent records from this area. Therefore, a surviving population would be locally significant. Studies from Port Kennedy Scientific Park recorded a Dunnart species which may have been *Sminthopsis griseoventer* (DEC, 2010).

Cercartetus concinnus Western Pygmy-Possum

C. concinnus is not listed as a threatened or priority species and is moderately common in suitable habitat throughout southern Australia. This species is listed as CS3, because the Swan Coastal Plain population has declined and is now fragmented.

There are no recent records of this species near the Port Kennedy area and as a result the Western Pygmy-possum is considered unlikely to occur within the project area. This species has been recorded from the Mandurah area (DEC, 2011).

Tarsipes rostratus Honey Possum

T. rostratus is not listed as a threatened or priority species and is common to abundant in suitable habitat in south-western Western Australia. This species is listed as CS3 because the Swan Coastal Plain population has declined and is now fragmented. *T. rostratus* is an obligate nectarivore and can only survive in areas that support a diverse range of nectar producing plants that ensure a year-around supply of food. There are no recent records of this species in the local area and due to a lack of suitable habitat this species is not expected to occur in the project area.

Rattus fuscipes Western Bush Rat (Moodit)

In Western Australia, the Bush Rat occurs in coastal and near coastal areas from Jurien Bay south-east to Point Dempster (WAM, 2008). This species inhabits forest, woodland, coastal thickets and sedgelands (Strahan, 1995). *R. fuscipes* is not listed as a threatened or priority species and is moderately common to common in suitable near-coastal habitat throughout southern and eastern Australia. This species is listed as CS3 because the Swan Coastal Plain population has declined and is now fragmented.

The Bush Rat is considered likely to occur within the project area. This species has been recorded in the adjacent Rockingham Lakes Regional Park, from Point Peron and also Port Kennedy Scientific Park (DEC, 2011). The Bush Rat inhabits sedgeland of *Lepidosperma longitudinale* in dune swales on the Swan Coastal Plain (J. Turpin, pers obs.), a habitat occurring within the project area.

Trichosurus vulpecula vulpecula Common Brushtail Possum

The Common Brushtail Possum has undergone a significant reduction in distribution in Western Australia, and the Midwest in particular (How and Hilcox 2000). In Western Australia it is now generally confined to the temperate south-west, Kimberley and Pilbara coast. This species inhabits a range of habitats including forests and woodlands containing large hollow bearing trees and ground refuges (such as hollow logs, DEC, 2008). The Common Brushtail Possum occurs patchily on the Swan Coastal Plain but due to the lack of hollow bearing trees is unlikely to rely on habitats within the project area. However, it may move through the project area as it occurs in adjacent bushland including from Rockingham DEC, (2011), and Paganoni Rd Bushland (DEC, 2011).

Pseudomys albocinereus Noodji or Ashy-grey Mouse

The Ash-grey Mouse has declined in the Perth region due to the loss of habitat and is now probably extinct south of the Gnangara region (M. Bamford pers. obs). There are no recent records of this species on the Swan Coastal Plain south of the Swan River. As a result the Ash-grey Mouse is considered unlikely to occur within the project area.

4.2.6 Short-range Endemic Invertebrates

Invertebrates in general are beyond the scope of assessment for environmental impact assessment because there are so many species and their taxonomy is so poorly understood, but it is possible to focus on a small range of taxa that are short-range endemics. Harvey (2002) notes that the majority of invertebrate species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Schizomida (schizomids; spider-like arachnids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish).

Significant species are discussed below:

Conservation Significance Level 1

- Graceful Sunmoth (*Symenon grantiosa*, Castniidae). **EPBC Endangered,** Schedule 1 (Endangered) of the WA Act. The Graceful Sun-Moth *Synemon gratiosa* (Castniidae) is noted as occurring in few locations from Yanchep south to Mandurah and to be threatened by land clearing. This species inhabits *Lomandra maritima* on coastal dunes and *Lomandra hermaphrodita* within Banksia Woodland and Heath. The Graceful Sunmoth has been recorded patchily on the Swam Coastal Plain from several areas of remnant vegetation. It was recorded in the project area during surveys conducted by Emerge Associates in March 2011.
- *Leioproctus douglasiellus* (Native Bee). Schedule 1. This species is known only from a few records on the Swan Coastal Plain including from Pearce, Forrestdale Lake Nature Reserve and Brixton Street Wetlands. It has been collected from flowers of *Goodenia filiformis* and *Anthotium junciforme*.

Conservation Significance Level 2

- *Austrosaga spinifer* (a cricket) Priority 3. Recorded from heathlands between Perth and Cervantes, but the nature of these heathlands is not known.
- *Hyaleus globuliferus* (Native Bee) Priority 3. Forages on the flowers of Woollybush *Adenanthos cygnorum* and some other species. No *Adenanthos* species were observed during the site inspection.
- *Leioproctus contrarius* (Native Bee) Priority 3. Apparently dependent upon flowers of Goodeniaceae and known from Banksia woodlands. Recent surveys have shown that it is more widespread that previously thought. This species has been recorded at Forrestdale and Murdoch however there are no local records near Port Kennedy.
- *Leioproctus bilobatus* (Native Bee) Priority 2. This species is known only from a few records on the Swan Coastal Plain however there are no local records near Port Kennedy.
- the cricket *Throscodectes xiphos* (Priority 1). Associated with Banksia Woodland which is absent from the proposed project area.

The Graceful Sunmoth (CS1) has been recorded within the project area and due the extensive amount of favourable habitat (coupled with land clearance in the region) a significant local population may occur. Liaison with the DEC is highly recommended.

While the Graceful Sunmoth has been recorded within the project area, no other threatened invertebrate species have been recorded on DEC's NatureMap database within 20km of the project area. However due to large scale clearing in the area remnant vegetation is small, isolated and fragmented within a regional context. As a result a number of invertebrate species occurring within the proposed Port Kennedy Business Park project area may exhibit restricted ranges.

5. DISCUSSION

Due to widespread vegetation clearing in the region, few areas of intact native vegetation remain. As a result, intact native vegetation in the Port Kennedy area is of local importance to fauna and provides habitat for some species of conservation significance. Significant habitats and species of conservation significance are summarized below (see also Table 5). Impacts upon fauna due to the construction and operation of the project are discussed in a separate report.

5.1 Habitat Types

Habitats of conservation significance tend to be those that are both rare across the landscape and that are important for significant species and/or for biodiversity. Due to the extensive clearing in the region, all remaining native vegetation is likely to be of value to fauna and support isolated and fragmented faunal populations. However, while two broad fauna habitats were recorded from the project area one habitat is considered of high conservation significance:

- Sedgelands in Holocene Dune Swales of the southern Swan Coastal Plain.

The Sedgelands in Holocene Dune Swales have a highly restricted distribution on the Swan Coastal Plain. Within the project area they are restricted to small areas mostly concentrated on the western margin of the site (see Figure 6). A total of 22 wetlands (equivalent to the sedgeland habitat) have been recorded from the project area comprising sumplands and damplands.

The sedgeland (wetland) areas are a highly significant fauna habitat supporting species of conservation significance, restricted fauna and breeding populations of amphibians. The conservation significant Quenda (DEC Priority 4) was recorded from several wetland areas. The Closed Sedgeland of *Baumea juncea, B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale* is a favoured habitat of this species and is expected to support the highest densities of Quenda in the project area.

Additionally several CS3 bird species are expected to be dependant on the wetland habitat including the White-browed Scrubwren and Splendid Fairy-wren. The conservation significant Carpet Python and *Ctenotus gemmula* may also occur within this habitat. The low lying wetland areas also contain some Proteaceae species which may also be suitable foraging habitat for the Short-billed Cockatoo.

Many additional fauna species (particularly invertebrates) may be restricted to this fauna habitat. As a result of the restricted range of the habitat, fauna dependant on the habitat may have very localised distributions.

Three of the largest wetland areas also support breeding populations *H. eyrei* (see Figure 6). These three wetlands comprised a closed sedgeland of *Baumea juncea*, *B. articulata* and / or *Ficinia nodosa* and *Lepidosperma longitudinale*. The species was only recorded from the larger wetlands (and therefore largest areas of sedgeland) in the deepest swales with the densest sedgeland. These wetlands are likely to be better suited to the frog's ecology which requires seasonal inundation of burrows for breeding (WAM, 2011). Other wetlands areas such as those containing *Melaleuca* or *Lepidosperma* appeared either too small in size or too dry (too high in the landscape) to support frogs.

The Sedgelands in Holocene Dune Swales are listed as Endangered under the EPBC Act and are a significant fauna habitat. Disturbances to this habitat should be avoided. DEC policy recommends a minimum buffer of 50m around wetlands (RPS, 2006). Since several conservation significant fauna species occur in the wetland habitats (eg. Quenda, Bush Rat, Splendid Fairy-wren, White-browed Scrubwren) impacts to such fauna will be reduced if the wetland areas are retained.

Figure 6. Mapped Wetlands within the Project Area (circled green, source: RPS, 2006). Wetlands where the Quenda (Q) or *Heleioporus eyrei* (H) were recorded are noted.

5.2 Significant species

Forty-seven conservation significant species may occur within the proposed Port Kennedy Business Park Project Area. Eight Conservation Significant Fauna species were recorded and include:

1. Forest Red-tailed Black Cockatoo (CS1 – flying overhead, unlikely to depend on habitats within project area)
2. Quenda or Southern Brown Bandicoot (CS2 – DEC Priority listed)
3. Brown Goshawk (CS3 – DEP declining species)
4. Common Bronzewing (CS3 – DEP declining species)
5. Splendid Fairy-wren (CS3 – DEP declining species)
6. Inland Thornbill (CS3 – DEP declining species)
7. Western Thornbill (CS3 – DEP declining species)
8. White-browed Scrubwren (CS3 – DEP declining species)
9. White-cheeked Honeyeater (CS3 – DEP declining species)

An additional 28 species are considered likely to occur within the proposed Port Kennedy Business Park or utilise a home range that includes the Project Area. These include eight reptile, 18 bird and two mammal species as listed below. Species marked with an asterisk (*) have been recorded from adjacent remnant vegetation. The reptiles may all be resident species while several of the bird species would be expected as occasional visitors. Some CS3 species such as the White-breasted Robin and Bush Rat are likely to occur as a resident population.

<u>Reptiles</u>

1. *Carpet Python (*Morelia imbricata*, CS1, potential resident)
2. *Perth Lined Lerista (*Lerista lineata*, CS2, likely resident)
3. Black-striped Snake (*Neelaps calonotus*, CS2, likely resident)
4. Jewelled Ctenotus (*Ctenotus gemmula*, CS2, likely resident)
5. *Black-headed Tree Goanna (*Varanus tristis*, CS3, likely resident)
6. *Gould's Sand Goanna (*Varanus gouldii*, CS3, likely resident)
7. Rosenberg's Goanna (*Varanus rosenbergi*, CS3, likely resident)
8. Keeled Legless-lizard (*Pletholax gracilis*, CS3, likely resident)

<u>Birds</u>

1. *Carnaby's Cockatoo (*Calyptorhynchus latirostris*, CS1, likely visitor)
2. *Peregrine Falcon (*Falco peregrinus*, CS1, likely visitor)
3. *Rainbow Bee-eater (*Merops ornatus*, CS1, likely visitor)
4. Fork-tailed Swift (*Apus pacificus*, CS1: rare aerial visitor)
5. *Scarlet Robin (*Petroica multicolour*, CS3, likely visitor)
6. Golden Whistler (*Pachycephala pectoralis*, CS3, likely resident)
7. Grey Shrike-thrush (*Colluricincla harmonica*, CS3, likely resident)

8. Square-tailed Kite (*Lophoictinia isura*, CS3, occasional visitor)
9. Whistling Kite (*Haliastur sphenurus*, CS3, occasional visitor)
10. Collared Sparrowhawk (*Accipiter cirrhocephalus*, CC3, likely visitor)
11. Wedge-tailed Eagle (*Aquila audax*, CS3, occasional visitor)
12. Little Eagle (*Hieraaetus morphnoides*, CS3, occasional visitor)
13. *Brown Falcon (*Falco berigora*, CS3, occasional visitor)
14. Painted Button-quail (*Turnix varia*, CS3, occasional visitor)
15. Western Wattlebird (*Anthochaera lunulata*, CS3, likely visitor)
16. New Holland Honeyeater (*Phylidonyris novaehollandiae*, CS3, likely resident)
17. Tawny-crowned Honeyeater (*Phylidonyris melanops*, CS3, likely visitor)
18. Black-faced Woodswallow (*Artamus cinereus*, CS3, likely visitor)
19. Additionally conservation significant waterbird species may occur in adjacent habitats or during seasonal flooding of the site.

Mammals

1. Bush Rat (*Rattus fuscipes*, CS3, likely resident)
2. Brush Wallaby (*Macropus irma*, CS2, occasional visitor)

The majority of the CS3 species listed above are described as declining and surviving in small and fragmented populations on the Swan Coastal Plain (DEP, 2000).

The DEC Priority listed Quenda occurs within the project area. This species was recorded from wetland habitat (see Figure 6). The CS1 Carnaby's Black-Cockatoo may occasionally forage within wetland habitat and proteaceous heaths. This species is able to utilise even small remnants on the Swan Coastal Plain.

Several of the above conservation significant fauna occur in the wetland habitats (eg. Quenda, Bush Rat, Splendid Fairy-wren, White-browed Scrubwren). As a result, impacts to such fauna will be reduced if the wetland areas are retained.

Many of the conservation significant bird species likely to occur in the area occupy large home ranges, with the project area forming a small component of the overall foraging range of several species (such as the Peregrine Falcon, Carnaby's Cockatoo, Rainbow Bee-eater). Impacts to such species associated with the proposal are considered to be minimal.

Impacts are likely to be greater to those species residing within the project area. Such species include the Quenda, Bush Rat, possibly the Carpet Python, DEC Priority listed Perth Lined Lerista and Jewelled Ctenotus, Varanid species, Keeled Legless-lizard, Brush Wallaby and several resident CS3 bird species (Fairy-wrens, Thornbills, Honeyeaters and White-browed Scrubwren). The exact disturbance footprint is not known however should be minimised to minimise the disturbance on such species.

5.2.1 EPBC Species

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) the Short-billed Black Cockatoo (Carnaby's Black-Cockatoo) is listed as Endangered, the Forest Red-tailed Black-Cockatoo is listed as Vulnerable and the Rainbow Bee-eater is listed as Migratory. A number of EPBC Act Policy Statements have been released by the Federal Government including "Policy Statement 1.1: Significant Impact Guidelines" The purpose of this Policy Statement is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the Australian Government under the EPBC Act. The guidelines contain "Significant Impact Criteria" for each matter of national environmental significance.

The Forest Red-tailed Black-Cockatoo was recorded flying overhead during the site inspection. Due to a lack of suitable habitat this species is not expected to depend on habitats found within the project area. The Carnaby's Black-Cockatoo may be a rare visitor to the site as small areas of foraging habitat occur, mostly on the fringes of the wetlands. However there are no areas of breeding habitat (tree hollows in Eucalypts) for either Cockatoo species present within the project area. If the wetland areas are retained the impacts on the Carnaby's Black-Cockatoo is expected to be reduced.

TABLE 1. Frogs Recorded or Expected in the vicinity of the project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Species		Status	RLRP	PK SP	DEC	Port Kennedy BP
HYLIDAE (Tree frogs)						
Litoria adelaidensis	Slender Tree Frog		X		X	
Litoria moorei	Motorbike Frog		X		X	
MYOBATRACHIDAE (Ground frogs)						
Heleioporus eyrei	Moaning Frog		X		X	X
Heleioporus psammophilus	Sand Frog		X			
Limnodynastes dorsalis	Banjo Frog		X		X	
Crinia glauerti	Glauert's Froglet		X		X	
Crinia insignifera	Squelching Froglet		X		X	
Myobatrachus gouldii	Turtle Frog					
Pseudophryne guentheri	Günther's Toadlet					
Number of Species Expected: 9						
Number of Species Recorded: 1			**7**	**0**	**6**	**1**

TABLE 2. Reptiles Recorded or Expected in the vicinity of the project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Species		Status	RL RP	PK SP	DEC	Port Kennedy BP
Chelidae (freshwater tortoises)						
Long-necked Tortoise	*Chelodina oblonga*				**X**	
Gekkonidae (geckoes)						
Marbled Gecko	*Christinus marmoratus*		**X**		**X**	
White-spotted Ground Gecko	*Diplodactylus alboguttatus*					
Spiny-tailed Gecko	*Strophurus spinigerus*		**X**			
Pygopodidae (legless lizards)						
Sandplain Worm Lizard	*Aprasia repens*				**X**	
Fraser's Legless Lizard	*Delma fraseri*					
Grey's Legless Lizard	*Delma greyii*					
Burton's Legless Lizard	*Lialis burtonis*		**X**		**X**	
Keeled Legless-lizard	*Pletholax gracilis*	**CS3**				
Common Scaleyfoot	*Pygopus lepidopodus*					
Agamidae (dragon lizards)						
Sandhill Dragon	*Ctenophorus adelaidensis*			**X**		
Western Bearded Dragon	*Pogona minor*		**X**			
Varanidae (monitors or goannas)						
Gould's Sand Goanna	*Varanus gouldii*	**CS3**	**X**		**X**	
Rosenberg's Goanna	*Varanus rosenbergi*	**CS3**				
Black-headed Tree Goanna	*Varanus tristis*	**CS3**	**X**			
Scincidae (skink lizards)						
South-West Cool Skink	*Acritoscincus trilineatum*		**X**			
Fence Skink	*Cryptoblepharus buchananii*		**X**			
Western Ctenotus	*Ctenotus australis*				**X**	
West coast Ctenotus	*Ctenotus fallens*					
Jewelled Ctenotus	*Ctenotus gemmula*	**CS2**				
South-west Odd-striped Ctenotus	*Ctenotus impar*					
Western Slender Blue-tongue	*Cyclodomorphus celatus*					
King's Skink	*Egernia kingii*		**X**		**X**	
Western Swamp Egernia	*Lissolepis luctuosa*	**CS3**				
Salmon-bellied Skink	*Egernia napoleonis*					
Two-toed Earless Skink	*Hemiergis quadrilineata*		**X**		**X**	**X**
West Coast Four-toed Lerista	*Lerista elegans*				**X**	
Perth Lined Lerista	*Lerista lineata*	**CS2**	**X**	**X**	**X**	

Species	Status	RL RP	PK SP	DEC	Port Kennedy BP
Western Worm Lizard *Lerista praepedita*		X			
Dwarf Skink *Menetia greyii*		X		X	
Western pale-flecked Morethia *Morethia lineoocellata*		X			
Southern pale-flecked Morethia *Morethia obscura*		X			
Western Blue-tongue *Tiliqua occipitalis*					
Bobtail *Tiliqua rugosa*		X		X	
Typhlopidae (blind snakes)					
Southern Blind Snake *Ramphotyphlops australis*		X		X	
Beaked Blind Snake *Ramphotyphlops waitii*	**CS3**				
Boidae (pythons)					
South-West Carpet Python *Morelia spilota imbricata*	**CS1**	X	X	X	
Elapidae (front-fanged snakes)					
Narrow Banded Snake *Brachyurophis fasciolata*					
Southern Half-girdled Snake *Brachyurophis semifasciatus*		X		X	
Yellow-faced Whipsnake *Demansia psammophis*				X	
Bardick *Echiopsis curta*					
Crowned Snake *Elapognathus coronatus*				X	
Black-naped Snake *Neelaps bimaculatus*					X
Black-striped Snake *Neelaps calonotos*	**CS2**	X		X	
Tiger Snake *Notechis scutatus*		X		X	
Dugite *Pseudonaja affinis*		X		X	X
Gould's Snake *Parasuta(Rhinoplocephalus) gouldii*				X	
Jan's Bandy-Bandy *Simoselaps(Vermicella) bertholdi*				X	X
Total Number of species expected: 48		**22**	**3**	**22**	**4**

TABLE 3. Birds Recorded or Expected in the vicinity of the Project area.
Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer), BA (Birds Australia database - project area plus 10km buffer, denoted by B). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park). Species for which no suitable habitat is present are excluded.

Species		Status	DEC / BA	RLRP	PK SP	Port Kennedy BP
Phasianidae (pheasants and quails)						
Brown Quail	*Coturnix ypsilophora*		B			
Stubble Quail	*Coturnix pectoralis*		B			
Anatidae (ducks, geese and swans)						
Australian Shelduck	*Tadorna tadornoides* [w]		X			
Pacific Black Duck	*Anas superciliosus* [w]		X	X		
Grey Teal	*Anas gibberifrons* [w]		X	X		
Ardeidae (herons and egrets)						
White-faced Heron	*Egretta novaehollandiae* [w]		X	X		
Little Egret	*Egretta garzetta* [w]		B			
White-necked Heron	*Ardea pacifica* [w]		B			
Eastern Great Egret	*Egretta alba* [w]	CS1	X	X		
Cattle Egret	*Ardea ibis* [w]	CS1	B			
Nankeen Night Heron	*Nycticorax caledonicus* [w]	CS3	B			
Little Bittern	*Ixobrychus minutus* [w]	CS2	B	X		
Black Bittern	*Ixobrychus flavicollis* [w]	CS3				
Australasian Bittern	*Botaurus poiciloptilus* [w]	CS1		X		
Plataleidae (ibis and spoonbills)						
Glossy Ibis	*Plegadis falcinellus* [w]	CS1	B			
Australian White Ibis	*Threskiornis molucca*		B	X		
Straw-necked Ibis	*Threskiornis spinicollis*		B			
Accipitridae (kites, hawks and eagles)						
Black-shouldered Kite	*Elanus notatus*		B			
Square-tailed Kite	*Lophoictinia isura*	CS3	B			
Whistling Kite	*Haliastur sphenurus*	CS3	X			
Swamp Harrier	*Circus approximans*		X	X		
Spotted Harrier	*Circus assimilis*		B		X	
Brown Goshawk	*Accipiter fasciatus*	CS3	X			**X**
Collared Sparrowhawk	*Accipiter cirrhocephalus*	CS3	B			
Wedge-tailed Eagle	*Aquila audax*	CS3	X			
Little Eagle	*Hieraaetus morphnoides*	CS3	X			
Falconidae (falcons)						
Peregrine Falcon	*Falco peregrinus*	CS1	B	X		
Australian Hobby	*Falco longipennis*		B		X	

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Brown Falcon	*Falco berigora*	CS3	B			
Nankeen Kestrel	*Falco cenchroides*		X		X	
Turnicidae (button-quails)						
Painted Button-quail	*Turnix varia*	CS3				
Rallidae (crakes and rails)						
Buff-banded Rail	*Rallus philippensis* [w]		B			
Baillon's Crake	*Porzana pusilla* [w]		B			
Spotless Crake	*Porzana tabuensis* [w]		B			
Australian Crake	*Porzana fluminea* [w]		B			
Dusky Moorhen	*Gallinula tenebrosa* [w]	CS3				
Purple Swamphen	*Porphyrio porphyrio* [w]		B			
Eurasian Coot	*Fulica atra* [w]			X		
Charadriidae (lapwings and plovers)						
Banded Lapwing	*Vanellus tricolor*		X			
Laridae (Skuas, gulls, terns and allies)						
Silver Gull	*Larus novaehollandiae* [w]		X			**X**
Columbidae (pigeons and doves)						
Rock Dove	*Columba livia*	INT	B			**X**
Laughing Turtle-Dove	*Streptopelia senegalensis*	INT	B		X	**X**
Spotted Turtle-Dove	*Streptopelia chinensis*	INT	B			
Common Bronzewing	*Phaps chalcoptera*	CS3	X			**X**
Brush Bronzewing	*Phaps elegans*	CS3	B			
Crested Pigeon	*Ocyphaps lophotes*		B			
Cacatuidae (cockatoos)						
Forest Red-tailed Black-Cockatoo	*Calyptorhynchus banksia naso*	CS1	B			**X**
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	CS1	B	X		
Baudin's Black-Cockatoo	*Calyptorhynchus baudinii*	CS1	B			
Galah	*Cacatua roseicapilla*		X			
Little Corella	*Cacatua sanguinea*		B			**X**
Long-billed Corella	*Cacatua tenuirostris*	INT	B			
Psittacidae (lorikeets and parrots)						
Rainbow Lorikeet	*Trichoglossus haematodus*	INT	B			
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*		B			
Regent Parrot	*Polytelis anthopeplus*		B			
Red-capped Parrot	*Purpureicephalus spurius*		X		X	
Australian Ringneck	*Barnardius zonarius*		X			
Elegant Parrot	*Neophema elegans*		B			
Cuculidae (cuckoos)						
Pallid Cuckoo	*Cuculus pallidus*		B			
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*		X			**X**
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		B			
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		X			

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Strigidae (hawk-owls)						
Barking Owl	*Ninox connivens*	CS2				
Southern Boobook Owl	*Ninox novaeseelandiae*		B			
Tytonidae (barn owls)						
Masked Owl	*Tyto novaehollandiae*	CS2	B			
Barn Owl	*Tyto alba*		B			
Podargidae (frogmouths)						
Tawny Frogmouth	*Podargus strigoides*		B			
Caprimulgidae (nightjars)						
Spotted Nightjar	*Eurostopodus argus*		B			
Aegothelidae (owlet-nightjars)						
Australian Owlet-nightjar	*Aegotheles cristatus*		B			
Apodidae (swifts)						
Fork-tailed Swift	*Apus pacificus*	CS1	B			
Halcyonidae (forest kingfishers)						
Laughing Kookaburra	*Dacelo novaeguineae*	INT	X			
Sacred Kingfisher	*Todiramphus sanctus*		B			
Meropidae (bee-eaters)						
Rainbow Bee-eater	*Merops ornatus*	CS1	X			
Maluridae (fairy-wrens)						
Southern Emu-wren	*Stipiturus malachurus*	CS3	B			
Splendid Fairy-wren	*Malurus splendens*	CS3	X		X	**X**
Pardalotidae (pardalotes)						
Spotted Pardalote	*Pardalotus punctatus*		X			
Striated Pardalote	*Pardalotus striatus*		X			
White-browed Scrubwren	*Sericornis frontalis*	CS3	X		X	**X**
Western Gerygone	*Gerygone fusca*		X			**X**
Weebill	*Smicrornis brevirostris*	CS3	X			
Inland Thornbill	*Acanthiza apicalis*	CS3	X		X	**X**
Western Thornbill	*Acanthiza inornata*	CS3	B			**X**
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	CS3	B			
Meliphagidae (honeyeaters)						
Red Wattlebird	*Anthochaera carunculata*		X			
Western Wattlebird	*Anthochaera lunulata*		B			
Yellow-throated Miner	*Manorina flavigula*	CS3	B			
Singing Honeyeater	*Lichenostomus virescens*		X			**X**
Brown Honeyeater	*Lichmera indistincta*		X			**X**
New Holland Honeyeater	*Phylidonyris novaehollandiae*	CS3	B			
White-cheeked Honeyeater	*Phylidonyris nigra*	CS3	B			**X**
Tawny-crowned Honeyeater	*Phylidonyris melanops*	CS3	B			
Western Spinebill	*Acanthorhynchus superciliosus*		B			
White-fronted Chat	*Epthianura albifrons*		B			

Species		Status	DEC / BA	RL RP	PK SP	Port Kennedy BP
Petroicidae (Australian robins)						
Red-capped Robin	*Petroica goodenovii*		B			
Hooded Robin	*Melanodryas cucullata*	CS3	B			
Scarlet Robin	*Petroica multicolor*	CS3	X			
Western Yellow Robin	*Eopsaltria griseogularis*	CS3	B			
Neosittidae (sittellas)						
Varied Sittella	*Daphoenositta chrysoptera*	CS3	B			
Pachycephalidae (whistlers)						
Golden Whistler	*Pachycephala pectoralis*	CS3	X		X	
Rufous Whistler	*Pachycephala rufiventris*		X			
Grey Shrike-thrush	*Colluricincla harmonica*	CS3	X		X	
Dicruridae (flycatchers)						
Magpie-lark	*Grallina cyanoleuca*		X			**X**
Grey Fantail	*Rhipidura fuliginosa*		X		X	**X**
Willie Wagtail	*Rhipidura leucophrys*		B			**X**
Restless Flycatcher	*Myiagra inquieta*	CS3	B			
Campephagidae (cuckoo-shrikes)						
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X			
White-winged Triller	*Lalage sueurii*		B			
Artamidae (woodswallows)						
Black-faced Woodswallow	*Artamus cinereus*	CS3	B			
Dusky Woodswallow	*Artamus cyanopterus*	CS3	B			
Grey Butcherbird	*Cracticus torquatus*		X		X	**X**
Australian Magpie	*Gymnorhina tibicen*		X			**X**
Corvidae (ravens and crows)						
Grey Currawong	*Strepera versicolor*	CS3	B			
Australian Raven	*Corvus coronoides*		X		X	**X**
Motacillidae (pipits and true wagtails)						
Australasian (Richard's Pipit	*Anthus novaeseelandiae*		X			
Hirundinidae (swallows)						
White-backed Swallow	*Cheramoeca leucosternus*		B			
Welcome Swallow	*Hirundo neoxena*		X		X	**X**
Tree Martin	*Hirundo nigricans*		X		X	**X**
Dicaeidae (flower-peckers)						
Mistletoebird	*Dicaeum hirundinaceum*		B			
Sylviidae (old world warblers)						
Clamorous Reed-Warbler	*Acrocephalus stentoreus* [w]		B	X		
Little Grassbird	*Megalurus gramineus* [w]		X			
Rufous Songlark	*Cincloramphus mathewsi*		B			
Brown Songlark	*Cincloramphus cruralis*		B			
Zosteropidae (white-eyes)						
Silvereye	*Zosterops lateralis*		X		X	**X**
Total: (Number of Species Expected: 122)		56	136	14	15	**25**

TABLE 4. Mammals Recorded or Expected in the vicinity of the Project area. Expected occurrence is primarily based on known species distributions and available habitats. Levels of Conservation Significance are discussed in the "Assessment of Conservation Significance" section. Species previously recorded from the local area are listed under RLRP (Rockingham Lakes Regional Park including Lake Cooloongup and adjacent bushland), PK SP (Port Kennedy Scientific Park, immediately south of the project area), DEC (NatureMap database search of project area plus 10km buffer). Species recorded during the site inspection are listed under Port Kennedy BP (Port Kennedy Businesses Park).

Several mammals identified in the desktop review have been left on the expected list but are considered unlikely to reside in the project area (eg. Grey-bellied Dunnart, Western Pygmy-Possum, Rakali and Ash-grey Mouse). Locally extinct species are not listed. These are: Numbat *Myrmecobius fasciatus*, Quokka *Setonix brachyurus,* Brush-tailed Phascogale *Phascogale tapoatafa* and Chuditch *Dasyurus geoffroii*.

Species	Status	DEC	RL RP	PK SP	Port Kennedy BP
Tachyglossidae (echidnas)					
Echidna *Tachyglossus aculeatus*			X		
Dasyuridae					
Chuditch *Dasyurus geoffroii*	CS1	X			
Grey-bellied Dunnart *Sminthopsis griseoventer*	CS3		X		
Peramelidae (bandicoots)					
Quenda or Brown Bandicoot *Isoodon obesulus*	CS2	X	X	X	**X**
Phalangeridae (brushtail possums)					
Brush-tailed Possum *Trichosurus vulpecula*	CS3	X			
Tarsipedidae (honey possum)					
Honey Possum *Tarsipes rostratus*	CS3				
Burramyidae					
Western Pygmy-Possum *Cercartetus concinnus*	CS3				
Macropodidae (kangaroos and wallabies)					
Western Grey Kangaroo *Macropus fuliginosus*			X		**X**
Brush or Black-gloved Wallaby *Macropus irma*	CS2		X		
Mollosidae (mastiff bats)					
White-striped Bat *Tadarida australis*					
Western Freetail Bat *Mormopterus planiceps*	CS3				
Vespertilionidae (vesper bats)					
Southern Forest Bat *Vespadelus regulus*					
Gould's Wattled Bat *Chalinolobus gouldii*		X			
Chocolate Wattled Bat *Chalinolobus morio*					
Lesser Long-eared Bat *Nyctophilus geoffroyi*					
Greater Long-eared Bat *Nyctophilus timoriensis*					
Western False Pipistrelle *Falsistrellus mackenziei*	CS2				

Species	Status	DEC	RL RP	PK SP	Port Kennedy BP
Muridae (rats and mice)					
Water-rat, Rakali *Hydromys chrysogaster*	CS2				
Noodji or Ashy-grey Mouse *Pseudomys albocinereus*	CS3				
Moodit or Bush-Rat *Rattus fuscipes*	CS3		X		
INTRODUCED MAMMALS					
House Mouse *Mus musculus*		X			
Black Rat *Rattus rattus*		X			
Rabbit *Oryctolagus cuniculus*		X			
European Red Fox *Vulpes vulpes*					
Feral Cat *Felis catus*		X			**X**
Dog *Canis lupus*					**X**
Number of native mammal species expected:	20	4	6	1	**2**
Number of introduced mammal species expected:	6	4	-	-	**2**

TABLE 5. **Conservation status of significant fauna species expected to occur in the Port Kennedy area. See Appendix 1 for explanation of status codes. Species previously recorded in the project area are highlighted.**

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
CONSERVATION SIGNIFIANCE 1 (CS1)						
Morelia spilota imbricata	Carpet Python		Schedule 4 (Specially protected).	Priority 4.		**Yes**
Ardea alba	Great Egret	Migratory.	Schedule 3 (JAMBA).			No
Ardea ibis	Cattle Egret	Migratory.	Schedule 3 (JAMBA).			No
Plegadis falcinellus	Glossy Ibis	Migratory.				No
Falco peregrinus	Peregrine Falcon		Schedule 4 (Specially protected).			**Yes - visitor**
MIGRATORY WATERBIRDS		Migratory.	Schedule 3 (JAMBA).			No
Calyptorhynchus banksii naso			Schedule 1 (Vulnerable).			**RECORDED**
Calyptorhynchus latirostris	Carnaby's Cockatoo	Endangered.	Schedule 1 (Endangered).			**Yes**
Calyptorhynchus baudinii	Baudin's Cockatoo	Vulnerable.	Schedule 1 (Endangered).			**No**
Apus pacificus	Fork-tailed Swift	Migratory.				**Yes -Vagrant**
Merops ornatus	Rainbow Bee-eater	Migratory.				**Yes**
Dasyurus geoffroii	Chuditch	Vulnerable.	Schedule 1 (Vulnerable).			No
Synemon gratiosa	Graceful Sun-Moth		Schedule 1			Yes
Leioproctus bilobatus	Native Bee		Schedule 1			No
Leioproctus douglasiellus	Native Bee		Schedule 1			No
CONSERVATION SIGNIFIANCE 2 (CS2)						
Lerista lineata	Perth Lined Lerista			Priority 3.		**Yes**
Neelaps calonotos	Black-striped Snake			Priority 3.		**Yes**
Ctenotus gemmula	Jewelled Ctenotus			Priority 3.		**Yes**
Ixobrychus minutus	Little Bittern			Priority 4.		No
Thinornis rubricollis	Hooded Plover			Priority 4.		No
Tyto novaehollandiae novaehollandiae	Masked Owl			Priority 3.		No
Ninox connivens connivens	Southern Barking Owl			Priority 4.		**No**
Isoodon obesulus fusciventer	Quenda			Priority 5.		**RECORDED**
Macropus irma	Brush Wallaby			Priority 4.		**Yes**
Falsistrellus mackenziei	Western False Pipistrelle			Priority 4.		**No**
Hydromys chrysogaster	Water-Rat			Priority 4		**No**
Austrosaga spinifer	A Cricket			Priority 3		Unknown

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
Hyaleus globuliferus	A Native Bee			Priority 3		Unknown
Leioproctus contrarius	A Native Bee			Priority 3		Unknown
Throscodectes xiphos	A Cricket			Priority 1		Unknown
CONSERVATION SIGNIFIANCE 3 (CS3)						
Pletholax gracilis	Keeled Legless-lizard				Range edge	Yes
Varanus tristis	Black-headed Tree Goanna				Local Decline	Yes
Varanus gouldii	Gould's Sand Goanna				Local Decline	Yes
Varanus rosenbergi	Rosenberg's Goanna				Local Decline	Yes
Lissolepis luctuosa	Western Swamp Egernia				Local Decline	No
Ramphotyphlops waitii	Beaked Blind Snake				Range Edge	No
Lophoictinia isura	Square-tailed Kite				Local decline	Visitor
Haliastur sphenurus	Whistling Kite				Local decline	Visitor
Accipiter fasciatus	Brown Goshawk				Local decline	**RECORDED**
Accipiter cirrhocephalus	Collared Sparrowhawk				Local decline	Yes
Aquila audax	Wedge-tailed Eagle				Local decline	Yes
Hieraaetus morphnoides	Little Eagle				Local decline	Yes
Falco berigora	Brown Falcon				Local decline	Yes
Turnix varia	Painted Button-quail				Local decline	Yes
Phaps chalcoptera	Common Bronzewing				Local decline	**RECORDED**
Phaps elegans	Brush Bronzewing				Local decline	No
Platycercus icterotis	Western Rosella				Local decline	Vagrant
Neophema petrophila	Rock Parrot				Local decline	No
Malurus splendens	Splendid Fairy-wren				Local decline	**RECORDED**
Stipiturus malachurus	Southern Emu-wren				Local decline	No
Sericornis frontalis	White-browed Scrubwren				Local decline	**RECORDED**
Smicrornis brevirostris	Weebill				Local decline	No
Acanthiza apicalis	Inland Thornbill				Local decline	**RECORDED**
Acanthiza inornata	Western Thornbill				Local decline	**RECORDED**
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				Local decline	Yes
Anthochaera lunulata	Western Wattlebird				Local decline	Yes

Species		Reason for Significance				
		EPBC	WA Wildlife Conservation Act	DEC	CS3	Likely to occur on site
Melithreptus lunatus	White-naped Honeyeater				Local decline	No
Phylidonyris novaehollandiae	New Holland H'eater				Local decline	Yes
Phylidonyris nigra	White-cheeked Honeyeater				Local decline	**RECORDED**
Phylidonyris melanops	Tawny-crowned Honeyeater				Local decline	Yes
Petroica multicolor	Scarlet Robin				Local decline	No
Eopsaltria georgiana	White-breasted Robin				Local decline	Yes
Daphoenositta chrysoptera	Varied Sittella				Local decline	Yes
Pachycephala pectoralis	Golden Whistler				Local decline	Yes
Colluricincla harmonica	Grey Shrike-thrush				Local decline	Yes
Myiagra inquieta	Restless Flycatcher				Local decline	No
Artamus cinereus	Black-faced Woodswallow				Local decline	Yes
Artamus cyanopterus	Dusky Woodswallow				Local decline	No
Strepera versicolor	Grey Currawong				Local decline	No
Cercartetus concinnus	Western Pygmy-possum				Local decline	No
Tarsipes rostratus	Honey Possum				Local decline	No
Rattus fuscipes	Western Bush Rat				Local decline	Yes
Pseudomys albocinereus	Ashy-grey Mouse				Local decline	No
Sminthopsis griseoventer	Grey-bellied Dunnart				Local decline	Potential Resident

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Appendix 1. ***Categories used in the assessment of conservation status***

IUCN categories (based on review by Mace and Stuart 1994) **as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act**.

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act.

Schedule 1. Rare and Likely to become Extinct.
Schedule 2. Extinct.
Schedule 3. Migratory species listed under international treaties.
Schedule 4. Other Specially Protected Fauna.

WA Department of Conservation and Land Management Priority species
(species not listed under the Conservation Act, but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

APPENDIX 9

CONCEPT PLAN

Concept Plan

Lot 4 & Lot 17, Port Kennedy Drive

Date: 07 December 2020 Scale: NTS @A1 Drawing No. **717-278** Staff: LR Checked: MR

0 20 40m

element.

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Appendix E Engineering Servicing Report

PORT KENNEDY ENTERPRISE PARK

ENGINEERING SERVICES REPORT

PREPARED FOR DEVELOPMENTWA

Porter
Consulting Engineers

Report Prepared For:

DEVELOPMENT WA

Prepared by	**Porter Consulting Engineers**
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Job number	18-6-73
Date	11 October 2023
Our reference	R44G.18
Checked	*MC*

HISTORY AND STATUS OF THE DOCUMENT

Revision	Date issued	Author	Issued to	Revision type
Rev A	03/8/2018	S Highman	L Strange, LandCorp	First issue
Rev B	21/08/2018	S Highman	L Strange, LandCorp	Second issue
Rev C	09/10/2019	M Cook	Doug Stirling, LandCorp	Third issue
Rev D	14/4/2021	S Highman	Doug Stirling, DevelopmentWA	For Structure Plan
Rev E	31/1/2023	S Highman	Doug Stirling, DevelopmentWA	For WAPC Approval
Rev F	27/2/2023	S Highman	Doug Stirling, DevelopmentWA	For WAPC Approval
Rev G	11/10/2023	S Highman	DevelopmentWA	For WAPC Approval

CONTENTS

1.0 INTRODUCTION

Porter Consulting Engineers were engaged by Development WA to complete an assessment of engineering and servicing requirements to support the subdivision application of Lot 4 and Lot 17 Port Kennedy Drive, Port Kennedy for an Industrial Park development. The location of the site is shown below.

The engineering advice relates to existing infrastructure in the vicinity of the site and an assessment of the future servicing requirements to subdivide the site.

2.0 SITE

The Site is currently vacant coastal heath land. The soils are calcareous sands of high permeability with moderate bearing capacity. A site classification of 'Class A' in accordance with AS2870-2011 could be expected. Douglas Partners July 2011 Geotechnical Report provides a guide for future engineering designs.

The landscape features consist of low north south longitudinal dunal ridges that are part of the Becher Plain, and occasional damplands that occur in the interdunal depressions. The site has an elevation of approximately RL 10m AHD near Ennis Avenue down to approximately RL 6m AHD near Bakewell Drive with the localized depressions as low as RL 4.0m AHD.

The existing site features are shown in **Attachment 1**.

The JDA May 2011 monitoring report shows the groundwater level ranged from 2.64m AHD to 4.25m AHD across the Site. The depth to maximum groundwater level below natural surface varied from 1.72m to 4.25m across the Site. Surficial groundwater flow is eastwards towards Lake Walyungup.

The Western Australian Planning Commission (WAPC) Acid Sulphate Soil Atlas indicates that there is a low risk of acid sulphate soils occurring down to 3m.

WAPC subdivision approval was issued on 1 March 2018 for the site (Refer **Attachment 2**). Condition 1 requires the creation of a Conservation area, these have been nominated including a central reserve as shown in **Attachment 6.**

The site is registered on the Unexploded Ordnance (UXO) website and its perimeter is sign posted accordingly.

3.0 EXISTING INFRASTRUCTURE

The site is surrounded by existing infrastructure. The following is a summary of the existing services and transport infrastructure.

3.1 Roads

The site is bounded by:

- Ennis Avenue to the east - a controlled access divided dual carriageway that is a primary road and is indicated in the Metropolitan Region Scheme as an Important Regional Road.
- Port Kennedy Drive to the south - a two lane median separated dual carriageway. It is a district distributor road that is indicated in the Metropolitan Region Scheme as a Regional Road.
- Bakewell Drive to the west - is a two way industrial standard local road.

There is control of access restrictions to Ennis Avenue. Access off Ennis Avenue is not permitted.

3.2 Water Supply

The Site is within the Water Corporation water supply scheme area, but is not yet serviced. There is a 150mm diameter main generally reticulated through the existing industrial estate to the west of the site, with a 200mm main along Blackburn Drive that currently terminates at the intersection with Port Kennedy Drive. Refer **Attachment 3**.

3.3 Sewer

The Site is within Water Corporation sewer scheme area, but is not yet serviced. There are 300mm and 225mm diameter sewer mains constructed in the existing subdivision to the west. Refer **Attachment 4.**

3.4 Power

There is underground power in the residential subdivision to the north and in the industrial subdivision to the west of Bakewell Drive. Refer **Attachment 5**.

3.5 Telecommunications

There is Telstra and NBN (fibre to the kerb) infrastructure in the industrial subdivision to the west of the site, and Telstra and NBN (fibre to the node) infrastructure to the residential subdivision to the north of the site.

3.6 Gas

The residential land to the north is reticulated by gas, as is part of the industrial land to the west.

4.0 PROPOSED SITE DEVELOPMENT

DevelopmentWA propose to develop the site in accordance with the permitted planning uses whilst accommodating the existing environmental constraints.

The proposed development Structure Plan is shown in **Attachment 6**. The plan preserves significant amounts of public open space in the form of a Conservation lot and a wetland reserve.

Due to the size of the site, it is anticipated it will be subdivided in a staged manner. The current staging plan is presented at **Attachment 13**.

5.0 DEVELOPMENT SERVICING REQUIREMENTS

The Site is currently zoned Industrial under the Metropolitan Region Scheme and Port Kennedy Business Enterprise under the City of Rockingham Town Planning Scheme No. 2. With these zoned land uses, service authorities have included the site in their future planning scenarios.

Infrastructure will be required to an industrial land use standard to enable the subdivision. The following summarises these requirements.

5.1 Roads and Paths

The control of access along the eastern boundary of the site prohibits a connection onto Ennis Avenue. The proposed road networks (**Attachment 6**) shows two connections to Port Kennedy Drive, these road and intersection requirements are detailed in the Traffic Impact Assessment. The proposed Port Kennedy Drive intersections (round-abouts) can be accommodated in the existing road reserve plus the addition of new road reserve created from the site's parent lot.

The two entry roads off Port Kennedy Drive have a wider road reserve (25m) as noted in the Traffic Impact Assessment. It is expected these will have separate lanes and a continuous raised central median to prohibit right turn movements into their fronting lots. All other roads will be 10m wide and built to the City of Rockingham's industrial standard.

The detailed designs of the internal intersections will occur post WAPC subdivision approval. Modification to cadastral truncations will be considered at that point in time to ensure sufficient verge widths are provided.

Port Kennedy Drive is mapped as RAV 4 restricted use, it is expected the development will be RAV 4 compliant with some limitations as noted in the Traffic Impact Assessment.

The Traffic Impact Assessment comments on the operation of the Port Kennedy Drive – Ennis Avenue intersection and the required upgrades over the next 15 years. The Ennis Avenue intersection upgrade can be accommodated in the existing road reserves.

A footpath network will be established throughout the estate and connect to the existing network. It is expected this will include a loop around the wetland and CCW.

Principle Shared Paths (Ennis Avenue) and Dual Use Paths (Port Kennedy Drive) have been identified as part of the Department of Transport's long term cycle network. These will be installed by others when the demand requires it.

5.2 Drainage

Strategen JBS+G have prepared the Local Water Management Strategy (LWMS) which addresses stormwater management across the site. Porters have been working with Strategen JBS+G to co-ordinate this drainage strategy. Below is a summary of the LWMS outcomes.

5.2.1 Road Reserve Drainage

Due to the highly permeable nature of the site and flat topography, at source detention and disposal will be implemented to manage various storm events. It is expected the more frequent events will be managed via localised gardens and treatment areas. Larger events will be managed via below ground storage and infiltration arrangements. Extreme events will be managed via above ground storage, linear flow paths along the road network and disposal in open aired basins.

Stormwater quality will be managed for the more frequent events, as these convey the majority of the pollutants.

Verge levels will be set based on based on drainage requirements including ground water separation to drainage infrastructure. Minimum flood level separation will be achieved to all lots as typically detailed with any development.

A concept drainage plan is presented in **Attachment 7**.

5.2.2 Lot Drainage

Stormwater collected from each lot will be managed within each lot. Lots will not be connected to the road reserve network. Lot drainage is typically collected via gutters and standard pavement inlet pits for storage and disposal via infiltration in below ground tanks. Lots will be set at an elevation to enable the installation of standard infrastructure to manage the disposal.

Some lot owners may choose to install rain water tanks for irrigation purposes or in other non-potable uses. These owners will need to seek specific approvals as required for this.

5.3 Sewer

Water Corporation will require a sewer to be extended from the existing in Bessemer Road and then advanced in an easterly direction throughout the subdivision. Refer **Attachment 8** for their sewer catchment planning. Consistent with this, a concept sewer layout has been prepared and is presented in **Attachment 9**.

The gravity sewer crosses under the Conservation Category Wetland (CCW) via trenchless techniques, before it branches out to service the estate. The subdivision sewers will be 225mm diameter and developed on a frontage basis. Standard chambers and property connections are required.

The north western corner of the site is serviced via a separate sewer. This reduces fill requirements and allow the seamless lot tie in with the existing Bakewell Drive.

Approval in principle has been provided by the Water Corporation for this layout.

5.4 Water

The Water Corporation will require all lots to be serviced with water, compliant with industrial subdivision standards. A concept water main layout is shown in **Attachment 10**. This shows a new DN200 loop main extending from the existing 200mmm water main at the intersection of Blackburn Drive/ Port Kennedy Drive, through the estate and back to the 200mm main at the intersection Bakewell Drive / Paxton Way. All other water main are DN150.

Approval in principle has been provided by the Water Corporation for this layout.

5.5 Power

The Feasibility Study as issued by Western Power in June 2011 is presented in **Attachment 11**. This study is well out of date, however the site's power demand requirements remain unchanged.

The Western Power Feasibility Study indicates:

- 7MVA (7000kVA) expected capacity based on minimum usable land.
- there is spare capacity in the network equaling 2MVA (2000kVA) or 2-3x 630kVA transformers.
- More than 2MVA requires a new HV feeder to be installed from the Waikiki zone substation (approx. 4.5km).

Current Western Power mapping (Forecast of Remaining Capacity 2026) suggests the area has 15-20MVA spare capacity. It appears an upgrade has occurred over the last 10 years. Further discussions with Western Power are required to verify what reinforcing works have been completed since 2011 and what impact this has on their previous advice. This happens at

detailed design stage, as per the normal subdivision process.

A high and low voltage underground network will be established to service the estate. Street lighting is required and will be installed compliant with governing standards.

A concept layout of the major power infrastructure is also shown in **Attachment 11**.

The development of new technology in the power industry has presented opportunities to mitigate consumer costs. Innovations that could be utilised within this development include:

- Solar Power Supply with battery support.
- Solar Hot Water System.
- Heat Transfer Hot Water System (Low Power).
- Wind Pods (Wind Power).

5.6 Telecommunications

There are NBN telecommunication networks in the surrounding suburbs to the north and west which will be extended to, and reticulated throughout, the proposed subdivision.

5.7 Gas

Gas infrastructure is typically not required in industrial developments as its use is very low. The developers will have to fund all gas infrastructure if required, this is a normal requirement in non- residential developments.

It is noted gas is a fossil fuel with many businesses now looking at carbon neutral options. Although possible, it is not expected that gas will be reticulated throughout this development.

5.8 Earthworks

UXO sweeping and clearance is required prior to any site works. This is a standard process and will ensure the site is safe to develop. Standard UXO sweeping requires the clearing of vegetation, this will be completed across the majority of the site. It is expected alternate UXO sweeping techniques will be used (electromagnetic) in environmentally sensitive areas as this can be completed without the need to clear.

Due to the regular occurrence of dune ridges, the site will be earthworked in full to create generally level lots. Based on ground water levels, drainage requirements and sewer servicing, filling will be required. An indicative bulk earthwork plan is shown in **Attachment 12**.

There are two environmentally sensitive areas, the CCW to the west and the central POS. Earthworks will not encroach into their 50m buffer zones.

The soils and climatic conditions are such that dust may be an issue during construction. The Contractor will prepare and obtain approvals for a dust management plan, this will nominate strict control measures to mitigate dust blow off during each stage. It is expected these controls will include on site storage of construction water, regular stabilisation, dust fencing and staging

their construction activities.

6.0 CONCLUSION

Having reviewed the existing services that are available and discussed the planned extension to those services with the relevant authorities, Porter Consulting Engineers are of the opinion that the development of the Port Kennedy Enterprise Park can be undertaken.

ATTACHMENT 1
Existing Site Features

NOTES

This plan has been prepared for the client and should not be used for any other purpose unless authorised by Whelans (WA) Pty Ltd.

The location of cadastral boundaries shown has been extracted from Landgate's database on 8/6/11 and are subject to survey.

Prior to the commencement of any work, relevant authorities should be contacted for the location of underground services.

Levels are based on AHD and derived from SSM

Due to overwriting some levels may be switched off for this plot only.

This note is an integral part of this plan.

LEGEND

- CADASTRAL BOUNDARIES
- EASEMENTS
- DBYD POWER
- DBYD SEWER
- DBYD TELECOM
- DBYD WATER
- MAPPING CONTOUR (INDEX)
- MAPPING CONTOUR (INTERMEDIATE)

NOTES:

AERIAL IMAGERY HAS BEEN SOURCED FROM LANDGATE.
CAPTURED: MAY 2011; RESOLUTION:0.1m; ACCURACY:2m;

MAPPING DATA IS BASED ON AAM IMAGERY CAPTURED MAY 2001 WITH EXPECTED VERTICAL AND HORIZONTAL ACCURACY OF 0.1m

CONTOUR INTERVAL IS 0.5m

north

NOTE:
UNDERGROUND SERVICE INFORMATION SOURCED FROM 'DIAL BEFORE YOU DIG' AND IS VALID FOR 14 DAYS FROM APPLICATION DATE. THIS INFORMATION IS FOR INDICATIVE PURPOSES ONLY. LIFTING OF COVERS AND EXCAVATION MUST BE DONE FOR ACCURATE IDENTIFICATION AND LOCATION OF SERVICES.

TELSTRA DATA IS SCHEMATIC AND ONLY INDICATES THE PRESENCE OF INFRASTRUCTURE.

SCALE:	1:2000	DATE DRAWN:	13/6/11
V.DATUM:	AHD	DRAWN BY:	N.G.A.
H.DATUM:	PCG94	CHECKED BY:	A.B.B.
SURVEY DATE:	29/5/11	DATA FILE:	14834_mapping_Pt_Kennedy_pcg94.dwg
SURVEYOR:	N/A		
JOB NO:	14834		
FILE:	S:\Projects\14\14834\ortho\drawings\14834-001.dwg		

whelans
133 Scarborough Beach Road, Mount Hawthorn WA 6016
PO Box 99, MOUNT HAWTHORN WA 6915
T: 08 9443 1511 F: 08 9444 3901
E: whelans@whelans.com.au W: www.whelans.com.au

AERIAL MAPPING & DBYD SERVICES
LOTS 17 WARNBRO SOUND AVE & 4 ENNIS AVE
PORT KENNEDY

CLIENT: LANDCORP

ORIGINAL SHEET SIZE: A1

REV 0

PLAN 14834-001

SHEET 1 OF 1

BSI ISO 9001:2008 FS 521002

ATTACHMENT 2
Western Australian Planning Commission Conditions

Western Australian Planning Commission

Your Ref : 17-278

TPG Town Planning, Urban Design And Heritage
Level 18 191 St Georges Terrace
PERTH WA 6000

Approval Subject To Condition(s)
Freehold (Green Title) Subdivision

Application No : 156342

Planning and Development Act 2005

Applicant	:	TPG Town Planning, Urban Design And Heritage Level 18 191 St Georges Terrace PERTH WA 6000
Owner	:	Landcorp The Esplanade PERTH WA 6000
Application Receipt	:	1 March 2018

Lot Number	:	4 & 17
Diagram / Plan	:	D065566, D094300
Location	:	
C/T Volume/Folio	:	1663/339, 2126/431
Street Address	:	Lots 4 And 17 Port Kennedy Drive, Port Kennedy
Local Government	:	City of Rockingham

The Western Australian Planning Commission has considered the application referred to and is prepared to endorse a deposited plan in accordance with the plan date-stamped **01 March 2018** once the condition(s) set out have been fulfilled.

This decision is valid for **three years** from the date of this advice, which includes the lodgement of the deposited plan within this period.

The deposited plan for this approval and all required written advice confirming that the requirement(s) outlined in the condition(s) have been fulfilled must be submitted by **06 July 2021** or this approval no longer will remain valid.

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www.dplh.wa.gov.au
ABN 35 482 341 493

Western Australian Planning Commission

Reconsideration - 28 days

Under section 151(1) of the *Planning and Development Act 2005*, the applicant/owner may, within 28 days from the date of this decision, make a written request to the WAPC to reconsider any condition(s) imposed in its decision. One of the matters to which the WAPC will have regard in reconsideration of its decision is whether there is compelling evidence by way of additional information or justification from the applicant/owner to warrant a reconsideration of the decision. A request for reconsideration is to be submitted to the WAPC on a Form 3A with appropriate fees. An application for reconsideration may be submitted to the WAPC prior to submission of an application for review. Form 3A and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Right to apply for a review - 28 days

Should the applicant/owner be aggrieved by this decision, there is a right to apply for a review under Part 14 section 251 of the *Planning and Development Act 2005*. The application for review must be submitted in accordance with part 2 of the *State Administrative Tribunal Rules 2004* and should be lodged within 28 days of the date of this decision to: the State Administrative Tribunal, Level 6, State Administrative Tribunal Building, 565 Hay Street, PERTH, WA 6000. It is recommended that you contact the tribunal for further details: telephone 9219 3111 or go to its website: http://www.sat.justice.wa.gov.au

Deposited plan

The deposited plan is to be submitted to the Western Australian Land Information Authority (Landgate) for certification. Once certified, Landgate will forward it to the WAPC. In addition, the applicant/owner is responsible for submission of a Form 1C with appropriate fees to the WAPC requesting endorsement of the deposited plan. A copy of the deposited plan with confirmation of submission to Landgate is to be submitted with all required written advice confirming compliance with any condition(s) from the nominated agency/authority or local government. Form 1C and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Condition(s)

The WAPC is prepared to endorse a deposited plan in accordance with the plan submitted once the condition(s) set out have been fulfilled.

The condition(s) of this approval are to be fulfilled to the satisfaction of the WAPC.

The condition(s) must be fulfilled before submission of a copy of the deposited plan for endorsement.

The agency/authority or local government noted in brackets at the end of the condition(s) identify the body responsible for providing written advice confirming that the WAPC's requirement(s) outlined in the condition(s) have been fulfilled. The written advice of the agency/authority or local government is to be obtained by the applicant/owner. When the written advice of each identified agency/authority or local government has been obtained, it

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e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

should be submitted to the WAPC with a Form 1C and appropriate fees and a copy of the deposited plan.

If there is no agency/authority or local government noted in brackets at the end of the condition(s), a written request for confirmation that the requirement(s) outlined in the condition(s) have been fulfilled should be submitted to the WAPC, prior to lodgement of the deposited plan for endorsement.

Prior to the commencement of any subdivision works or the implementation of any condition(s) in any other way, the applicant/owner is to liaise with the nominated agency/authority or local government on the requirement(s) it considers necessary to fulfil the condition(s).

The applicant/owner is to make reasonable enquiry to the nominated agency/authority or local government to obtain confirmation that the requirement(s) of the condition(s) have been fulfilled. This may include the provision of supplementary information. In the event that the nominated agency/authority or local government will not provide its written confirmation following reasonable enquiry, the applicant/owner then may approach the WAPC for confirmation that the condition(s) have been fulfilled.

In approaching the WAPC, the applicant/owner is to provide all necessary information, including proof of reasonable enquiry to the nominated agency/authority or local government.

The condition(s) of this approval, with accompanying advice, are:

CONDITIONS

1. The boundary between proposed Lots 1 and 2 being amended as per the attached plan dated 3 July 2018. (Local Government)

Environment

2. Prior to the commencement of subdivisional works a Conservation Area Management Plan is to be prepared for Conservation Area Lot 1 in consultation with the Department of Biodiversity, Conservation and Attractions and the City of Rockingham and approved to ensure the protection and management of the site's environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Biodiversity, Conservation and Attractions)

Fire and emergency infrastructure

3. Prior to the commencement of subdivision works, the proposed lots are to be searched for unexploded ordnance to a depth of at least one metre. (Department of Fire and Emergency Services)

4. A notification pursuant to section 165 of the *Planning and Development Act 2005* is to be placed on the certificate of title of the proposed lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification to state as follows:

   "This land has been used as an artillery range and for heavy explosive ordnance dumping and may contain unexploded ordnance. While the land has been searched to a depth of one metre no guarantee can be given that all unexploded ordnance have been located. Any ordnance found should be treated as dangerous and its location reported to police or defence establishment." (Western Australian Planning Commission)

Transport

5. Pursuant to Section 150 of the *Planning and Development Act 2005* and Division 3 of the *Planning and Development Regulations 2009* a covenant preventing vehicular access onto Ennis Avenue and part of Port Kennedy Drive (as per the attached plan dated 3 July 2018) being lodged on the certificate of title of proposed Lot 2 at the full expense of the landowner/applicant. The covenant is to prevent access, to the benefit of Main Roads Western Australia, and the covenant is to specify:

   "*No vehicular access is permitted to or from Ennis Avenue or this section of Port Kennedy Drive*." (Main Roads Western Australia)

ADVICE

1. With regard to Condition 2, the Conservation Area Management Plan is to include measures to rehabilitate degraded areas and monitor hydrology and vegetation health. Weed control, rubbish removal, safe management access and the installation of appropriate fencing or barriers is also be addressed. The Plan is to include a commitment and timeline for amending the classification of the Conservation Area with the vesting in the appropriate authority.

2. The City of Rockingham favours the retention of wetlands 15 and 17 within proposed Lot 2 as part of its future development.

3. The Department of Fire and Emergency Services (DFES) advises that historical research has revealed that during the past 100 years, former elements of the Australian Defence Forces may have conducted training and/or operational activities within or close to the area of the proposed subdivision. It is possible that as a result of these activities, the subject area may contain unexploded ordnance (UXO). Whilst it is considered that the possible risk from UXO on the land subject to this approval is minimal, an absolute guarantee that the area is free from UXO cannot be given. Should, during subdivisional works, or at any other time, a form or suspected form of UXO be located, DFES has advised that the following process should be initiated:

Western Australian Planning Commission

a) do not disturb the site of the known or suspected UXO;
b) without disturbing the immediate vicinity, clearly mark the site of the UXO;
c) notify Police of the circumstances/situation as quickly as possible; and
d) maintain a presence near the site until advised to the contrary by a member of the WA Police Service or Defence Forces.

Further advice on this issue may be obtained by contacting the Unexploded Ordnance Unit, Department of Fire and Emergency Services.

Ms Sam Fagan
Secretary
Western Australian Planning Commission
6 July 2018

Enquiries : Regan Douglas (Ph 6551 9289)

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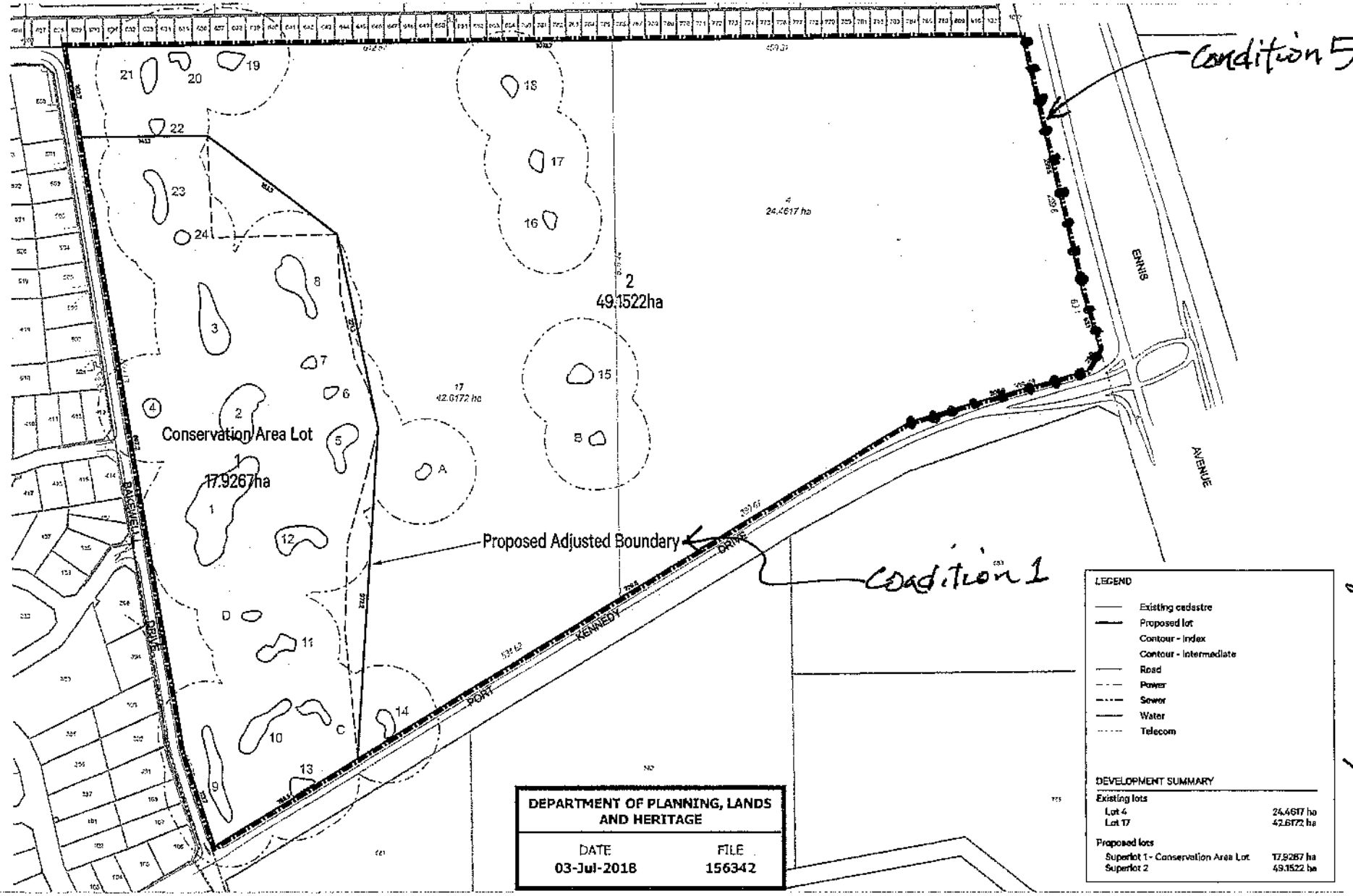
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493



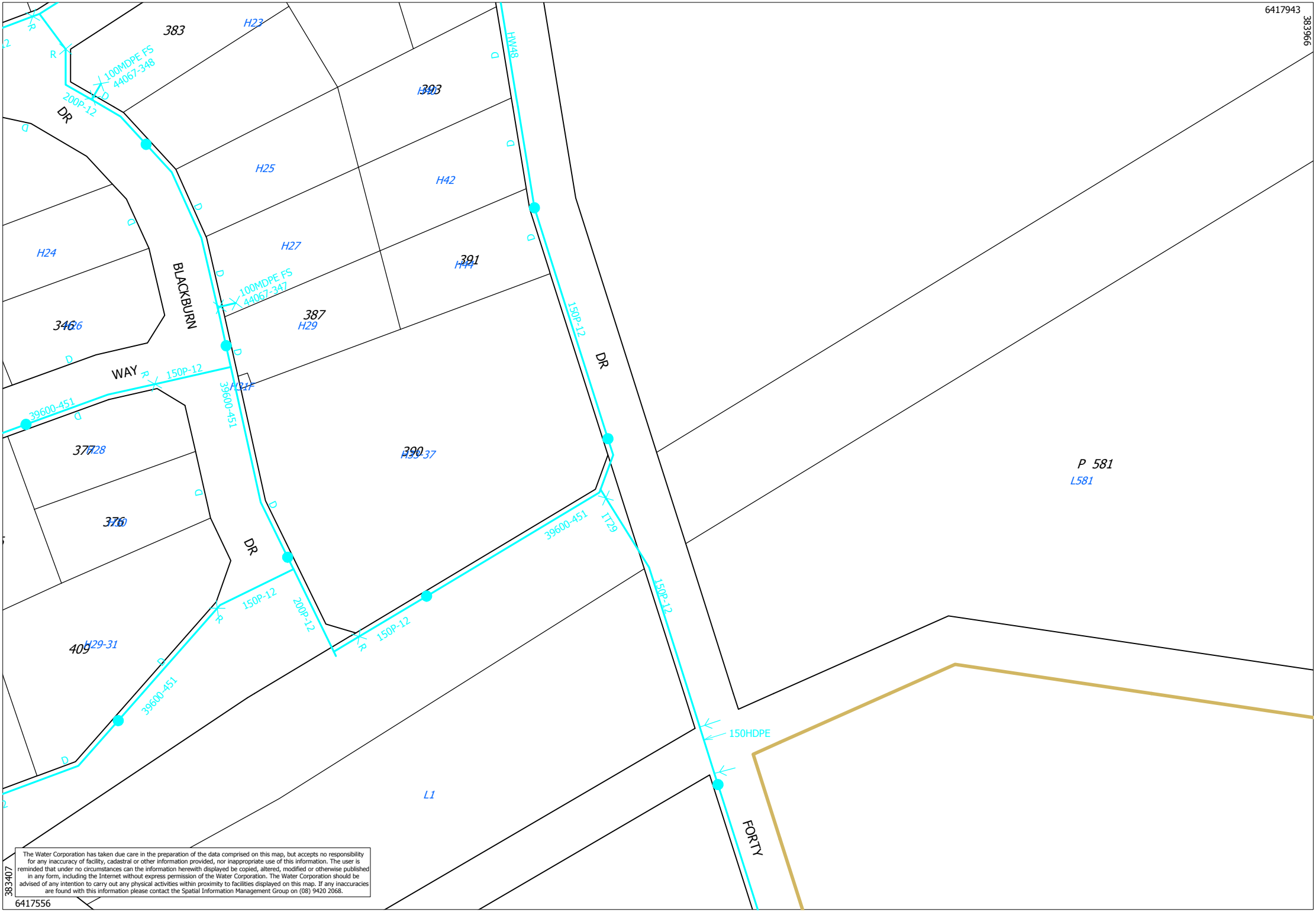
Attached Plan

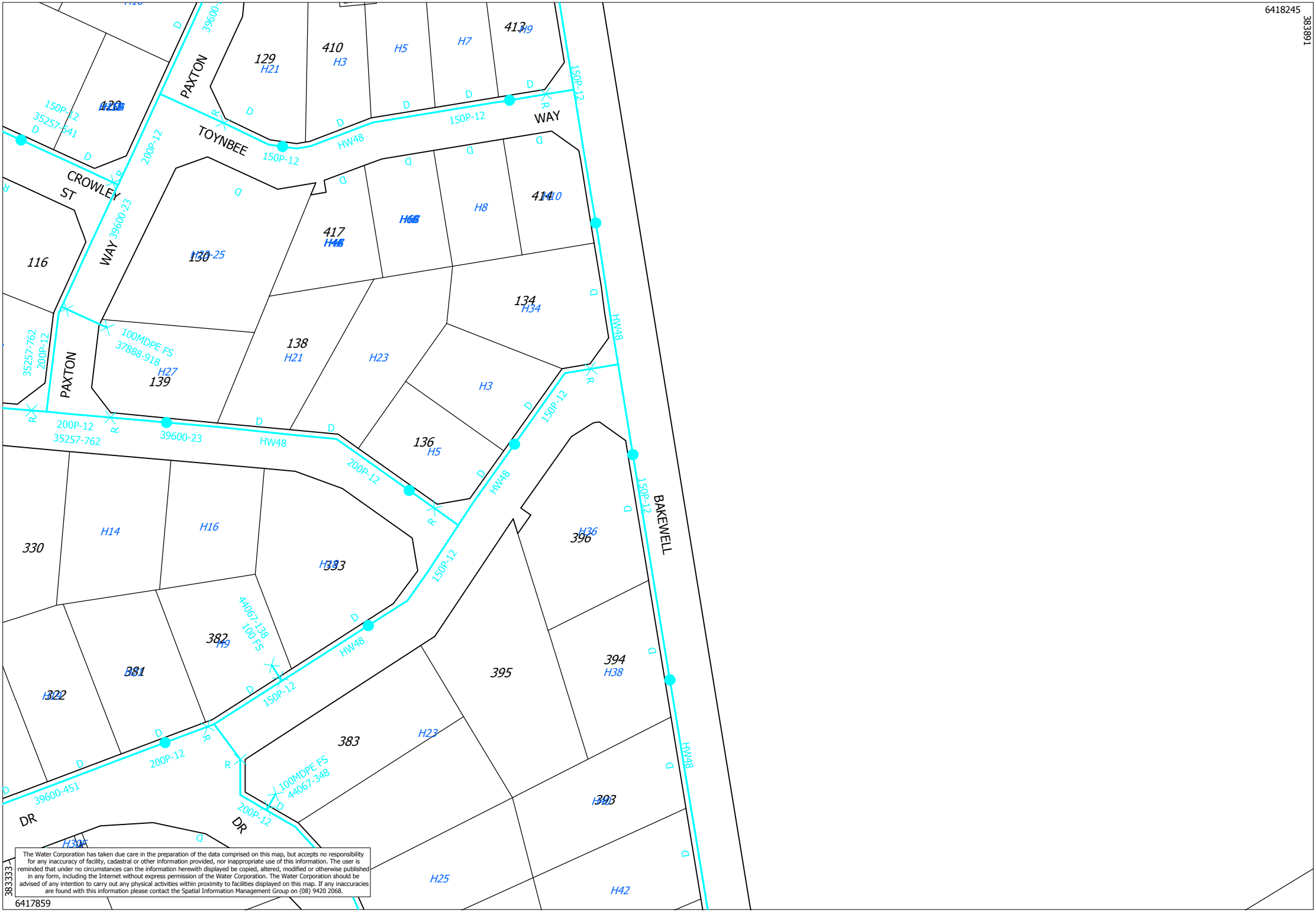
Subdivision Plan - Amended

Lots 4 & 17 Port Kennedy Drive, Port Kennedy

element.

ATTACHMENT 3
Existing Water Reticulation





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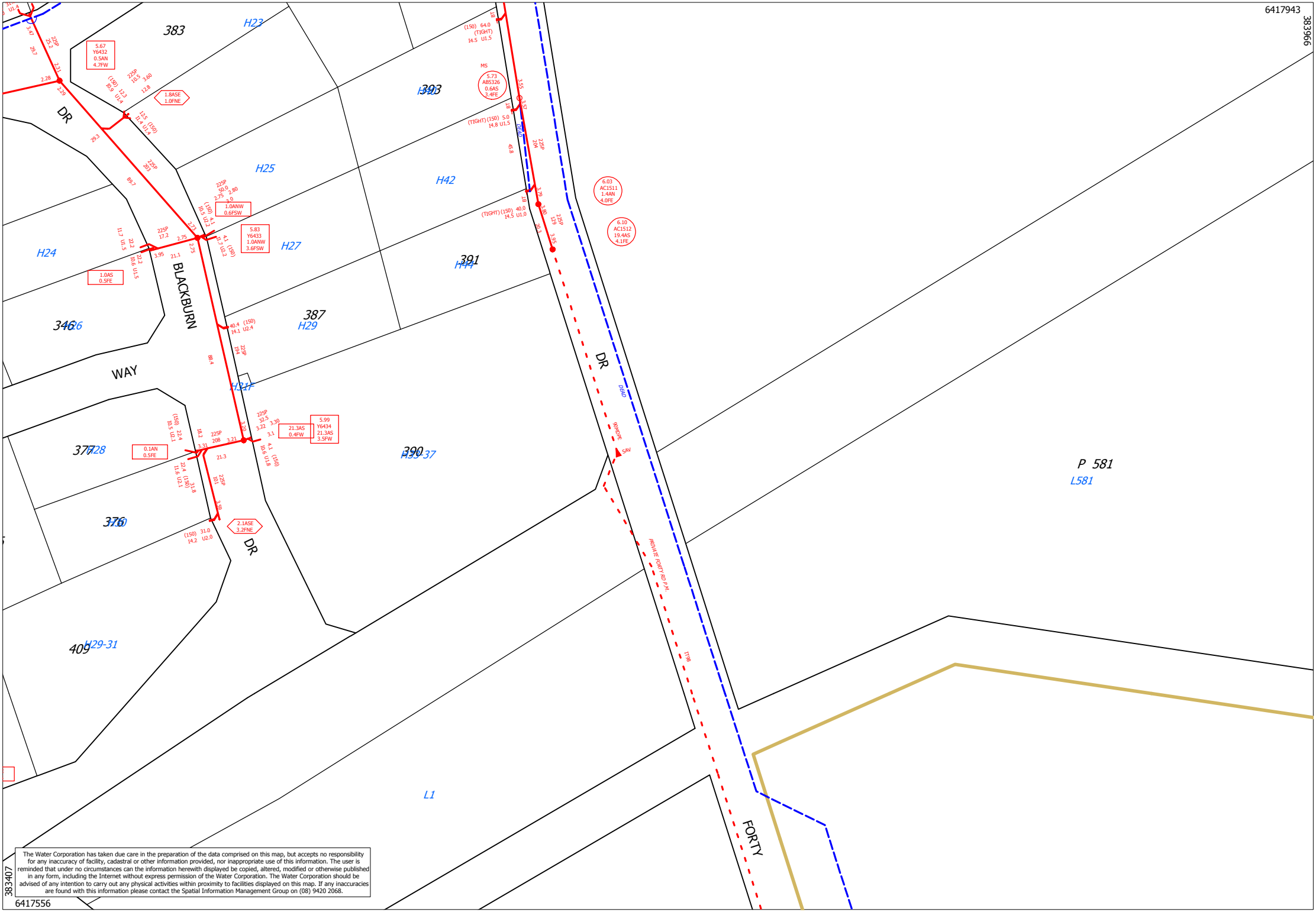
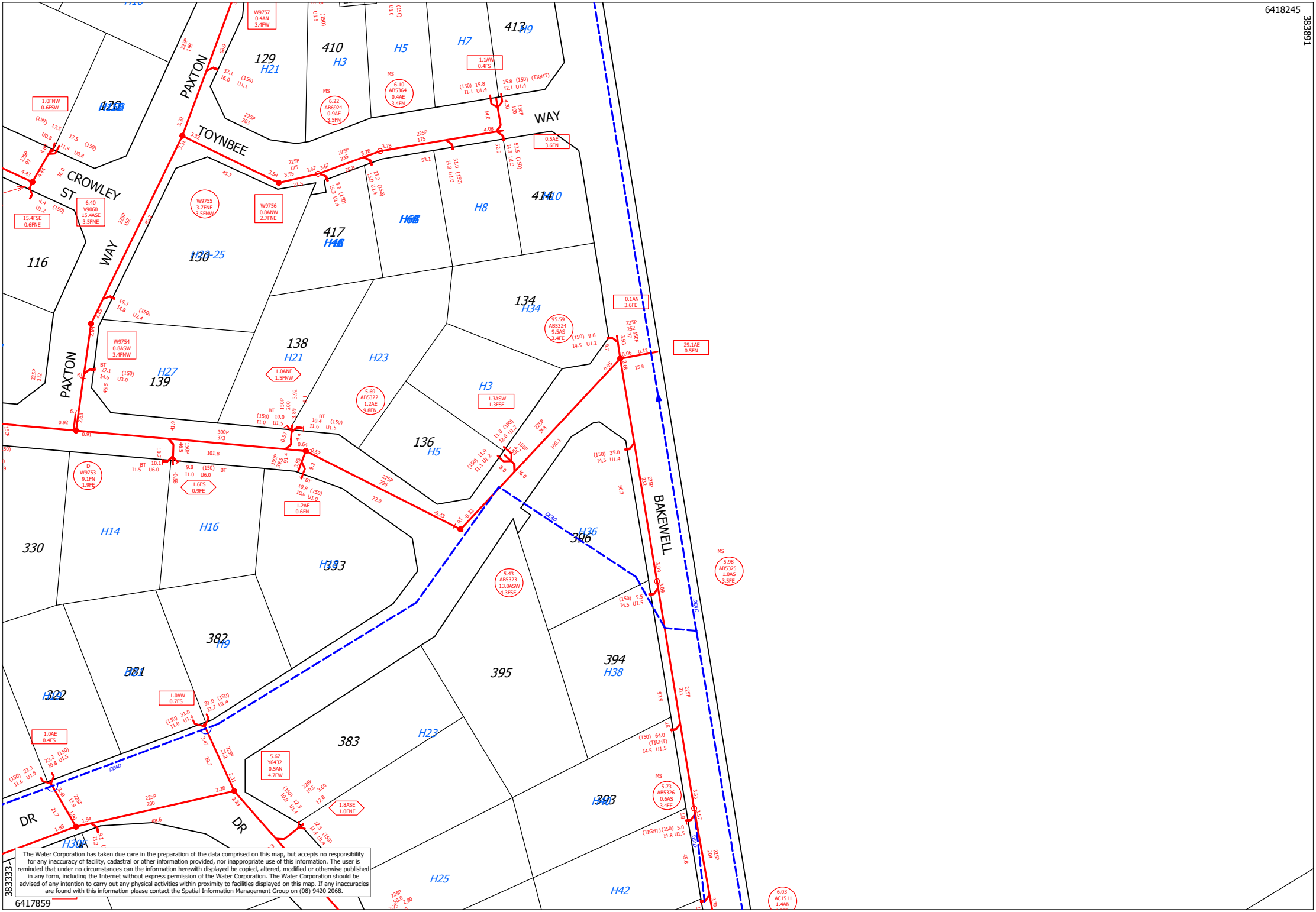
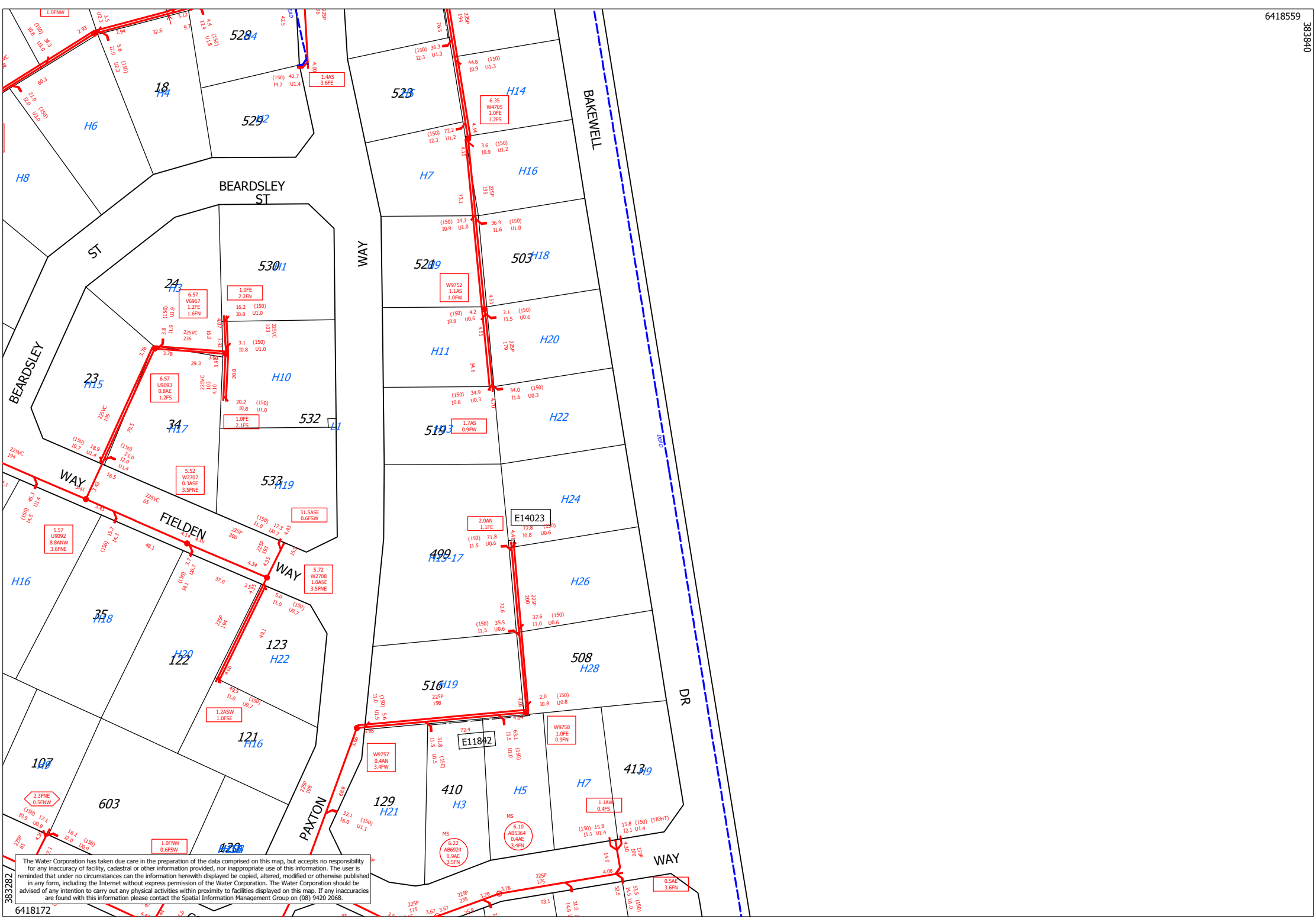
ATTACHMENT 4
Existing Sewer Reticulation



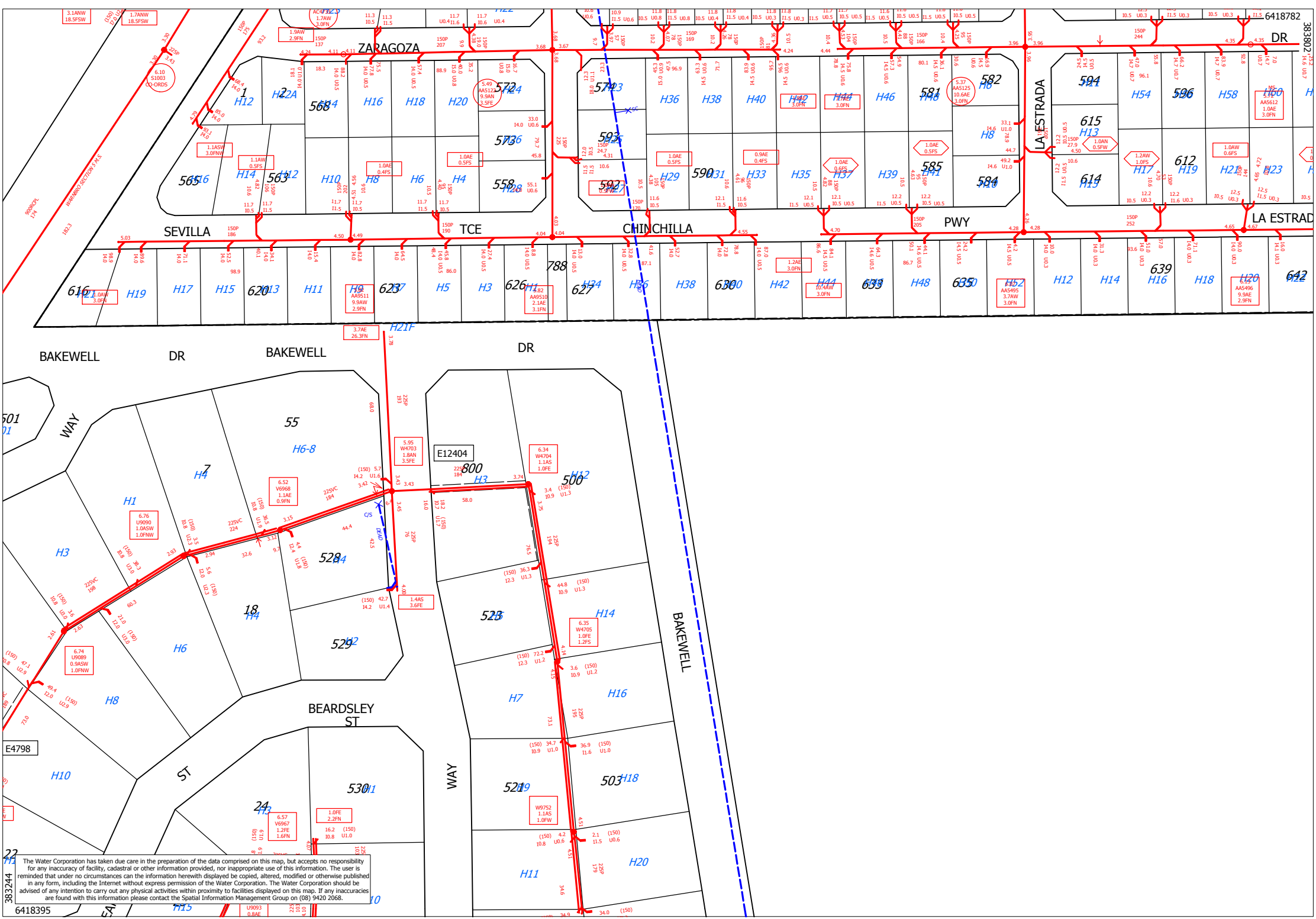
2_DBYD SEWER Screen bg33/08.18 PEEL Date Printed: 14/07/10 10:12:31 Coordinate System: MGA94 Zone 50 Height Datum: AHD



2_DBYD SEWER Screen bg33/08.18 PEEL Date Printed: 14/07/10 10:12:50 Coordinate System: MGA94 Zone 50 Height Datum: AHD



2_DBYD SEWER Screen bg33/08.19 PEEL Date Printed: 14/07/10 10:13:12 Coordinate System: MGA94 Zone 50 Height Datum: AHD



2_DBYD SEWER Screen bg33/08.19 PEEL Date Printed: 14/07/10 10:13:24 Coordinate System: MGA94 Zone 50 Height Datum: AHD

ATTACHMENT 5
Existing Power Supply

SEVILLA TCE
CHINCHILLA PWY
LA ESTRADA WY
MERIDA LP
BURGES L
MONTILLA CR
TOLEDO CCT
N
S2888
PAXTON WY
BAKEWELL DR
18
1698
S2561
MS012061
24
3
8044
PAXTON
34
8046
PAXTON WY
518
15
BAKEWELL DR
S3221
28 BAKEWELL DR
122
20
123
17
4
120
15
L417 TOYNBEE WAY
TOYNBEE WY
130
138
21
137
MS011771
1 BESSEMER RD
331
14
333
7
396
36
382
381
21
394
38
383
BESSEMER RD
393
40
385
25
392
42
386
391
44
347
33
BLACKBURN 1
390
37
581
582
583
765
PORT KENNEDY DR
ENNIS 2
ENNIS AVE
WARNBRO SOUND AVE
BLACKBURN

Windows DFIS Map Printed: Fri Aug 05 16:34:41 2011 User: dtwyman
32ø22'00"S, 115ø46'03"E MGA (Zone 50): (38406590,641822514) Scale: 1:3412 Profile: ALL

ATTACHMENT 6
Proposed Development Concept

Legend

Structure Plan Boundary

MRS Reserves

Parks and Recreation

Local Reserves

Public Open Space and Drainage

Local Zones

Port Kennedy Enterprise Zone

Other

Local Distributor Road

Local Access Road

Pedestrian Path

Dual Use Path

Principal Shared Path

Wetland

Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Lot 4 and 17 Port Kennedy Drive, Port Kennedy

Date: 27 Sep 2023 Scale: 1:4000 @ A3 1:2000 @ A1 File: **717-278 ST-1** Staff: MR GW Checked: MR

0 40 80m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

ATTACHMENT 7
Drainage

CCW

RESERVE

BAREWELL DRIVE

ENNIS AVENUE

PORT KENNEDY DRIVE

4.0 GWL

3.0 GWL

583

582

581

LEGEND

- SITE BOUNDARY
- 7.60 FINISHED LOT LEVEL
- PROPOSED KERB
- PROPOSED DRAINAGE
- —2.0m AAGWL— ANNUAL AVERAGE GROUND WATER LEVEL
- 50m ENVIRONMENTAL BUFFER
- AT SOURCE DISPOSAL AT LOW POINT
- AT SOURCE DISPOSAL VIA LINEAR OPEN DRAIN
- AT SOURCE DISPOSAL VIA BELOW GROUND LINEAR SYSTEM
- AT SOURCE DISPOSAL LEADING TO OPEN AIRED BASIN FOR LARGER EVENTS
- OPEN AIRED BASIN

1:2000 0 20 40 80 120
Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@portereng.com.au
www.portereng.com.au

TUSMO Pty Ltd ACN 070 097 168 as trustee for The Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 626 396 385

CLIENT: DevelopmentWA

DRAWING:
CONCEPT DRAINAGE DISPOSAL PLAN

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/904**

REV No. **D**

ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-904.dwg

BAREWELL DRIVE

ENNS AVENUE

PORT KENNEDY DRIVE

CCW

RESERVE

4.0 GWL

3.0 GWL

3.5 GWL

583

582

581

LEGEND

- SITE BOUNDARY
- 7.40 FINISHED LOT LEVEL
- PROPOSED KERB
- PROPOSED DRAINAGE
- PROPOSED DRAINAGE BASIN
- 2.0m AAGWL ANNUAL AVERAGE GROUND WATER LEVEL
- 6.70 PROPOSED ROAD LEVELS
- PROPOSED DRAINAGE FLOW
- CATCHMENT BOUNDARY
- 50m ENVIRONMENTAL BUFFER

1:2000 0 20 40 80 120
Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 117-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

Level 2 Kisborn Court
58 Kisborn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@porterseng.com.au
www.porterseng.com.au

TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **CONCEPT DRAWING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/905**

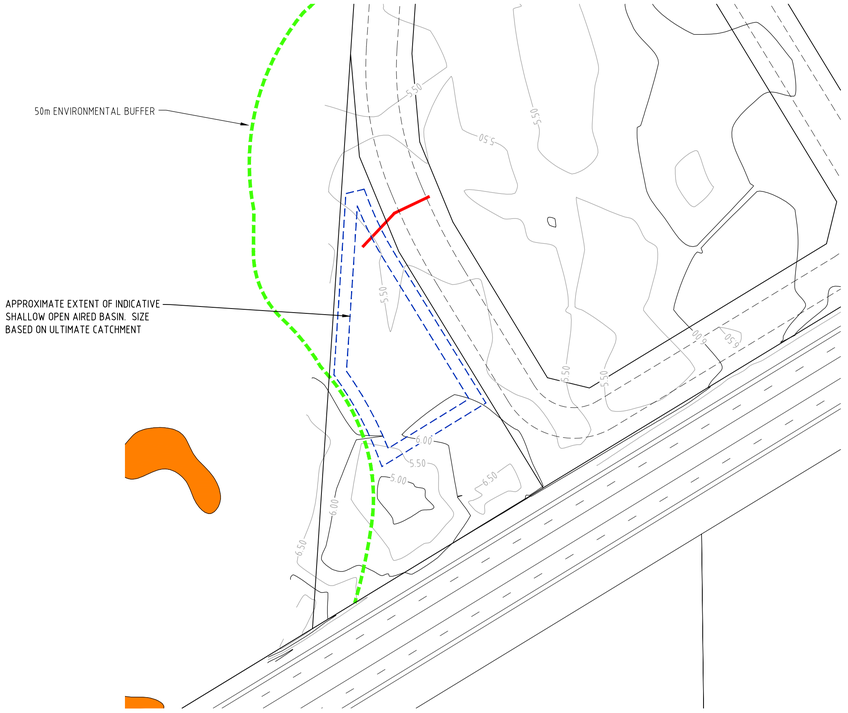
REV No. **D**

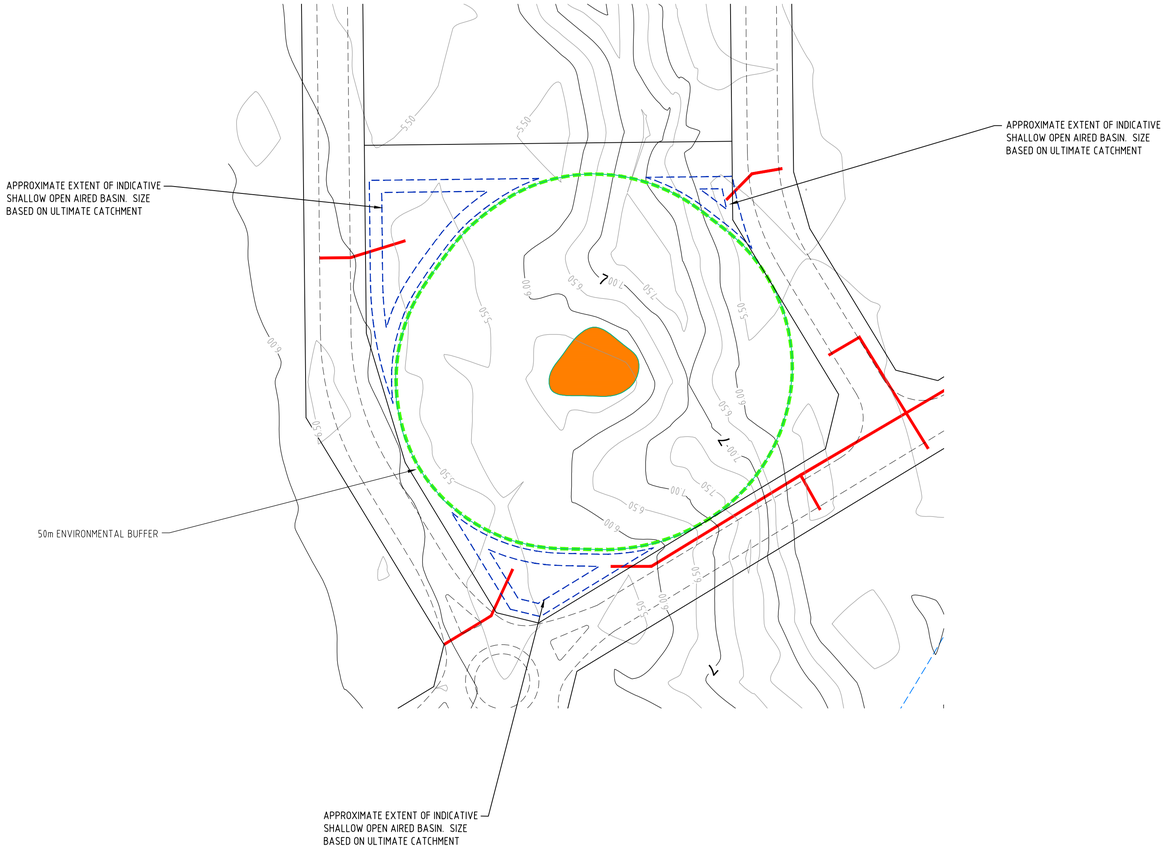
ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-905.dwg

LEGEND

- EXISTING CONTOURS
- PROPOSED KERB
- PROPOSED DRAINAGE
- PROPOSED OPEN AIRED DRAINAGE BASIN
- 50m BUFFER





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1:1000 0 10 20 40 60
Half Size 1:2000 - SCALE (m)

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No	DATE	REVISION	BY
C	10-10-2023	UPDATED STRUCTURE PLAN 7117-278 ST01A 2023-09-27	MEG
B	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
A	30-12-2021	CONCEPT	MEG

Porter Consulting Engineers
TUSMO Pty Ltd ACN 070 097 568 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385
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Canning Bridge 6153 WA
Tel (08) 9315 9955
Email office@porterseng.com.au
www.porterseng.com.au

CLIENT: DevelopmentWA

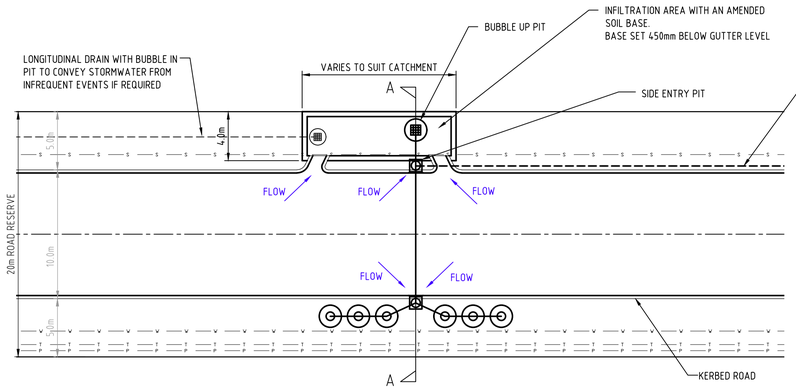
DRAWING: **PROPOSED DRAINAGE BASINS**

STATUS: **CONCEPT**

SCALE	1:1000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 18-6-73/906 | REV No. C | ORIGINAL DRAWING SIZE A1

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-906.dwg



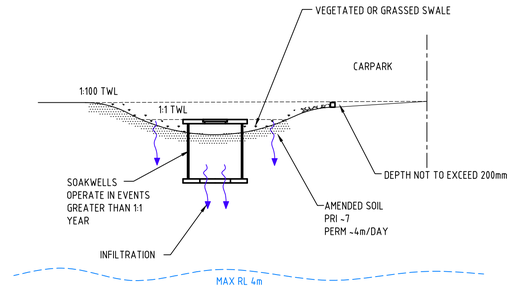
TYPICAL LOW POINT DRAINAGE ARRANGEMENT MAY INCLUDE
- 2 x INLET PITS
- 1 x BUBBLE UP PIT
- 6 x SOAKWELLS
- 4m WIDE INFILTRATION AREA APPROX 15m LONG

ALL CHAMBERS ARE Ø1.8m x 1.2m DEEP WITH SOAKAGE BASES

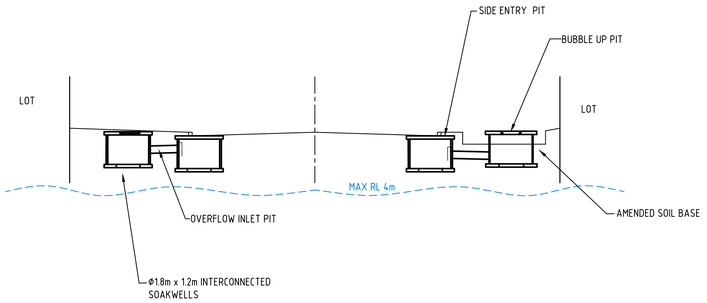
THIS WILL HOLD RUNOFF FROM 14.0m OF ROAD RESERVE (c=0.8) FOR THE 10% AEP EVENT WITH 100mm FREEBOARD TO GUTTER LEVEL

RUNOFF FROM THE 1% AEP EVENT IS HELD LOCALLY WITH ONLY MINOR FLOODING AT THE KERBLINE (70mm).

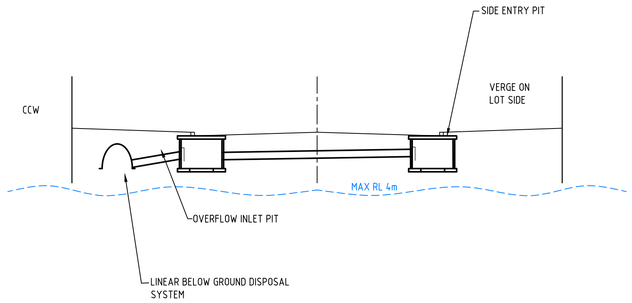
ROAD RESERVE- TYPICAL LOW POINT DRAINAGE
1:250



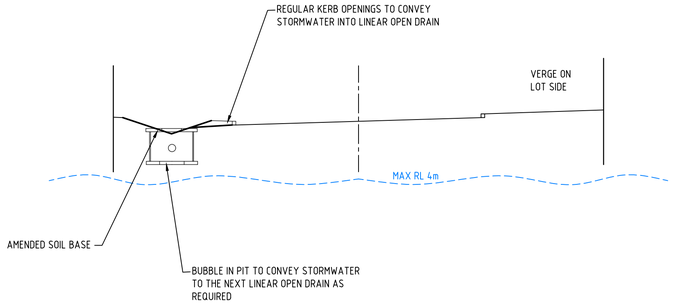
LOT STORMWATER DRAINAGE
1:100



ROAD RESERVE- TYPICAL LOW POINT DRAINAGE
1:125
SECTION A-A



ROAD RESERVE- TYPICAL BELOW GROUND LINEAR SYSTEM
1:125



ROAD RESERVE- TYPICAL LINEAR OPEN DRAIN
1:125

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PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers
Level 2 Kisborn Court
58 Kisborn Road
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PO Box 1036
Canning Bridge 6153 WA
Tel (08) 9315 9955
Email office@porterenq.com.au
www.porterenq.com.au
TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **DRAINAGE DETAILS**

STATUS: **CONCEPT**

SCALE	AS ABOVE
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/907**
REV No. **A**
ORIGINAL DRAWING SIZE **A1**
FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-907.dwg

ATTACHMENT 8
Water Corporation Sewer Catchment Planning

WARNBRO

SD072

CATCHMENT 'V2713 - 072'
SEWER DESIGN FLOW - 11.3L/s

CATCHMENT 'W9839 - 072'
SEWER DESIGN FLOW - 3.0L/s

CATCHMENT 'W9771 - 072'
SEWER DESIGN FLOW - 4.5L/s

WARNBRO P.S. 4-
ST RAPHAEL CR
PUMP STN 4 - 072'
REDUCTION 'S0993 - 072'
SEWER DESIGN FLOW - 24.5L/s
EXISTING PUMP RATE - 49.9L/s
LONG TERM PUMP RATE - 32.6L/s

CATCHMENT 'W4912 - 072'
SEWER DESIGN FLOW - 4.5L/s

CATCHMENT 'W9848 - 072'
SEWER DESIGN FLOW - 1.9L/s

CATCHMENT 'W9826 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V2432 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V9675 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V4706 - 072'
SEWER DESIGN FLOW - 2.4L/s

CATCHMENT 'A6685 - 072'
SEWER DESIGN FLOW - 1.9L/s

CATCHMENT 'V9811 - 072'
SEWER DESIGN FLOW - 3.5L/s

CATCHMENT 'A6692 - 072'
SEWER DESIGN FLOW - 6.9L/s

CATCHMENT 'A0600 - 072'
SEWER DESIGN FLOW - 8.2L/s

CATCHMENT '72 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT '71 - 072'
SEWER DESIGN FLOW - 2.6L/s

CATCHMENT 'X0957 - 072'
SEWER DESIGN FLOW - 2.9L/s

CATCHMENT '40 - 072'
SEWER DESIGN FLOW - 2.3L/s

CATCHMENT '35 - 072'
SEWER DESIGN FLOW - 2.0L/s

CATCHMENT '34 - 072'
SEWER DESIGN FLOW - 2.0L/s

CATCHMENT 'X8841 - 072'
SEWER DESIGN FLOW - 1.5L/s

CATCHMENT 'S0901 - 072'
SEWER DESIGN FLOW - 4.2L/s

CATCHMENT 'V4931 - 072'
SEWER DESIGN FLOW - 3.9L/s

CATCHMENT 'U3600 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'U3596 - 072'
SEWER DESIGN FLOW - 2.8L/s

CATCHMENT '50 - 072'
SEWER DESIGN FLOW - 5.5L/s

CATCHMENT '51 - 072'
SEWER DESIGN FLOW - 9.9L/s

CATCHMENT 'V4368 - 072'
SEWER DESIGN FLOW - 14.9L/s

WARNBRO P.S. 13-
ENDEAVOUR DR
PUMP STN '13 - 072'
REDUCTION 'S0995 - 072'
SEWER DESIGN FLOW - 56.6L/s
EXISTING PUMP RATE - 33.0L/s
LONG TERM PUMP RATE - 89.6L/s

ATTACHMENT 9
Concept Sewer Layout

LEGEND

- RETICULATION AREA BOUNDARY
- 7.90 FINISHED LOT LEVEL
- Φ225P PROPOSED SEWERS & ACCESS CHAMBER (AC) OR MAINTENANCE SHAFT (MS)
- SEWER INSTALLED VIA TRENCHLESS TECHNIQUES
- Φ225P @300 DN225 SEWER @1:300
- EXISTING GRAVITY SEWER
- PM EXISTING SEWER PRESSURE MAIN
- 2.0m GWL ANNUAL AVERAGE GROUND WATER LEVEL
- 1.70 PROPOSED SEWER FLOW
- IL 4.00 INDICATIVE SEWER LEVEL

LOT HAS MULTIPLE SEWER JUNCTIONS TO MANAGE FILLING REQUIREMENTS DUE TO THE SHAPE OF THE LOT

SECTION OF MAIN TO BE INSTALLED USING TRENCHLESS TECHNIQUES

CCW

RESERVE

BAKEWELL DRIVE

ENNIS AVENUE

PORT KENNEDY DRIVE

1.15ha SITE LOT SERVICED VIA GRAVITY AT 1:80

1.15ha SITE LOT SERVICED VIA GRAVITY AT 1:80

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:

PORT KENNEDY BUSINESS PARK
PORT KENNEDY

No	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	13-4-2021	CHANGES MADE TO CCW CROSSING AS PER WCWA EMAIL DATED 9-2-2021	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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TUSMO Pty Ltd ACN 070 097 948 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **CONCEPT WASTEWATER SERVICING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/901** REV No. **D** ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-901.dwg

ATTACHMENT 10
Concept Water Main Layout

CCW

RESERVE

ENNS AVENUE

BAKEWELL DRIVE

PORT KENNEDY DRIVE

DN200 TEE CONNECTION 3.0m TO THE WEST OF THE EXISTING HYDRANT

583

582

581

LEGEND

- RETICULATION AREA BOUNDARY
- 60 — FINISHED LOT LEVEL
- 150P-16 — PROPOSED 150mm WATER MAIN, PIPE SIZE AND MATERIAL DESIGNATION
- 200P-16 — PROPOSED 200mm WATER MAIN, PIPE SIZE AND MATERIAL DESIGNATION
- EXISTING WATER MAIN, HYDRANT & SLUICE VALVE

BEFORE YOU DIG www.byda.com.au

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
C	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
B	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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Email office@porterenq.com.au
www.porterenq.com.au

TUSMO Pty Ltd ACN 070 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 626 396 385

CLIENT: DevelopmentWA

DRAWING:

CONCEPT WATER SERVICING PLAN

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/902**

REV No. **C**

ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-902.dwg

ATTACHMENT 11
Western Power Feasibility Study and Concept Power Layout

Feasibility Study

Project Name:	MF010087 – Port Kennedy Business Park
Customer Ref:	SAA2011127
Number of lots:	106
Date:	June 2011

1. INTRODUCTION

Porter Consulting Engineers on behalf of the developer has requested a Feasibility Study for power supply to the proposed Port Kennedy Business Park development in Port Kennedy. The following information has been provided to us for conduct this study. Please refer to the Appendix for more information.

Number of lots	106 Lots
Number of stages	Not available at this stage
Load take-up	1 to 2 years for start of Stage 1, other Stages unknown
Proposed Load	Approximately 7MVA load based on 200kVA /ha.

2. EXISTING INFRASTRUCTURE

Figure 1 and Figure 2 below show the 22kV network and zone substations around the proposed Port Kennedy Business Park. Based on the current network configuration and feeders loads, there are insufficient spare capacities available on these networks to supply the 7MVA load in Port Kennedy Business Park.

With the size of the proposed development, a new feeder is likely to be required to supply the entire 7MVA load.

Figure 1: Existing 22kV Network around the Proposed Port Kennedy Business Park

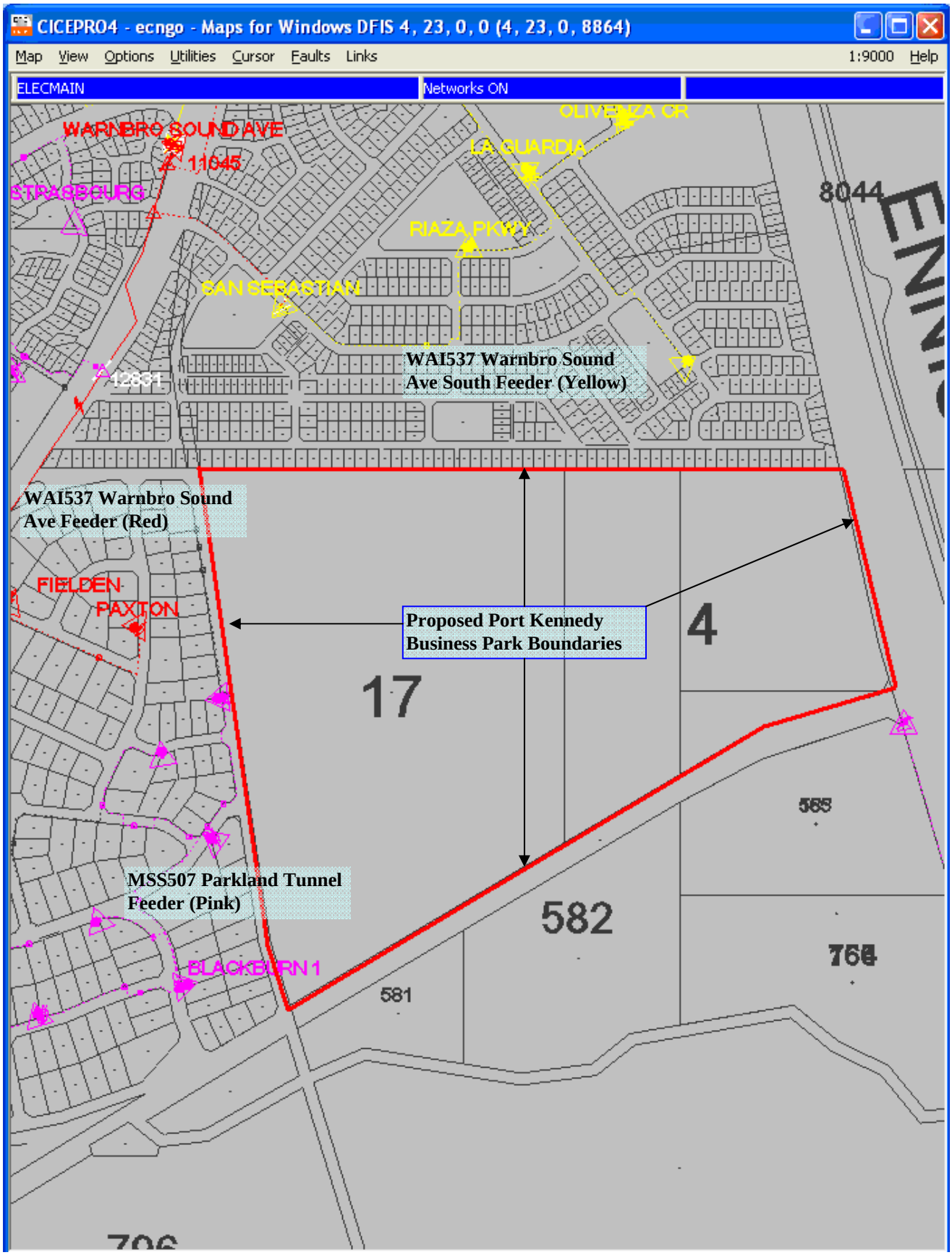


Figure 2: Extended MV network including Zone substations around the Proposed Development

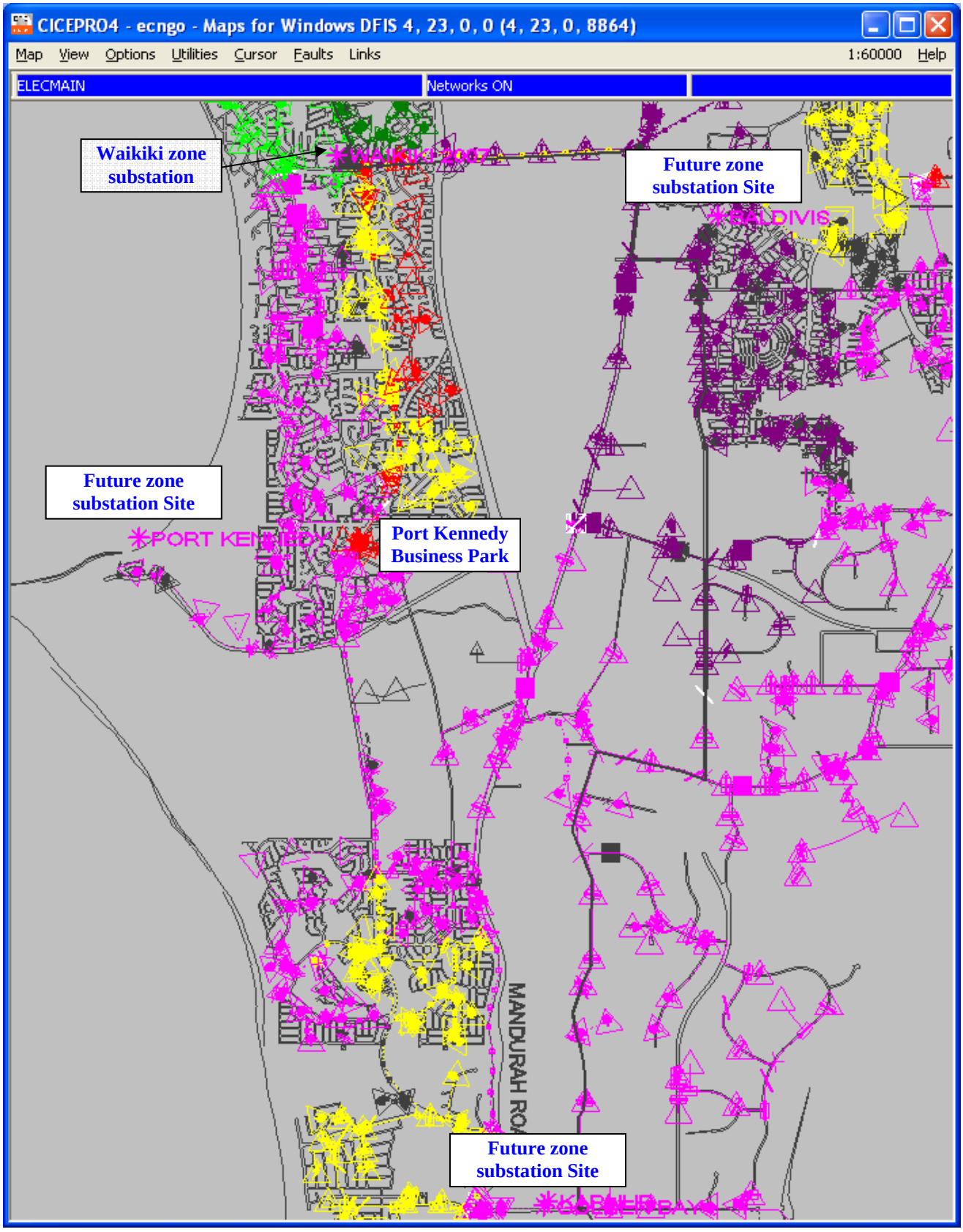
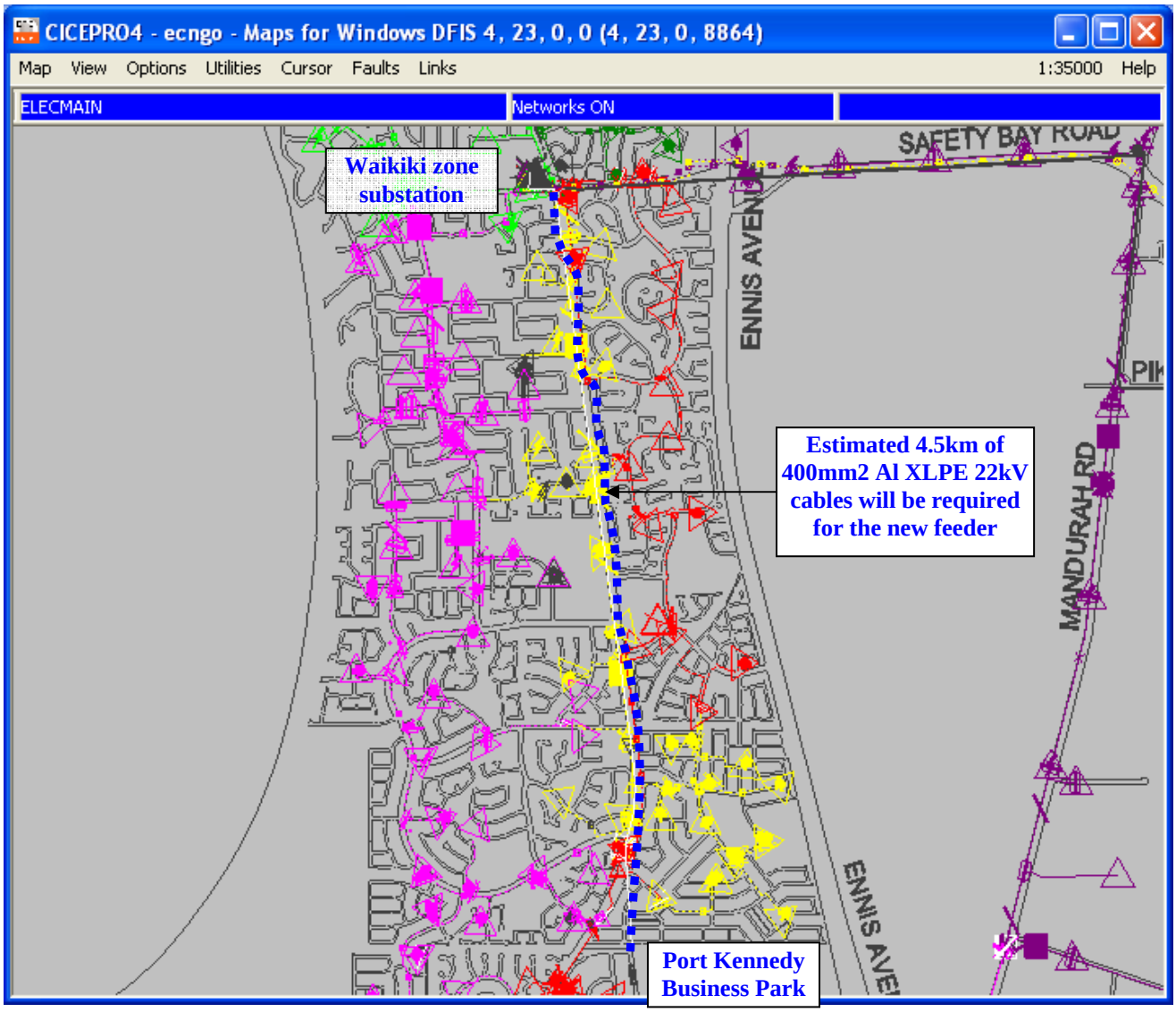


Figure 3: One option to supply the 7MVA Port Kennedy Business Park Load



3. STUDY DETAILS

Analysis of the proposed loads was conducted considering other load requests and predicted load growth in the surrounding region. Consideration was also given to the substation capacity shortfall in the surrounding area, as well as the distribution feeder capacity. The analysis indicates that reinforcements are required to cater for the proposed developments.

4. REINFORCEMENT ESTIMATE

Based on the present network configuration and feeders load, there are some spare network capacities available on the WAI 536 Warnbro Sound Ave South feeder and WAI 537 Warnbro Sound Ave feeder to supply around 2MVA of new loads in this area.

Once the spare network capacities are used up, one network reinforcement option is to install a new feeder from Waikiki zone substation which may require up to 4.5 km of 400mm2 Al XLPE 22kV cables. Please refer to Figure 3 for an indicative feeder route. The requirement and timing of this new feeder is dependant on the load growth of this and other surrounding developments in the area. It might also be possible to extend from a future feeder which has spare capacity.

Please note that the network reinforcement outlined above does not include any work within the development boundary.

5. GENERAL ASSESSMENT

The details in this feasibility study report are only indicative. Further in-depth study and analysis will be required to determine the exact requirement of the reinforcement works once a formal application to Western Power has been lodged. It would be appreciated that at the time of the initial application, a staging plan with expected takeoff dates be provided to Western Power.

Western Power can neither reserve capacity nor guarantee supply to this development without a formal request being lodged. In order to provide a firm connection proposal and cost, a formal application to Western Power will have to be made, in accordance with our connection policies.

Appendix: Customer Completed Feasibility Request Form

westernpower

Electricity Networks Corporation ABN 18 540 492 861

Part A - Application type

☐ Feasibility Enquiry ☑ Feasibility Study

Applicant details - for tax invoice

Title (e.g. Mr, Mrs)	Mr	Surname	Porter
Given name(s)	David		
Company or busines name	Porter Consulting Engineers		
		ABN	N/A
Postal address	PO Box 1036		
Suburb or town	Canning Bridge	Post code	6153
Email (optional)	david@portereng.com.au		
Mobile (optional)	N/A	Telephone	(08) 93159955
Fax (optional)	(08) 93159959		
Western Power reference number (if applicable)	N/A		

Part B - Land use

Residential	☐	Commercial/Industrial	☑	Special Rural	☐
Other (please describe)					
Number of lots	120	Number of stages	N/A	Number of lots per stage	N/A
Approximate commencment date for each stage.	12 months to 24 months for start of stage 1. Other stages unknown.				
Comments					

Part C - Project details

Please attached Stage Plan with this document.

Project name	Port Kennedy Business Park
Your project reference number	SAA2011127

Part D - Site address/location plan

Please attach a location plan or concept plan with this document.

Site address	Lots 4 & 17 Port Kennedy Drive
Suburb or town	Port Kennedy — Post code: 6172
Nearest cross street	Port Kennedy Drive between Ennis Ave and Bakewell Drive
Map number	N/A
Grid reference	N/A — From street directory

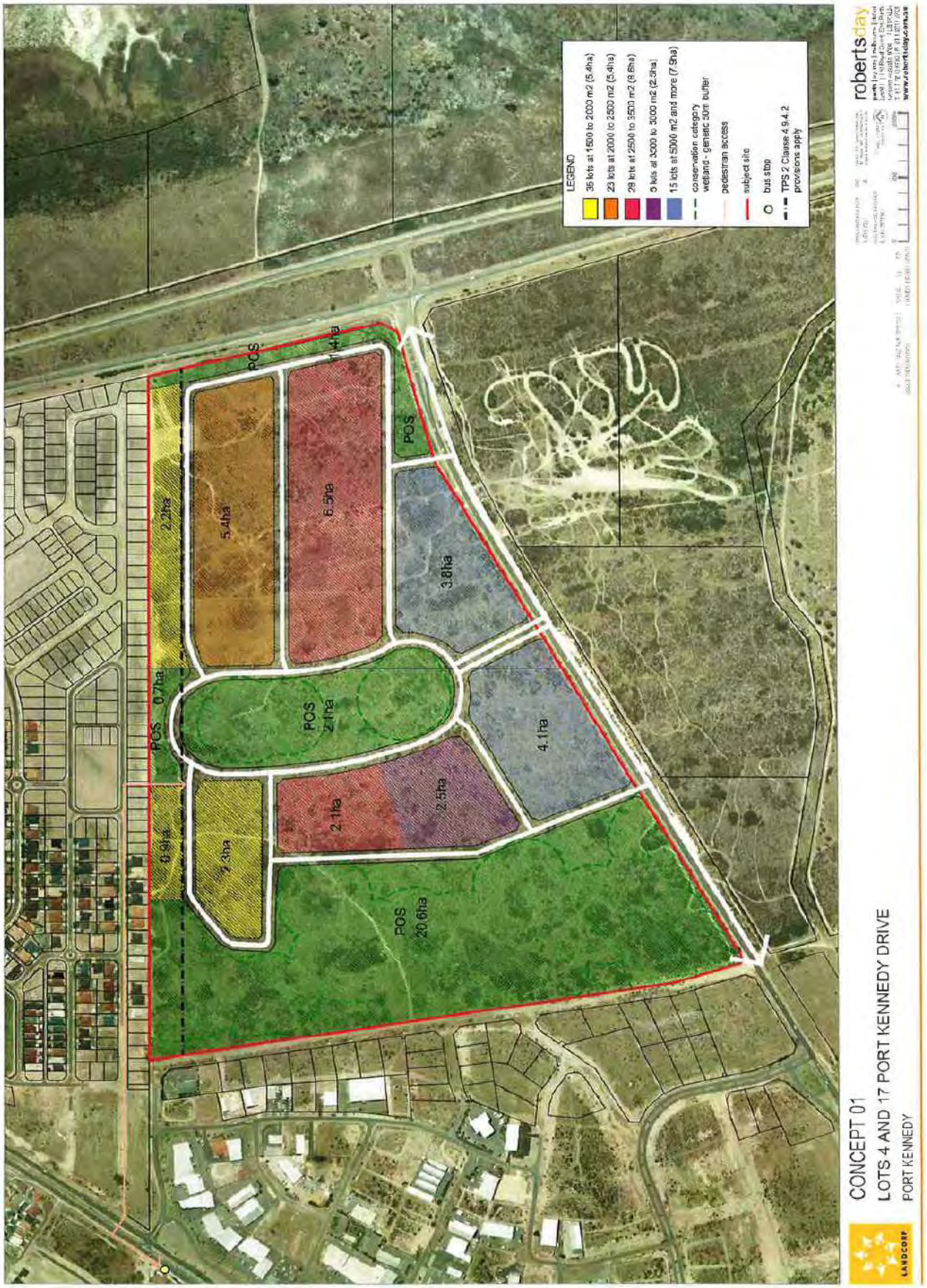
Part E - Proposed loading

ADMD per lot	200kVA/ha
Comments	Total usable area is 34.5ha equating to approximately 7MVA.

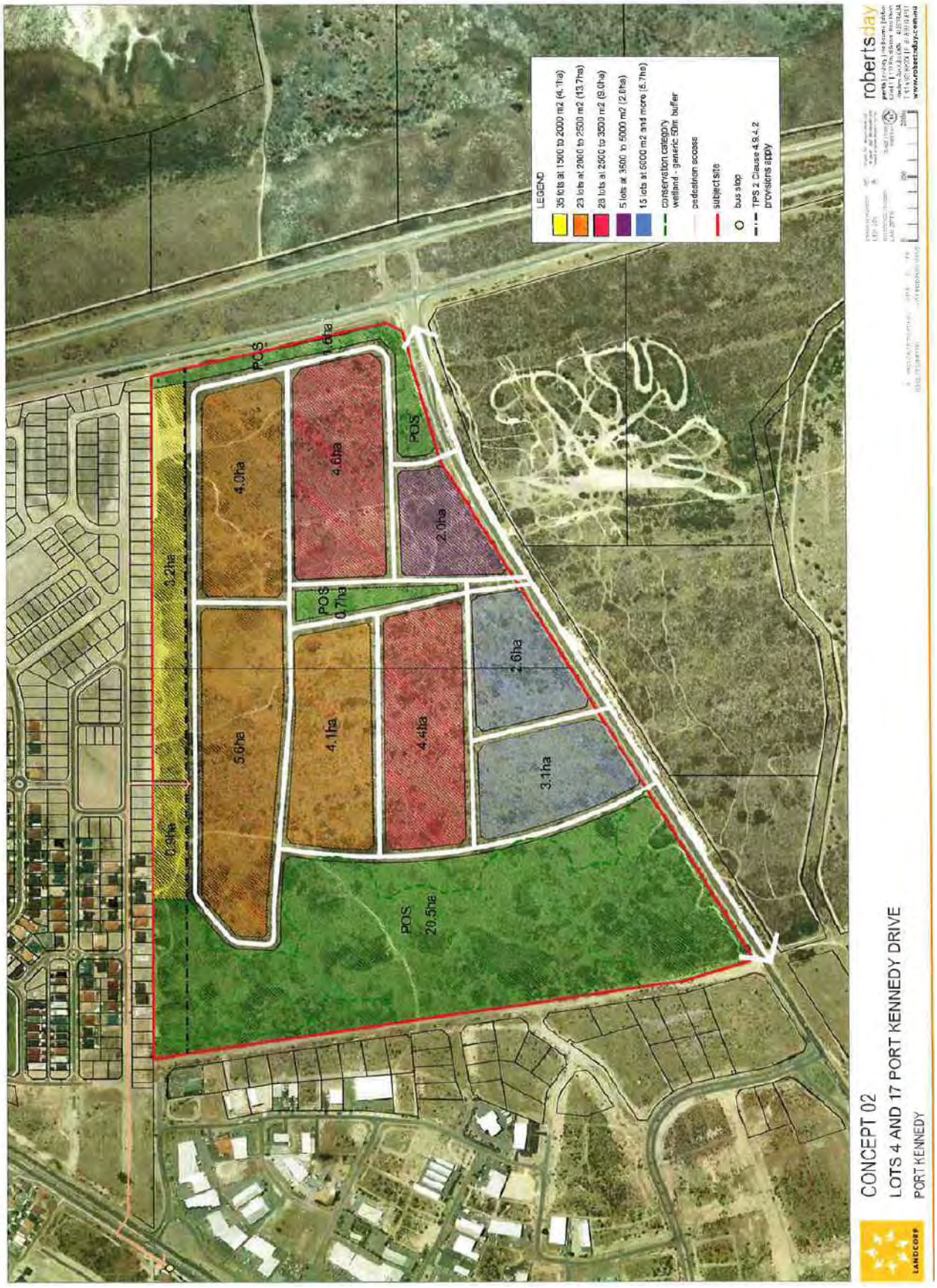
Part F - Approval

On signing this form as the duly authorised representative, the signatory accepts liability for payment of $315.00 (inc GST) for a Feasibility Enquiry or $775.00 (inc GST) for a Feasibility Study. Please refer to 'Terms & Conditions'.

Name	David Porter
Mobile (optional)	Telephone ([redacted]) 93159955
Signature	Date 27 / 05 / 2011



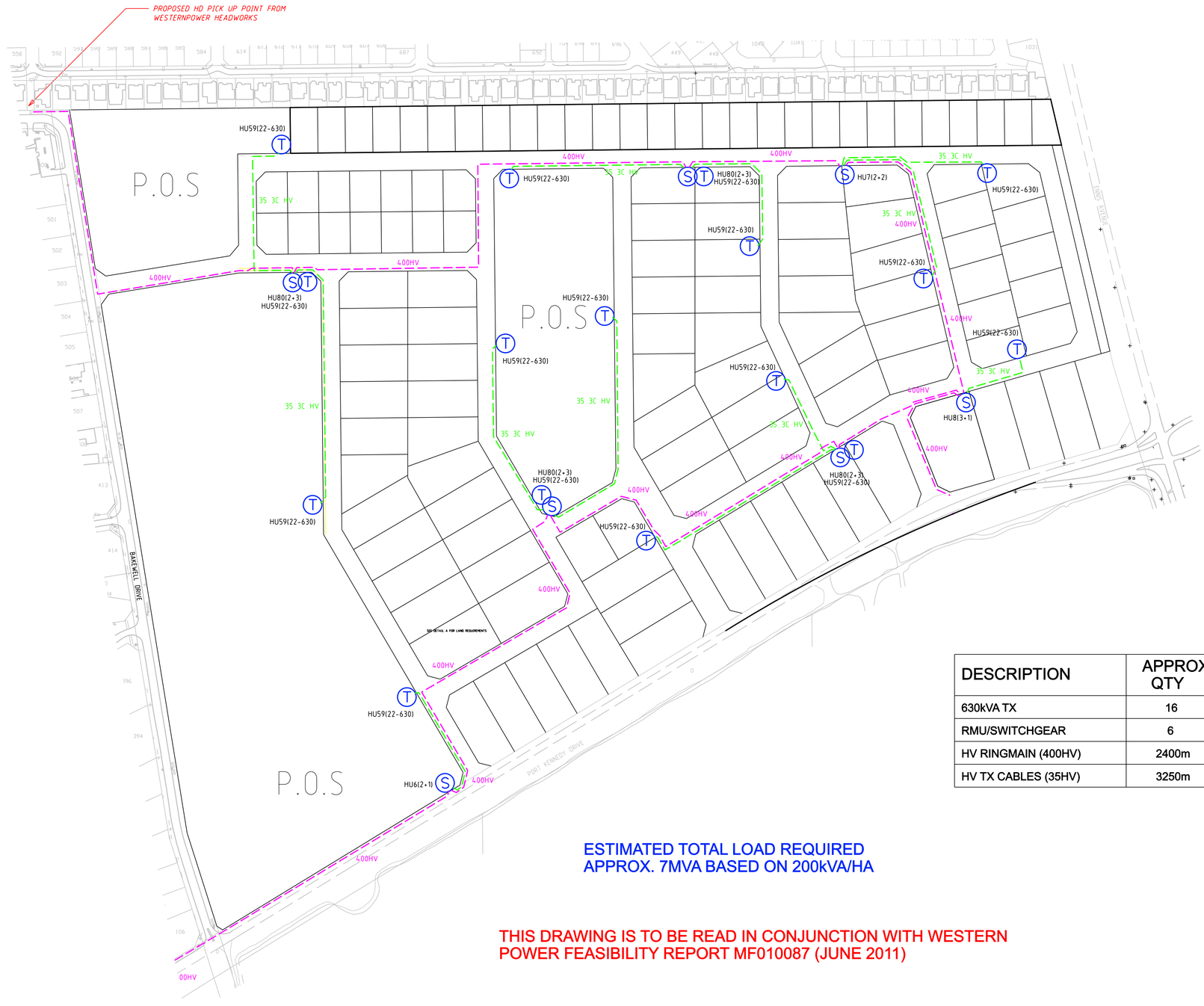
Proposed Development Plan – Concept 01



Proposed Development Plan – Concept 02

NOTES:

1. INSTALLATION TO BE IN ACCORDANCE WITH WESTERN POWER UNDERGROUND DISTRIBUTION SCHEMES POLICY AND INSTALLATION MANUALS, WAER, AS3000 AND ANY OTHER REGULATORY REQUIREMENTS.
2. ALL TRANSFORMER LAND REQUIREMENTS (IF REQUIRED) ARE TO BE LOCATED IN THE ROAD RESERVE OR P.O.S.
3. CABLE JOINTS SHOWN IN NOMINAL POSITIONS. TO BE INSTALLED IN REQUIRED LOCATION AND ONLY IF NECESSARY. FINAL LOCATIONS TO BE SHOWN ON 'AS CON' WITH DIMENSIONS FROM NEAREST PEG.



DESCRIPTION	APPROX QTY
630kVA TX	16
RMU/SWITCHGEAR	6
HV RINGMAIN (400HV)	2400m
HV TX CABLES (35HV)	3250m

ESTIMATED TOTAL LOAD REQUIRED
APPROX. 7MVA BASED ON 200kVA/HA

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH WESTERN POWER FEASIBILITY REPORT MF010087 (JUNE 2011)

CABLE		CONDUIT SIZE
400mm2	HV	160mm
240mm2	HV	150mm
185mm2	HV	150mm
95mm2	HV	150mm
50mm2	HV	150mm
35mm2	HV	100mm
240mm2	LV	100mm
185mm2	LV	100mm
120mm2	LV	100mm
25mm2	LV	50mm
16mm2	SL	50mm
10mm2	SL	50mm
40 C PILOT		50mm

STREET LIGHTS: 70W HPS, 150W HPS, 250W HPS, 70/75W MH, 150W MH, 250W MH, EXISTING, 42W CF

AERIAL CONDUCTORS AND POLES: NEW POLE (ANY TYPE AS INDICATED); EXISTING POLE (ANY TYPE AS INDICATED); EXISTING AERIAL CONDUCTORS (SIZE AND TYPE AS INDICATED)

PILLARS: UNIVERSAL, MINI, MINI -WORKING END, LINK, UMS PIT, 100AMP CUTOUT, 200AMP CUTOUT

TRANSFORMERS (T); SWITCHGEAR (S)

SCHEME BOUNDARY; RETAINING WALLS

DUCTS: ARROW DENOTES ALIGNMENT TO PEG; EXISTING DUCTS

DUCTS TO BE LAID TO WPC SPECIFICATION ES 3/16/84

METRES 125 0 125 250

LOCAL SHIRE: CITY OF ROCKINGHAM

Stapleton and Associates Pty. Ltd.
Consulting Electrical & Control Engineers
A.B.N. 50 008 949 755
Level 4, 524 Hay Street, Perth, Western Australia 6000.
Phone (08) 9325 4588 / Fax (08) 9221 3934
Email: info@stapletons.net.au

SHEET SIZE A1

REFERENCES

DRG. No.	DESCRIPTION

REVISIONS

No	DR'N	CHK'D	DATE	DESCRIPTION
0	D.E.T.	D.E.T.	05-08-11	ISSUED FOR CLIENT COMMENTS

SCALE 1:2500

0 10 20 30 40 50

DRAWN	D.E.T.	04-08-11
DESIGNED	D.E.T.	04-08-11
CHECKED	D.E.T.	04-08-11
PROJECT ENGINEER		
APPROVED		

CLIENT
PORTER CONSULTING ENGINEERS / LANDCORP

TITLE
PORT KENNEDY BUSINESS PARK
WPC U/G ELECTRICAL DEVELOPMENT
PROPOSED HIGH VOLTAGE RETICULATION

DRG. No. 2011127-E-001

REVISION 0

...\Microstation\2011127001.dgn 5/08/2011 4:42:28 PM

ATTACHMENT 12
Indicative Bulk Earthwork Re-contouring Plan

LEGEND

- EARTHWORKS AREA BOUNDARY
- 7.90 FINISHED LOT LEVEL
- — 2.0m AAGWL — ANNUAL AVERAGE GROUND WATER LEVEL
- PROPOSED KERB

NOTE:
EARTHWORKS ARE NOT TO ENCROACH INTO THE CCW OR RESERVE LOTS

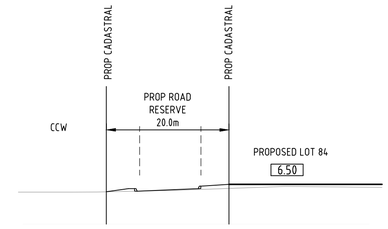
CCW

RESERVE

BAKEWELL DRIVE

PORT KENNEDY DRIVE

ENNIS AVENUE



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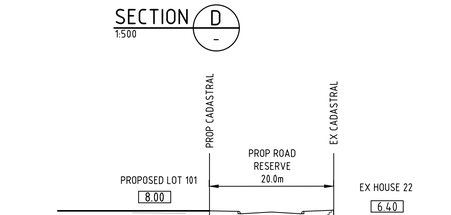

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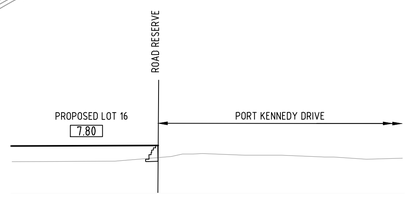

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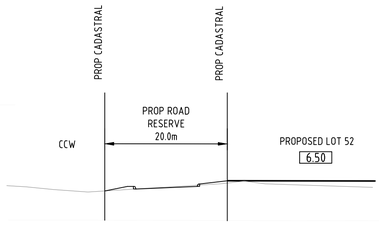
SECTION E 1:500



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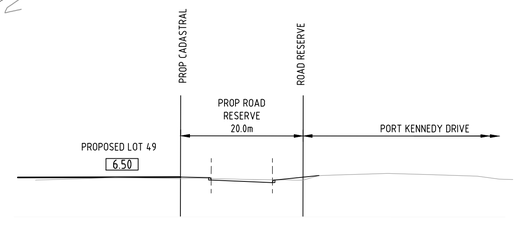

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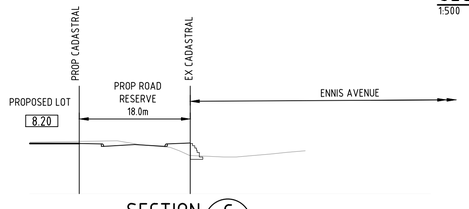

SECTION C 1:500

1:500 0 5 10 20 30 Half Size 1:1000 - SCALE (m)

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 6A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

Level 2 Kishorn Court
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Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@portereng.com.au
www.portereng.com.au

TUSMO Pty Ltd ACN 070 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: CONCEPT EARTHWORKS PLAN

STATUS: CONCEPT

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 18-6-73/903

REV No. D

ORIGINAL DRAWING SIZE A1

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-903.dwg

ATTACHMENT 13
Staging Plan

DIAL BEFORE YOU DIG www.1100.com.au

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
B	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **STAGING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/900** | REV No. **B** | ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-900.dwg

Porter
Consulting Engineers

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Appendix F New Groundwater Monitoring Data

1. Results

1.1 Standing Water Levels & Hydrogeology

The standing water levels (SWL) in the wells were measured over five separate events between 12 July 2022 and 04 November 2022 are presented in the tables (**Table 2 – Table 7**) below. The SWLs were reduced to the Australian Height Datum (m AHD) from the top of casing to allow the assessment of the groundwater flow direction across the site.

Table 2 – Groundwater Levels (July 2022)

Well ID	Standing Water Level (m below top of casing)	Total Well Depth (m below top of casing)	LNAPL / DNAPL Present	Well Collar Elevation (m AHD)[1]	Standing Water Level (m AHD)
PK2 NEW	3.206	5.565	No	6.527	3.321
PK2	3.115	4.80	No	6.458	3.343
PK3	3.235	4.980	No	6.969	3.734
PK4	3.29	5.550	No	5.919	2.629
PK5	2.14	5.040	No	5.973	3.833
PK7	5.58	7.610	No	7.785	2.205

The groundwater elevations at the site during the July 2022 GME range between 2.205 m AHD (PK7) and 3.734 m AHD (PK3). The groundwater elevation from each of the monitoring wells on site has been used to create the groundwater contour plot shown in **Figure 3A**, with groundwater inferred to flow within south-easterly direction, towards the Lake Walyungup.

Table 3 – Groundwater Levels (August 2022)

Well ID	Standing Water Level (m below top of casing)	Total Well Depth (m below top of casing)	LNAPL / DNAPL Present	Well Collar Elevation (m AHD)	Standing Water Level (m AHD)
PK2 NEW	2.775	5.565	No	6.527	3.752
PK2	2.714	4.814	No	6.458	3.744
PK3	2.775	5.005	No	6.969	4.194
PK4	2.93	5.555	No	5.919	2.989
PK5	2.752	5.040	No	5.973	2.288
PK7	5.375	7.614	No	7.785	2.239

The groundwater elevations at the site during the August 2022 GME range between 2.239 m AHD (PK7) and 4.194 m AHD (PK3). The groundwater elevation from each of the monitoring wells on site has been used to create the groundwater contour plot shown in **Figure 3B**, with groundwater inferred to flow within south-easterly direction, towards the Lake Walyungup.

Table 4 – Groundwater Levels (September 2022)

Well ID	Standing Water Level (m below top of casing)	Total Well Depth (m below top of casing)	LNAPL / DNAPL Present	Well Collar Elevation (m AHD)	Standing Water Level (m AHD)
PK2 NEW	2.775	5.560	No	6.527	3.752
PK2	2.465	4.840	No	6.458	3.993
PK3	2.565	5.002	No	6.969	4.404
PK4	2.663	5.560	No	5.919	3.256
PK5	2.521	5.042	No	5.973	3.452
PK7	4.961	7.615	No	7.785	2.824

[1] LandSurveys survey of all existing monitoring wells on 11 October 2016. Survey data for MW08 was not available at the time of reporting.

The groundwater elevations at the site during the September 2022 GME range between 2.824 m AHD (PK7) and 4.404 m AHD (PK3). The groundwater elevation from each of the monitoring wells on site has been used to create the groundwater contour plot shown in **Figure 3C**, with groundwater inferred to flow within south-easterly direction, towards the Lake Walyungup.

Table 5 – Groundwater Levels (October 2022)

Well ID	Standing Water Level (m below top of casing)	Total Well Depth (m below top of casing)	LNAPL / DNAPL Present	Well Collar Elevation (m AHD)	Standing Water Level (m AHD)
PK2 NEW	2.644	5.564	No	6.527	3.883
PK2	2.583	4.816	No	6.458	3.875
PK3	2.706	4.969	No	6.969	4.263
PK4	2.649	5.546	No	5.919	3.27
PK5	2.484	5.039	No	5.973	3.489
PK7	4.866	7.593	No	7.785	2.919

The groundwater elevations at the site during the October 2022 GME range between 2.919 m AHD (PK7) and 4.263 m AHD (PK3). The groundwater elevation from each of the monitoring wells on site has been used to create the groundwater contour plot shown in **Figure 3D**, with groundwater inferred to flow within south-easterly direction, towards the Lake Walyungup.

Table 6 – Groundwater Levels (November 2022)

Well ID	Standing Water Level (m below top of casing)	Total Well Depth (m below top of casing)	LNAPL / DNAPL Present	Well Collar Elevation (m AHD)	Standing Water Level (m AHD)
PK2 NEW	2.701	5.561	No	6.527	3.826
PK2	2.639	4.819	No	6.458	3.819
PK3	2.772	4.995	No	6.969	4.197
PK4	2.682	5.546	No	5.919	3.237
PK5	2.539	5.039	No	5.973	3.434
PK7	4.896	7.582	No	7.785	2.889

The groundwater elevations at the site during the November 2022 GME range between 2.889 m AHD (PK7) and 4.197 m AHD (PK3). The groundwater elevation from each of the monitoring wells on site has been used to create the groundwater contour plot shown in **Figure 3E**, with groundwater inferred to flow within south-easterly direction, towards the Lake Walyungup.

Table 7 – Groundwater Levels over time

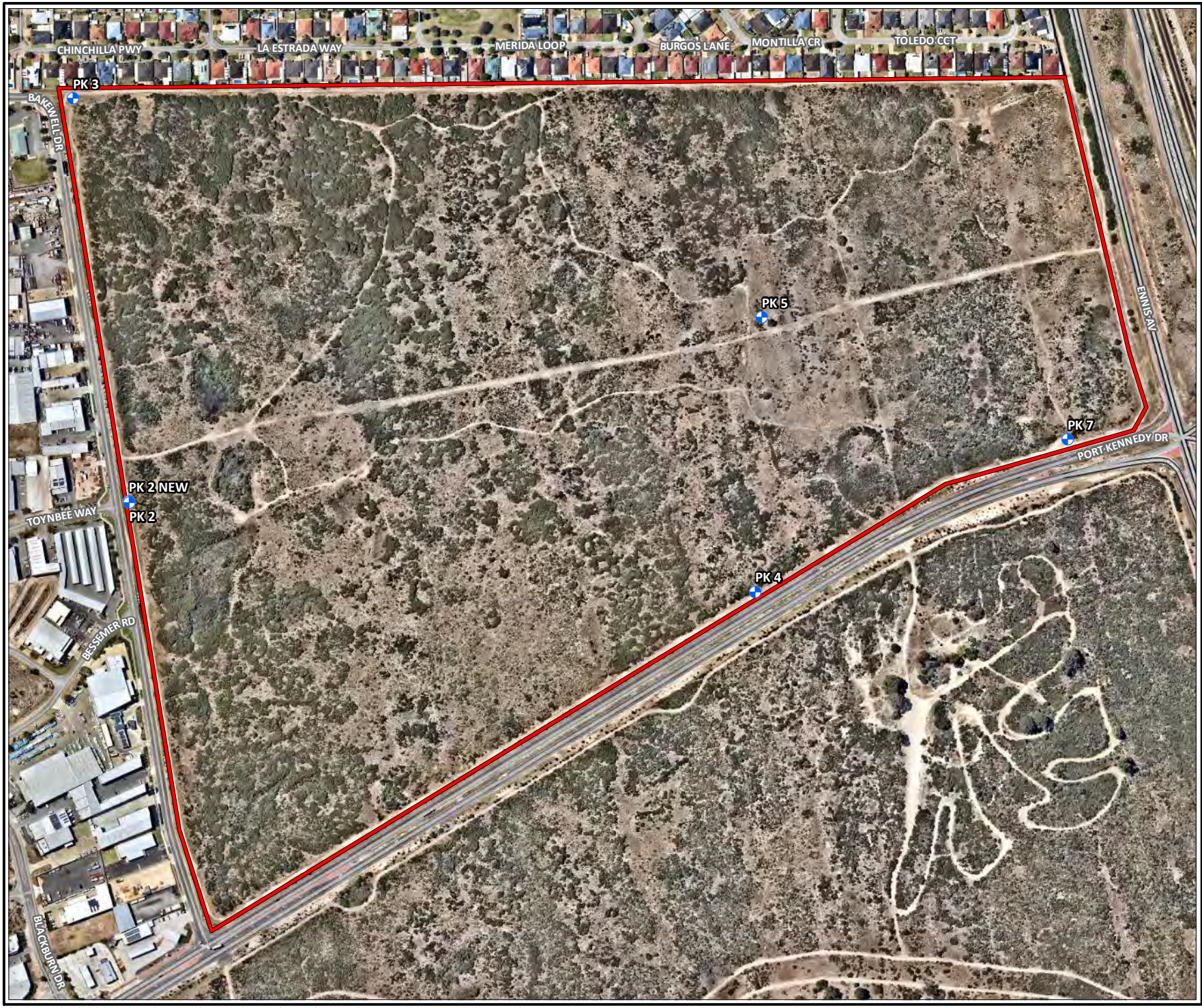
Well ID	Standing Water Level (m AHD)				
	12/07/22	12/08/22	16/09/22	14/10/22	04/11/22
PK2 NEW	3.321	3.752	3.752	3.883	3.826
PK2	3.343	3.744	3.993	3.875	3.819
PK3	3.734	4.194	4.404	4.263	4.197
PK4	2.629	2.989	3.256	3.27	3.237
PK5	3.833	0.598	3.452	3.489	3.434
PK7	2.205	5.033	2.824	2.919	2.889

Legend

- Project area
- Lot boundary
- Rockingham Lakes Regional Park
- Highways
- Main road
- Minor road
- Pedestrian way
- Track

Scale 1:15,000 at A4 (0 150 300 metres)	**Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA**
Coord. Sys. GDA 1994 MGA Zone 50	**SITE LOCATION**
Job No: 63539	
Client: Development WA	**FIGURE 1**
Version: A / Date: 08-Dec-2022	JBS&G
Drawn By: jcrute / Checked By: CT	

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_01_SiteLoc.mxd
Image Reference: SLIP Public Services Locate 2021.



Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater monitoring bore

JBS&G

Job No: 63539

Client: Development WA

Version: A	Date 8/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

SITE LAYOUT

FIGURE 2

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_02_SiteLayout.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater contours (mAHD)
- Groundwater flow direction
- Groundwater monitoring bore

JBS&G

Job No: 63539	
Client: Development WA	
Version: A	Date 9/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

GROUNDWATER CONTOUR FLOW (12/07/22)

FIGURE 3A

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_03A_GW_Contours_July2022.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater contours (mAHD)
- Groundwater flow direction
- Groundwater monitoring bore

JBS&G

Job No: 63539

Client: Development WA

Version: A	Date 9/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

GROUNDWATER CONTOUR FLOW (12/08/22)

FIGURE 3B

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_03B_GW_Contours_Aug2022.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater contours (mAHD)
- Groundwater flow direction
- Groundwater monitoring bore

JBS&G

Job No: 63539	
Client: Development WA	
Version: A	Date 9/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

GROUNDWATER CONTOUR FLOW (16/09/22)

FIGURE 3C

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_03C_GW_Contours_Sep2022.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater contours (mAHD)
- Groundwater flow direction
- Groundwater monitoring bore

JBS&G

Job No: 63539	
Client: Development WA	
Version: A	Date 9/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

0 100 200
metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

GROUNDWATER CONTOUR FLOW (14/10/22)

FIGURE 3D

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_03D_GW_Contours_Oct2022.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Legend

- Project area
- Highways
- Main road
- Minor road
- Groundwater contours (mAHD)
- Groundwater flow direction
- Groundwater monitoring bore

JBS&G

Job No: 63539	
Client: Development WA	
Version: A	Date 9/12/2022
Drawn By: jcrute	Checked By: CT

Scale 1:5,500 at A4

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metres

Coor. Sys. GDA 1994 MGA Zone 50

Lot 4 and Lot 17, Port Kennedy Dr Port Kennedy, WA

GROUNDWATER CONTOUR FLOW (04/11/22)

FIGURE 3E

File Name: W:\Projects\1)Open\DevelopmentWA\63539 Port Kennedy LWMS\GIS\Maps\R01_Rev_A\63539_03E_GW_Contours_Nov2022.mxd
Image Reference: www.nearmap.com© - Imagery Date: 21. November 2022.

Appendix G Landscaping Plans

TEC RATING:

- HIGH QUALITY
- MEDIUM QUALITY
- LOW QUALITY

LEGEND

01 ENTRY STATEMENT TO ESTATE WITH SIGNAGE WALL

02 EXISTING PEDESTRIAN ACCESS WAY

03 ENTRY TO BUSHLAND TRACK NETWORK INCLUDING EDUCATIONAL SIGNAGE AND ARTWORK/ INTERPRETATIVE ELEMENT (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

04 RETAINED VEGETATION IN EXISTING CONSERVATION AREA CEDED TO DBCA

05 OPEN MESH FENCE TO CONSERVATION AREA FOR VISUAL PERMEABILITY

06 *GRAVEL PATHWAYS ALONG EXISTING BUSH TRACKS

07 SEATING ON DECKING AT LOOKOUT POINTS WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19A- HOLOCENE SEDGELANDS (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

08 SCREENING NATIVE TREE AND SHRUB PLANTING ALONG BOUNDARY FENCE TO RESIDENCES

09 NEW *GRAVEL PATHWAY CONNECTION

10 VEGETATED SWALE WITH ENDEMIC WETLAND PLANTING AND MELALEUCA TREES WITH REFERENCE TO ADJACENT BUSHLAND SPECIES

11 PEDESTRIAN FOOTPATH NETWORK

12 STORMWATER MANAGEMENT INFRASTRUCTURE (INFILTRATION OR BIORETENTION) IN ROADSIDE TO BE PROVIDED AS PER THE INDICATIVE LOCATIONS SHOWN ON THE CONCEPT DRAINAGE PLAN (BY OTHERS)

13 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS

14 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)- SIGNAGE ENDORSED BY DBCA DESIGN STUDIO

15 *GRAVEL PATHWAYS TO TEC 19B- (HOLOCENE WOODLANDS) WITH REVEGETATION INCLUDING TREE PLANTING THROUGHOUT

16 ARTWORK/ INTERPRETIVE ELEMENT TO STREET CORNER AND DECKING OVER DRAINAGE BASIN

17 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS

18 VEGETATED DRAINAGE SWALE ALONG MEDIAN STRIP TO PORT KENNEDY DRIVE

19 VEGETATED DRAINAGE SWALE ALONG PORT KENNEDY DRIVE WITH BUFFER TREE AND SHRUB PLANTING. RETAIN EXISTING 3M WIDE BIKE PATH.

20 RETAIN EXISTING VERGE TREATMENT/ SWALES TO SOUTH SIDE OF PORT KENNEDY DRIVE

21 STREETSIDE PARKING ADJACENT TO CONSERVATION AREA INTERSPERSED WITH VERGE PLANTINGS - TOTAL 8 NO. PARKING BAYS

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

CONCEPT MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.101 REV N

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au

STREET TREE PLANTING

EUCALYPTUS LEUCOXYLON 'ROSEA'

EUCALYPTUS UTILIS

MELALEUCA RHAPHIOPHYLLA

AGONIS FLEXUOSA

EUCALYPTUS TORQUATA

EUCALYPTUS VICTRIX

EUCALYPTUS GOMPHOCEPHALA

ENTERPRISE PARK, PORT KENNEDY

STREET TREE MASTERPLAN
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.102

REV F

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
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LEGEND

01 DRAINAGE BASINS WITH WINTER-WET NATIVE PLANTINGS -NON-IRRIGATED

02 PROTECT AND RETAIN EXISTING REMMANT VEGETATION CORE TO THREATENED ECOLOGICAL COMMUNITY (TEC) 19B (HOLOCENE WOODLANDS)

03 REVEGETATION AREA WITHIN 50M BUFFER ZONE, RETAINING REMNANT VEGETATION AND WITH NEW LOCALLY NATIVE TREE & SHRUB PLANTINGS. TEMPORARY IRRIGATION TO NEW PLANTINGS AND WEED MANAGEMENT THROUGHOUT

04 SEATING ON DECKING AT LOOKOUT POINT WITH INTERPRETIVE SIGNAGE RELATING TO LOCAL ECOLOGY/ BOTANY OF THE AREA (SIGNAGE ENDORSED BY DBCA DESIGN STUDIO)

05 INFORMAL *GRAVEL PATHWAYS THROUGH REGETATION AREA FOR BUSH WALKING

06 STREET TREES & LOW NATIVE GROUNDCOVER PLANTINGS TO VERGE- NON-IRRIGATED

09 ARTWORK/ INTERPRETIVE SHADE ELEMENT TO STREET CORNER WITH INFORMAL SEATING AND/OR TABLES WITH DECKING OVER DRAINAGE BASIN

10 SHORT BOARDWALK ELEMENT OVER DRAINAGE BASIN

11 SMALL LOOKOUT OVER DRAINAGE BASIN

12 CONCRETE FOOTPATHS

13 FOOTPATH INTERFACE WITH LOW MANAGED VEGETATION TO REDUCE FIRE HAZARD TO LOTS- NON-IRRIGATED

14 LANDSCAPE BATTER & ROCKWORK TO MEET EXISTING LEVELS

15 STORMWATER MANAGEMENT INFRASTRUCTURE THAT INCLUDES SUITABLE ENDEMIC VEGETATION

*NOTE: FINISH TO GRAVEL PATHWAYS IS TO BE AGREED WITH DBCA AS PART OF THE CONSERVATION AREA MANAGEMENT PLAN

ENTERPRISE PARK, PORT KENNEDY

PRELIMINARY CONCEPT PLAN - POS 01
JULY 2024

JOB NO. 2011201
1:2500 @ A1

C1.103 REV D

0 25 50 100 150 250m

PLAN E
LANDSCAPE ARCHITECTS
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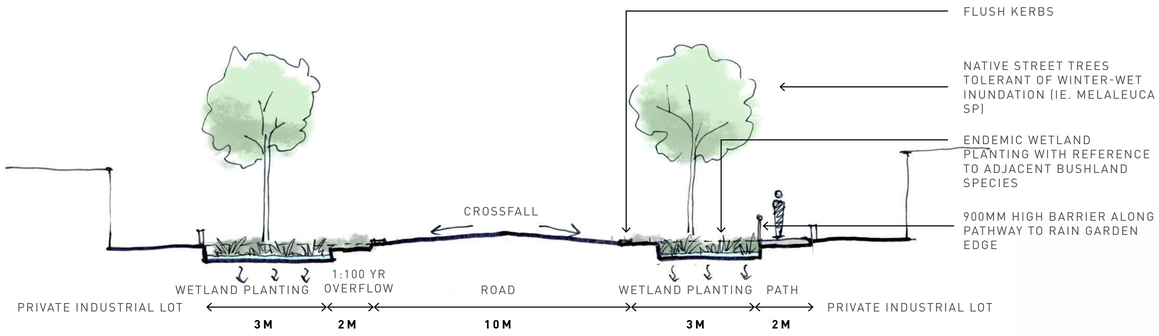
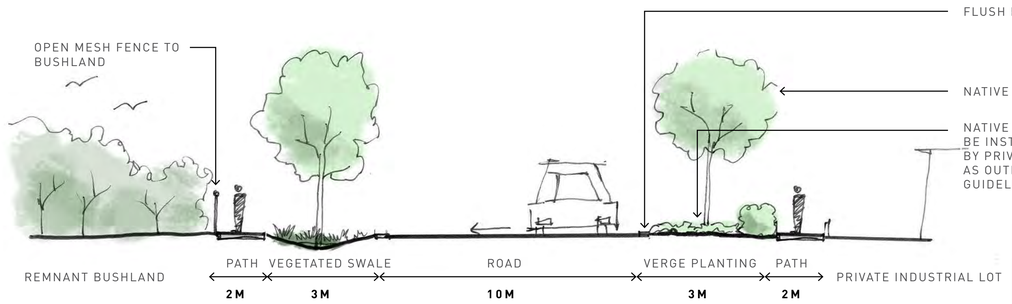
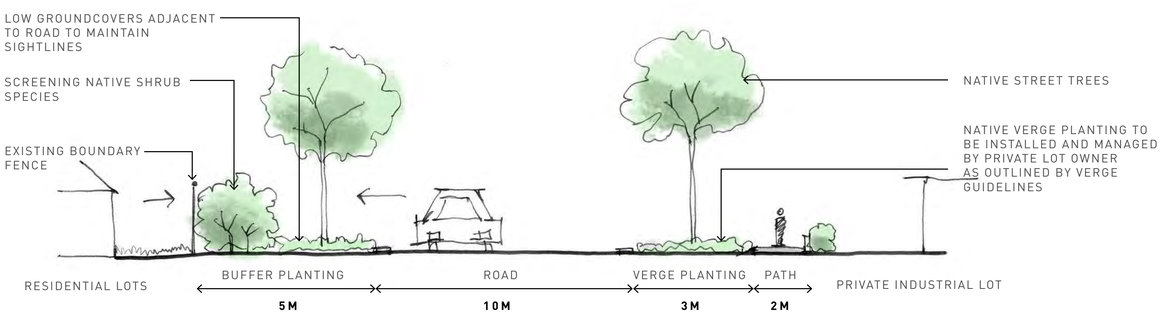


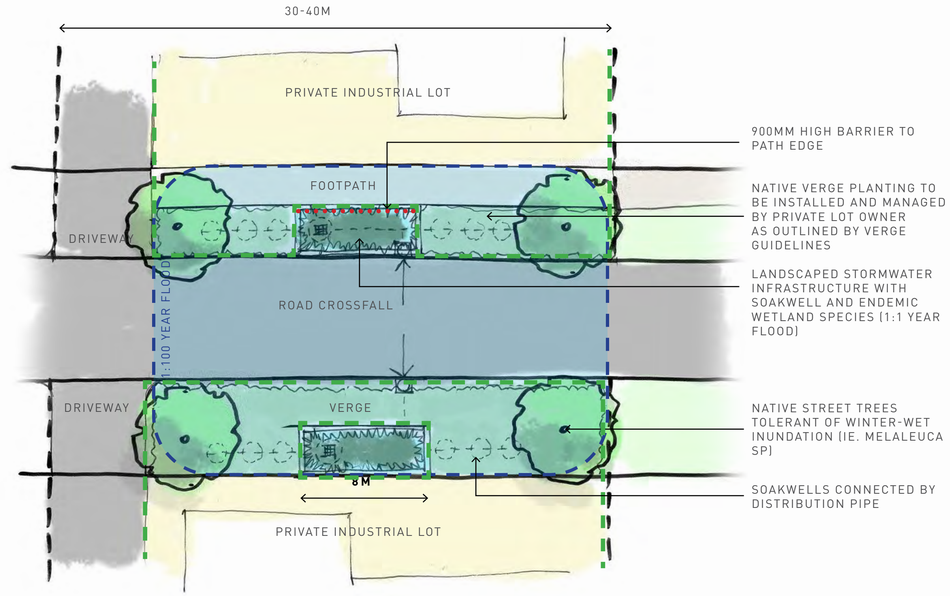
TYPICAL STREET SECTION- RAIN GARDENS



TYPICAL STREET SECTION- CONSERVATION AREA BOUNDARY



TYPICAL STREET SECTION - BUFFER TO RESIDENTIAL LOTS



TYPICAL STREET PLAN - STORMWATER INFRASTRUCTURE

ENTERPRISE PARK, PORT KENNEDY

TYPICAL SECTIONS
JULY 2024

JOB NO. 2011201
NTS

C2.101

REV E

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LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
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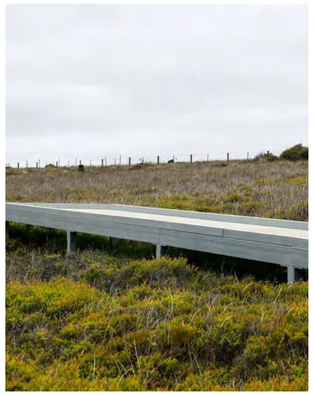
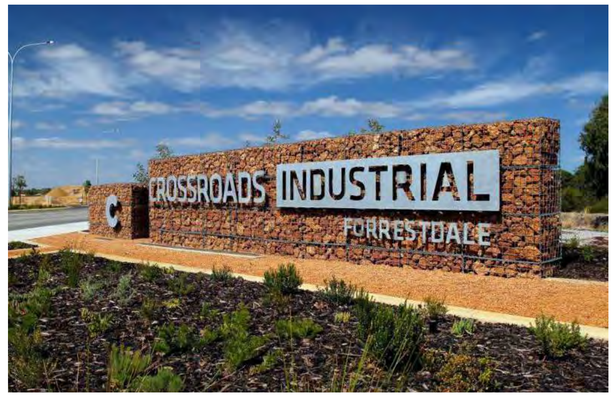
FRP LOW IMPACT AND DURABLE BOARDWALK

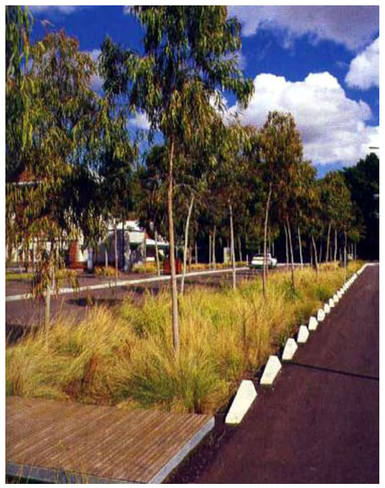
PERMASTRUCT COMPOSITE BOARDWALK



EXISTING REMNANT VEGETATION



TURF AND SHADE TREES IN AMENITY SPACE



RAIN GARDENS

VEGETATED SWALES AND FLUSH KERBING

ENTERPRISE PARK, PORT KENNEDY

CONCEPT IMAGERY
JULY 2024

JOB NO. 2011201 C3.101 REV A

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
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STREET TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


EUCALYPTUS UTILIS


MELALEUCA RHAPHIOPHYLLA


EUCALYPTUS TORQUATA


EUCALYPTUS VICTRIX


EUCALYPTUS LEUCOXYLON 'ROSEA'

POS/ REVEGETATION TREES


EUCALYPTUS GOMPHOCEPHALA


AGONIS FLEXUOSA


MELALEUCA RHAPHIOPHYLLA


MELALEUCA LANCEOLATA


CALLITRIS PRESEII


BANKSIA LITTORALIS


BANKSIA ATTENUATA

FEATURE PLANTING


XANTHORRHOEA PREISEII


ANIGOZANTHOS MANGLESEII


LEUCOPHYTA BROWNII


SCAEVOLA 'MAUVE CARPET'


KENNEDIA PROSTRATA


CONOSTYLIS CANDICANS


PIMELEA FERRUGINEA

STREET VERGES


HEMIANDRA PUNGENS


EREMOPHILA GLABRA PROSTRATE


SCAEVOLA CRASSIFOLIA PROSTRATE


DIANELLA 'LITTLE JESS'


WESTRINGIA 'MUNDI'


GREVILLEA CRITHMIFOLIA PROSTRATE


MELALEUCA 'LITTLE PENTA'

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

JOB NO. 2011201 C3.102 REV C

PLAN E
LANDSCAPE ARCHITECTS
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DRAINAGE SWALES/ RAINGARDENS


MACHAERINA JUNCEA


MACHAERINA ARTICULATA


FICINIA NODOSA


LEPIDOSPERMA LONGITUDINALE


CENTELLA ASIATICA


LOBELIA ANCEPS


ISOLEPIS CERNUA

POS/ REVEGETATION PLANTING


FICINIA NODOSA


OLEARIA AXILLARIS


GREVILLEA CRITHMIFOLIA


GUICHENOLTIA LEDIFOLIA


HARDENBERGIA COMPTONIANA


HAKEA PROSTRATA


MELALEUCA TERETIFOLIA


MELALEUCA SYSTENA


KENNEDIA PROSTRATA


MYOPORUM INSULARE


RHAGODIA BACCATA


ACACIA PULCHELLA


*ACACIA BENTHAMII


*JACKSONIA SERICEA

*RARE/PRIORITY FLORA

LARGE SHRUBS/ SCREEN PLANTING


CALOTHAMNUS QUADRIFIDUS


BANKSIA SESSILIS


ACACIA ROSTELLIFERA


DODONAEA HACKETTIANA


TEMPLETONIA RETUSA


MELALEUCA HUEGELLII


MELALEUCA SYSTENA

ENTERPRISE PARK, PORT KENNEDY

PLANTING PALETTE
JULY 2024

JOB NO. 2011201 C3.103 REV B

PLAN E
LANDSCAPE ARCHITECTS
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2	Electronic	DevelopmentWA	21/08/2024

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	C Jones	M Dunlop			17/10/2011
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D	Michelle Gellender/ Brendan Oversby	Brendan Oversby	Benn Prowse		20/08/2024
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Dharawal Country | Suite 1A, 280 - 286
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G. Engineering Servicing Report

PORT KENNEDY ENTERPRISE PARK

ENGINEERING SERVICES REPORT

PREPARED FOR DEVELOPMENTWA

Porter
Consulting Engineers

Report Prepared For:

DEVELOPMENT WA

Prepared by	**Porter Consulting Engineers**
Postal address	PO Box 1036 Canning Bridge WA 6153
Phone	(08) 9315 9955
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Job number	18-6-73
Date	11 October 2023
Our reference	R44G.18
Checked	*MC*

HISTORY AND STATUS OF THE DOCUMENT

Revision	Date issued	Author	Issued to	Revision type
Rev A	03/8/2018	S Highman	L Strange, LandCorp	First issue
Rev B	21/08/2018	S Highman	L Strange, LandCorp	Second issue
Rev C	09/10/2019	M Cook	Doug Stirling, LandCorp	Third issue
Rev D	14/4/2021	S Highman	Doug Stirling, DevelopmentWA	For Structure Plan
Rev E	31/1/2023	S Highman	Doug Stirling, DevelopmentWA	For WAPC Approval
Rev F	27/2/2023	S Highman	Doug Stirling, DevelopmentWA	For WAPC Approval
Rev G	11/10/2023	S Highman	DevelopmentWA	For WAPC Approval

CONTENTS

1.0 INTRODUCTION

Porter Consulting Engineers were engaged by Development WA to complete an assessment of engineering and servicing requirements to support the subdivision application of Lot 4 and Lot 17 Port Kennedy Drive, Port Kennedy for an Industrial Park development. The location of the site is shown below.

The engineering advice relates to existing infrastructure in the vicinity of the site and an assessment of the future servicing requirements to subdivide the site.

2.0 SITE

The Site is currently vacant coastal heath land. The soils are calcareous sands of high permeability with moderate bearing capacity. A site classification of 'Class A' in accordance with AS2870-2011 could be expected. Douglas Partners July 2011 Geotechnical Report provides a guide for future engineering designs.

The landscape features consist of low north south longitudinal dunal ridges that are part of the Becher Plain, and occasional damplands that occur in the interdunal depressions. The site has an elevation of approximately RL 10m AHD near Ennis Avenue down to approximately RL 6m AHD near Bakewell Drive with the localized depressions as low as RL 4.0m AHD.

The existing site features are shown in **Attachment 1**.

The JDA May 2011 monitoring report shows the groundwater level ranged from 2.64m AHD to 4.25m AHD across the Site. The depth to maximum groundwater level below natural surface varied from 1.72m to 4.25m across the Site. Surficial groundwater flow is eastwards towards Lake Walyungup.

The Western Australian Planning Commission (WAPC) Acid Sulphate Soil Atlas indicates that there is a low risk of acid sulphate soils occurring down to 3m.

WAPC subdivision approval was issued on 1 March 2018 for the site (Refer **Attachment 2**). Condition 1 requires the creation of a Conservation area, these have been nominated including a central reserve as shown in **Attachment 6.**

The site is registered on the Unexploded Ordnance (UXO) website and its perimeter is sign posted accordingly.

3.0 EXISTING INFRASTRUCTURE

The site is surrounded by existing infrastructure. The following is a summary of the existing services and transport infrastructure.

3.1 Roads

The site is bounded by:

- Ennis Avenue to the east - a controlled access divided dual carriageway that is a primary road and is indicated in the Metropolitan Region Scheme as an Important Regional Road.
- Port Kennedy Drive to the south - a two lane median separated dual carriageway. It is a district distributor road that is indicated in the Metropolitan Region Scheme as a Regional Road.
- Bakewell Drive to the west - is a two way industrial standard local road.

There is control of access restrictions to Ennis Avenue. Access off Ennis Avenue is not permitted.

3.2 Water Supply

The Site is within the Water Corporation water supply scheme area, but is not yet serviced. There is a 150mm diameter main generally reticulated through the existing industrial estate to the west of the site, with a 200mm main along Blackburn Drive that currently terminates at the intersection with Port Kennedy Drive. Refer **Attachment 3**.

3.3 Sewer

The Site is within Water Corporation sewer scheme area, but is not yet serviced. There are 300mm and 225mm diameter sewer mains constructed in the existing subdivision to the west. Refer **Attachment 4.**

3.4 Power

There is underground power in the residential subdivision to the north and in the industrial subdivision to the west of Bakewell Drive. Refer **Attachment 5**.

3.5 Telecommunications

There is Telstra and NBN (fibre to the kerb) infrastructure in the industrial subdivision to the west of the site, and Telstra and NBN (fibre to the node) infrastructure to the residential subdivision to the north of the site.

3.6 Gas

The residential land to the north is reticulated by gas, as is part of the industrial land to the west.

4.0 PROPOSED SITE DEVELOPMENT

DevelopmentWA propose to develop the site in accordance with the permitted planning uses whilst accommodating the existing environmental constraints.

The proposed development Structure Plan is shown in **Attachment 6**. The plan preserves significant amounts of public open space in the form of a Conservation lot and a wetland reserve.

Due to the size of the site, it is anticipated it will be subdivided in a staged manner. The current staging plan is presented at **Attachment 13**.

5.0 DEVELOPMENT SERVICING REQUIREMENTS

The Site is currently zoned Industrial under the Metropolitan Region Scheme and Port Kennedy Business Enterprise under the City of Rockingham Town Planning Scheme No. 2. With these zoned land uses, service authorities have included the site in their future planning scenarios.

Infrastructure will be required to an industrial land use standard to enable the subdivision. The following summarises these requirements.

5.1 Roads and Paths

The control of access along the eastern boundary of the site prohibits a connection onto Ennis Avenue. The proposed road networks (**Attachment 6**) shows two connections to Port Kennedy Drive, these road and intersection requirements are detailed in the Traffic Impact Assessment. The proposed Port Kennedy Drive intersections (round-abouts) can be accommodated in the existing road reserve plus the addition of new road reserve created from the site's parent lot.

The two entry roads off Port Kennedy Drive have a wider road reserve (25m) as noted in the Traffic Impact Assessment. It is expected these will have separate lanes and a continuous raised central median to prohibit right turn movements into their fronting lots. All other roads will be 10m wide and built to the City of Rockingham's industrial standard.

The detailed designs of the internal intersections will occur post WAPC subdivision approval. Modification to cadastral truncations will be considered at that point in time to ensure sufficient verge widths are provided.

Port Kennedy Drive is mapped as RAV 4 restricted use, it is expected the development will be RAV 4 compliant with some limitations as noted in the Traffic Impact Assessment.

The Traffic Impact Assessment comments on the operation of the Port Kennedy Drive – Ennis Avenue intersection and the required upgrades over the next 15 years. The Ennis Avenue intersection upgrade can be accommodated in the existing road reserves.

A footpath network will be established throughout the estate and connect to the existing network. It is expected this will include a loop around the wetland and CCW.

Principle Shared Paths (Ennis Avenue) and Dual Use Paths (Port Kennedy Drive) have been identified as part of the Department of Transport's long term cycle network. These will be installed by others when the demand requires it.

5.2 Drainage

Strategen JBS+G have prepared the Local Water Management Strategy (LWMS) which addresses stormwater management across the site. Porters have been working with Strategen JBS+G to co-ordinate this drainage strategy. Below is a summary of the LWMS outcomes.

5.2.1 Road Reserve Drainage

Due to the highly permeable nature of the site and flat topography, at source detention and disposal will be implemented to manage various storm events. It is expected the more frequent events will be managed via localised gardens and treatment areas. Larger events will be managed via below ground storage and infiltration arrangements. Extreme events will be managed via above ground storage, linear flow paths along the road network and disposal in open aired basins.

Stormwater quality will be managed for the more frequent events, as these convey the majority of the pollutants.

Verge levels will be set based on based on drainage requirements including ground water separation to drainage infrastructure. Minimum flood level separation will be achieved to all lots as typically detailed with any development.

A concept drainage plan is presented in **Attachment 7**.

5.2.2 Lot Drainage

Stormwater collected from each lot will be managed within each lot. Lots will not be connected to the road reserve network. Lot drainage is typically collected via gutters and standard pavement inlet pits for storage and disposal via infiltration in below ground tanks. Lots will be set at an elevation to enable the installation of standard infrastructure to manage the disposal.

Some lot owners may choose to install rain water tanks for irrigation purposes or in other non-potable uses. These owners will need to seek specific approvals as required for this.

5.3 Sewer

Water Corporation will require a sewer to be extended from the existing in Bessemer Road and then advanced in an easterly direction throughout the subdivision. Refer **Attachment 8** for their sewer catchment planning. Consistent with this, a concept sewer layout has been prepared and is presented in **Attachment 9**.

The gravity sewer crosses under the Conservation Category Wetland (CCW) via trenchless techniques, before it branches out to service the estate. The subdivision sewers will be 225mm diameter and developed on a frontage basis. Standard chambers and property connections are required.

The north western corner of the site is serviced via a separate sewer. This reduces fill requirements and allow the seamless lot tie in with the existing Bakewell Drive.

Approval in principle has been provided by the Water Corporation for this layout.

5.4 Water

The Water Corporation will require all lots to be serviced with water, compliant with industrial subdivision standards. A concept water main layout is shown in **Attachment 10**. This shows a new DN200 loop main extending from the existing 200mmm water main at the intersection of Blackburn Drive/ Port Kennedy Drive, through the estate and back to the 200mm main at the intersection Bakewell Drive / Paxton Way. All other water main are DN150.

Approval in principle has been provided by the Water Corporation for this layout.

5.5 Power

The Feasibility Study as issued by Western Power in June 2011 is presented in **Attachment 11**. This study is well out of date, however the site's power demand requirements remain unchanged.

The Western Power Feasibility Study indicates:

- 7MVA (7000kVA) expected capacity based on minimum usable land.
- there is spare capacity in the network equaling 2MVA (2000kVA) or 2-3x 630kVA transformers.
- More than 2MVA requires a new HV feeder to be installed from the Waikiki zone substation (approx. 4.5km).

Current Western Power mapping (Forecast of Remaining Capacity 2026) suggests the area has 15-20MVA spare capacity. It appears an upgrade has occurred over the last 10 years. Further discussions with Western Power are required to verify what reinforcing works have been completed since 2011 and what impact this has on their previous advice. This happens at

detailed design stage, as per the normal subdivision process.

A high and low voltage underground network will be established to service the estate. Street lighting is required and will be installed compliant with governing standards.

A concept layout of the major power infrastructure is also shown in **Attachment 11**.

The development of new technology in the power industry has presented opportunities to mitigate consumer costs. Innovations that could be utilised within this development include:

- Solar Power Supply with battery support.
- Solar Hot Water System.
- Heat Transfer Hot Water System (Low Power).
- Wind Pods (Wind Power).

5.6 Telecommunications

There are NBN telecommunication networks in the surrounding suburbs to the north and west which will be extended to, and reticulated throughout, the proposed subdivision.

5.7 Gas

Gas infrastructure is typically not required in industrial developments as its use is very low. The developers will have to fund all gas infrastructure if required, this is a normal requirement in non- residential developments.

It is noted gas is a fossil fuel with many businesses now looking at carbon neutral options. Although possible, it is not expected that gas will be reticulated throughout this development.

5.8 Earthworks

UXO sweeping and clearance is required prior to any site works. This is a standard process and will ensure the site is safe to develop. Standard UXO sweeping requires the clearing of vegetation, this will be completed across the majority of the site. It is expected alternate UXO sweeping techniques will be used (electromagnetic) in environmentally sensitive areas as this can be completed without the need to clear.

Due to the regular occurrence of dune ridges, the site will be earthworked in full to create generally level lots. Based on ground water levels, drainage requirements and sewer servicing, filling will be required. An indicative bulk earthwork plan is shown in **Attachment 12**.

There are two environmentally sensitive areas, the CCW to the west and the central POS. Earthworks will not encroach into their 50m buffer zones.

The soils and climatic conditions are such that dust may be an issue during construction. The Contractor will prepare and obtain approvals for a dust management plan, this will nominate strict control measures to mitigate dust blow off during each stage. It is expected these controls will include on site storage of construction water, regular stabilisation, dust fencing and staging

their construction activities.

6.0 CONCLUSION

Having reviewed the existing services that are available and discussed the planned extension to those services with the relevant authorities, Porter Consulting Engineers are of the opinion that the development of the Port Kennedy Enterprise Park can be undertaken.

ATTACHMENT 1
Existing Site Features

NOTES

This plan has been prepared for the client and should not be used for any other purpose unless authorised by Whelans (WA) Pty Ltd.

The location of cadastral boundaries shown has been extracted from Landgate's database on 8/6/11 and are subject to survey.

Prior to the commencement of any work, relevant authorities should be contacted for the location of underground services.

Levels are based on AHD and derived from SSM

Due to overwriting some levels may be switched off for this plot only.

This note is an integral part of this plan.

LEGEND

- CADASTRAL BOUNDARIES
- EASEMENTS
- DBYD POWER
- DBYD SEWER
- DBYD TELECOM
- DBYD WATER
- MAPPING CONTOUR (INDEX)
- MAPPING CONTOUR (INTERMEDIATE)

NOTES:
AERIAL IMAGERY HAS BEEN SOURCED FROM LANDGATE.
CAPTURED: MAY 2011; RESOLUTION:0.1m; ACCURACY:2m;

MAPPING DATA IS BASED ON AAM IMAGERY CAPTURED MAY 2001 WITH EXPECTED VERTICAL AND HORIZONTAL ACCURACY OF 0.1m

CONTOUR INTERVAL IS 0.5m

north

NOTE:
UNDERGROUND SERVICE INFORMATION SOURCED FROM 'DIAL BEFORE YOU DIG' AND IS VALID FOR 14 DAYS FROM APPLICATION DATE. THIS INFORMATION IS FOR INDICATIVE PURPOSES ONLY. LIFTING OF COVERS AND EXCAVATION MUST BE DONE FOR ACCURATE IDENTIFICATION AND LOCATION OF SERVICES.

TELSTRA DATA IS SCHEMATIC AND ONLY INDICATES THE PRESENCE OF INFRASTRUCTURE.

SCALE:	1:2000	DATE DRAWN:	13/6/11
V.DATUM:	AHD	DRAWN BY:	N.G.A.
H.DATUM:	PCG94	CHECKED BY:	A.B.B.
SURVEY DATE:	29/5/11	DATA FILE:	14834_mapping_Pt_Kennedy_pcg94.dwg
SURVEYOR:	N/A		
JOB NO:	14834		

FILE: S:\Projects\14\14834\ortho\drawings\14834-001.dwg

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AERIAL MAPPING & DBYD SERVICES
LOTS 17 WARNBRO SOUND AVE & 4 ENNIS AVE
PORT KENNEDY

CLIENT: LANDCORP

ORIGINAL SHEET SIZE: A1

REV 0

PLAN 14834-001

SHEET 1 OF 1

BSI ISO 9001:2008 FS 521002

ATTACHMENT 2
Western Australian Planning Commission Conditions

Western Australian Planning Commission

Your Ref : 17-278

TPG Town Planning, Urban Design And Heritage
Level 18 191 St Georges Terrace
PERTH WA 6000

Approval Subject To Condition(s)
Freehold (Green Title) Subdivision

Application No : 156342

Planning and Development Act 2005

Applicant	:	TPG Town Planning, Urban Design And Heritage Level 18 191 St Georges Terrace PERTH WA 6000
Owner	:	Landcorp The Esplanade PERTH WA 6000
Application Receipt	:	1 March 2018

Lot Number	:	4 & 17
Diagram / Plan	:	D065566, D094300
Location	:	
C/T Volume/Folio	:	1663/339, 2126/431
Street Address	:	Lots 4 And 17 Port Kennedy Drive, Port Kennedy
Local Government	:	City of Rockingham

The Western Australian Planning Commission has considered the application referred to and is prepared to endorse a deposited plan in accordance with the plan date-stamped **01 March 2018** once the condition(s) set out have been fulfilled.

This decision is valid for **three years** from the date of this advice, which includes the lodgement of the deposited plan within this period.

The deposited plan for this approval and all required written advice confirming that the requirement(s) outlined in the condition(s) have been fulfilled must be submitted by **06 July 2021** or this approval no longer will remain valid.

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e-mail: info@dplh.wa.gov.au; web address http://www.dplh.wa.gov.au
ABN 35 482 341 493

Western Australian Planning Commission

Reconsideration - 28 days

Under section 151(1) of the *Planning and Development Act 2005*, the applicant/owner may, within 28 days from the date of this decision, make a written request to the WAPC to reconsider any condition(s) imposed in its decision. One of the matters to which the WAPC will have regard in reconsideration of its decision is whether there is compelling evidence by way of additional information or justification from the applicant/owner to warrant a reconsideration of the decision. A request for reconsideration is to be submitted to the WAPC on a Form 3A with appropriate fees. An application for reconsideration may be submitted to the WAPC prior to submission of an application for review. Form 3A and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Right to apply for a review - 28 days

Should the applicant/owner be aggrieved by this decision, there is a right to apply for a review under Part 14 section 251 of the *Planning and Development Act 2005*. The application for review must be submitted in accordance with part 2 of the *State Administrative Tribunal Rules 2004* and should be lodged within 28 days of the date of this decision to: the State Administrative Tribunal, Level 6, State Administrative Tribunal Building, 565 Hay Street, PERTH, WA 6000. It is recommended that you contact the tribunal for further details: telephone 9219 3111 or go to its website: http://www.sat.justice.wa.gov.au

Deposited plan

The deposited plan is to be submitted to the Western Australian Land Information Authority (Landgate) for certification. Once certified, Landgate will forward it to the WAPC. In addition, the applicant/owner is responsible for submission of a Form 1C with appropriate fees to the WAPC requesting endorsement of the deposited plan. A copy of the deposited plan with confirmation of submission to Landgate is to be submitted with all required written advice confirming compliance with any condition(s) from the nominated agency/authority or local government. Form 1C and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Condition(s)

The WAPC is prepared to endorse a deposited plan in accordance with the plan submitted once the condition(s) set out have been fulfilled.

The condition(s) of this approval are to be fulfilled to the satisfaction of the WAPC.

The condition(s) must be fulfilled before submission of a copy of the deposited plan for endorsement.

The agency/authority or local government noted in brackets at the end of the condition(s) identify the body responsible for providing written advice confirming that the WAPC's requirement(s) outlined in the condition(s) have been fulfilled. The written advice of the agency/authority or local government is to be obtained by the applicant/owner. When the written advice of each identified agency/authority or local government has been obtained, it

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e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493

should be submitted to the WAPC with a Form 1C and appropriate fees and a copy of the deposited plan.

If there is no agency/authority or local government noted in brackets at the end of the condition(s), a written request for confirmation that the requirement(s) outlined in the condition(s) have been fulfilled should be submitted to the WAPC, prior to lodgement of the deposited plan for endorsement.

Prior to the commencement of any subdivision works or the implementation of any condition(s) in any other way, the applicant/owner is to liaise with the nominated agency/authority or local government on the requirement(s) it considers necessary to fulfil the condition(s).

The applicant/owner is to make reasonable enquiry to the nominated agency/authority or local government to obtain confirmation that the requirement(s) of the condition(s) have been fulfilled. This may include the provision of supplementary information. In the event that the nominated agency/authority or local government will not provide its written confirmation following reasonable enquiry, the applicant/owner then may approach the WAPC for confirmation that the condition(s) have been fulfilled.

In approaching the WAPC, the applicant/owner is to provide all necessary information, including proof of reasonable enquiry to the nominated agency/authority or local government.

The condition(s) of this approval, with accompanying advice, are:

CONDITIONS

1. The boundary between proposed Lots 1 and 2 being amended as per the attached plan dated 3 July 2018. (Local Government)

Environment

2. Prior to the commencement of subdivisional works a Conservation Area Management Plan is to be prepared for Conservation Area Lot 1 in consultation with the Department of Biodiversity, Conservation and Attractions and the City of Rockingham and approved to ensure the protection and management of the site's environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Biodiversity, Conservation and Attractions)

Fire and emergency infrastructure

3. Prior to the commencement of subdivision works, the proposed lots are to be searched for unexploded ordnance to a depth of at least one metre. (Department of Fire and Emergency Services)

4. A notification pursuant to section 165 of the *Planning and Development Act 2005* is to be placed on the certificate of title of the proposed lots advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification to state as follows:

   "This land has been used as an artillery range and for heavy explosive ordnance dumping and may contain unexploded ordnance. While the land has been searched to a depth of one metre no guarantee can be given that all unexploded ordnance have been located. Any ordnance found should be treated as dangerous and its location reported to police or defence establishment." (Western Australian Planning Commission)

Transport

5. Pursuant to Section 150 of the *Planning and Development Act 2005* and Division 3 of the *Planning and Development Regulations 2009* a covenant preventing vehicular access onto Ennis Avenue and part of Port Kennedy Drive (as per the attached plan dated 3 July 2018) being lodged on the certificate of title of proposed Lot 2 at the full expense of the landowner/applicant. The covenant is to prevent access, to the benefit of Main Roads Western Australia, and the covenant is to specify:

   "*No vehicular access is permitted to or from Ennis Avenue or this section of Port Kennedy Drive*." (Main Roads Western Australia)

ADVICE

1. With regard to Condition 2, the Conservation Area Management Plan is to include measures to rehabilitate degraded areas and monitor hydrology and vegetation health. Weed control, rubbish removal, safe management access and the installation of appropriate fencing or barriers is also be addressed. The Plan is to include a commitment and timeline for amending the classification of the Conservation Area with the vesting in the appropriate authority.

2. The City of Rockingham favours the retention of wetlands 15 and 17 within proposed Lot 2 as part of its future development.

3. The Department of Fire and Emergency Services (DFES) advises that historical research has revealed that during the past 100 years, former elements of the Australian Defence Forces may have conducted training and/or operational activities within or close to the area of the proposed subdivision. It is possible that as a result of these activities, the subject area may contain unexploded ordnance (UXO). Whilst it is considered that the possible risk from UXO on the land subject to this approval is minimal, an absolute guarantee that the area is free from UXO cannot be given. Should, during subdivisional works, or at any other time, a form or suspected form of UXO be located, DFES has advised that the following process should be initiated:

Western Australian Planning Commission

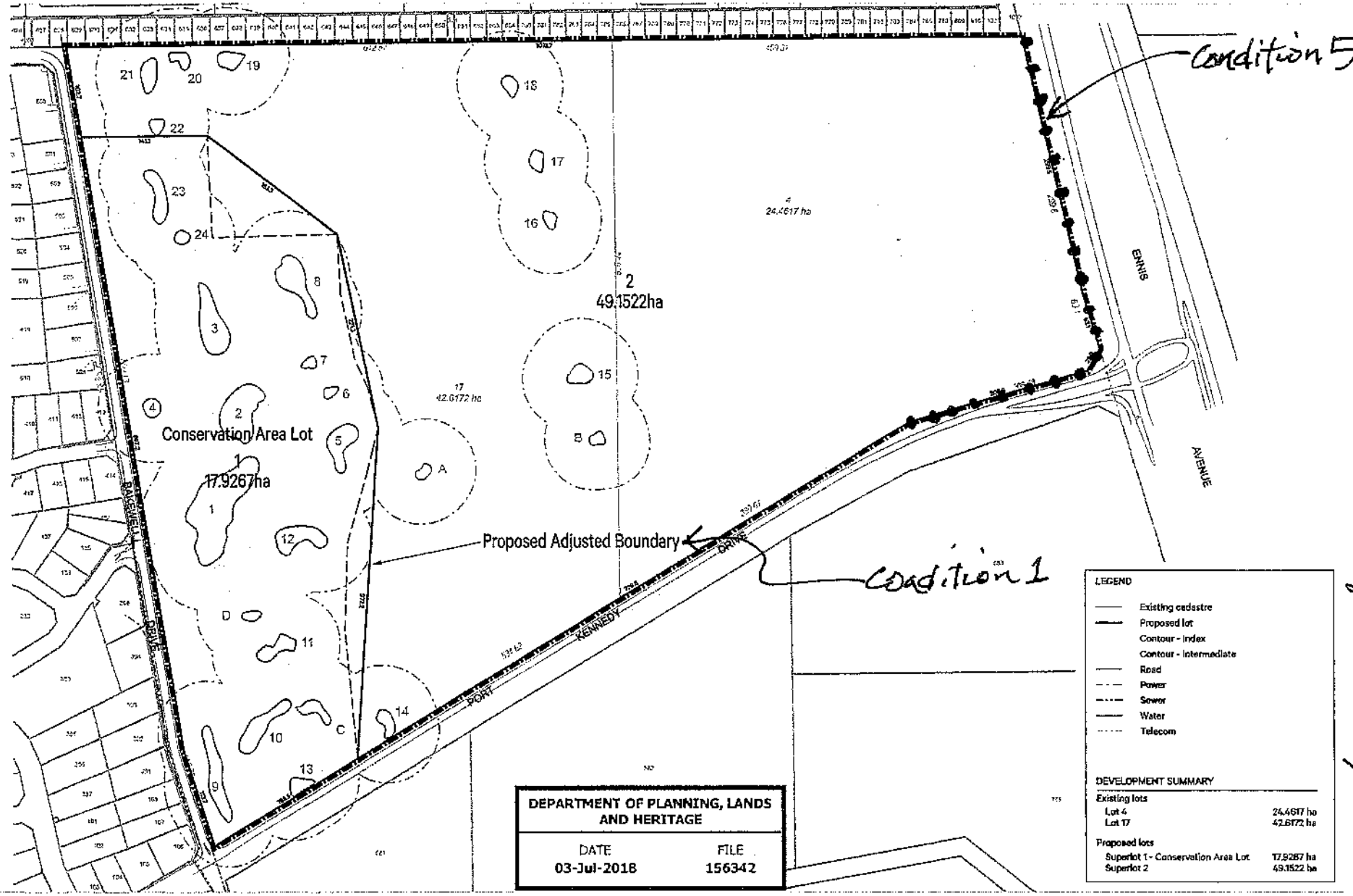
a) do not disturb the site of the known or suspected UXO;
b) without disturbing the immediate vicinity, clearly mark the site of the UXO;
c) notify Police of the circumstances/situation as quickly as possible; and
d) maintain a presence near the site until advised to the contrary by a member of the WA Police Service or Defence Forces.

Further advice on this issue may be obtained by contacting the Unexploded Ordnance Unit, Department of Fire and Emergency Services.

Ms Sam Fagan
Secretary
Western Australian Planning Commission
6 July 2018

Enquiries : Regan Douglas (Ph 6551 9289)

140 William Street, Perth, Western Australia 6000, Locked Bag 2506 Perth, 6001
Tel: (08) 6551 8002; Fax: (08) 6551 9001; Infoline: 1800 626 477
e-mail: info@dplh.wa.gov.au; web address http://www. dplh.wa.gov.au
ABN 35 482 341 493



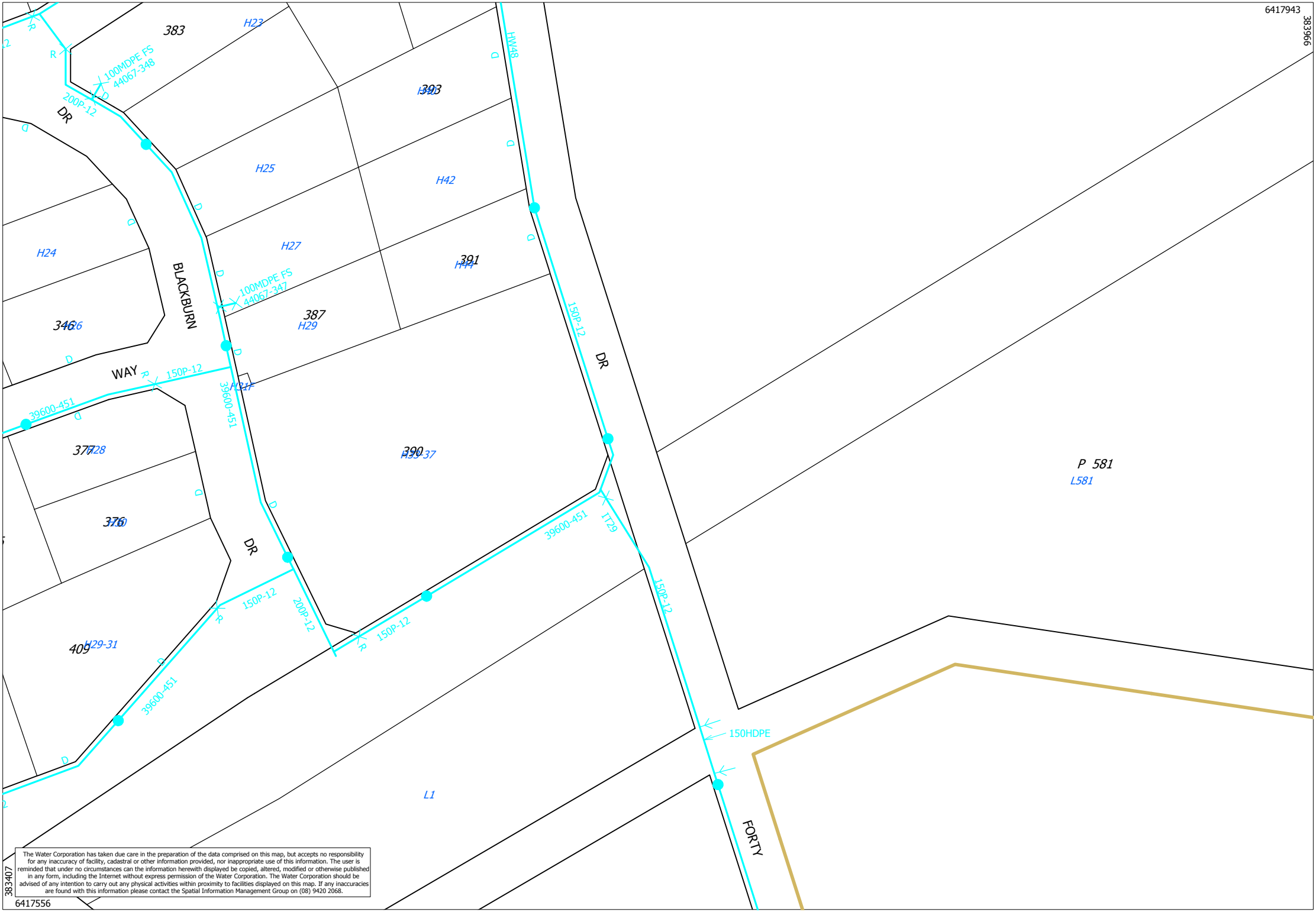
Attached Plan

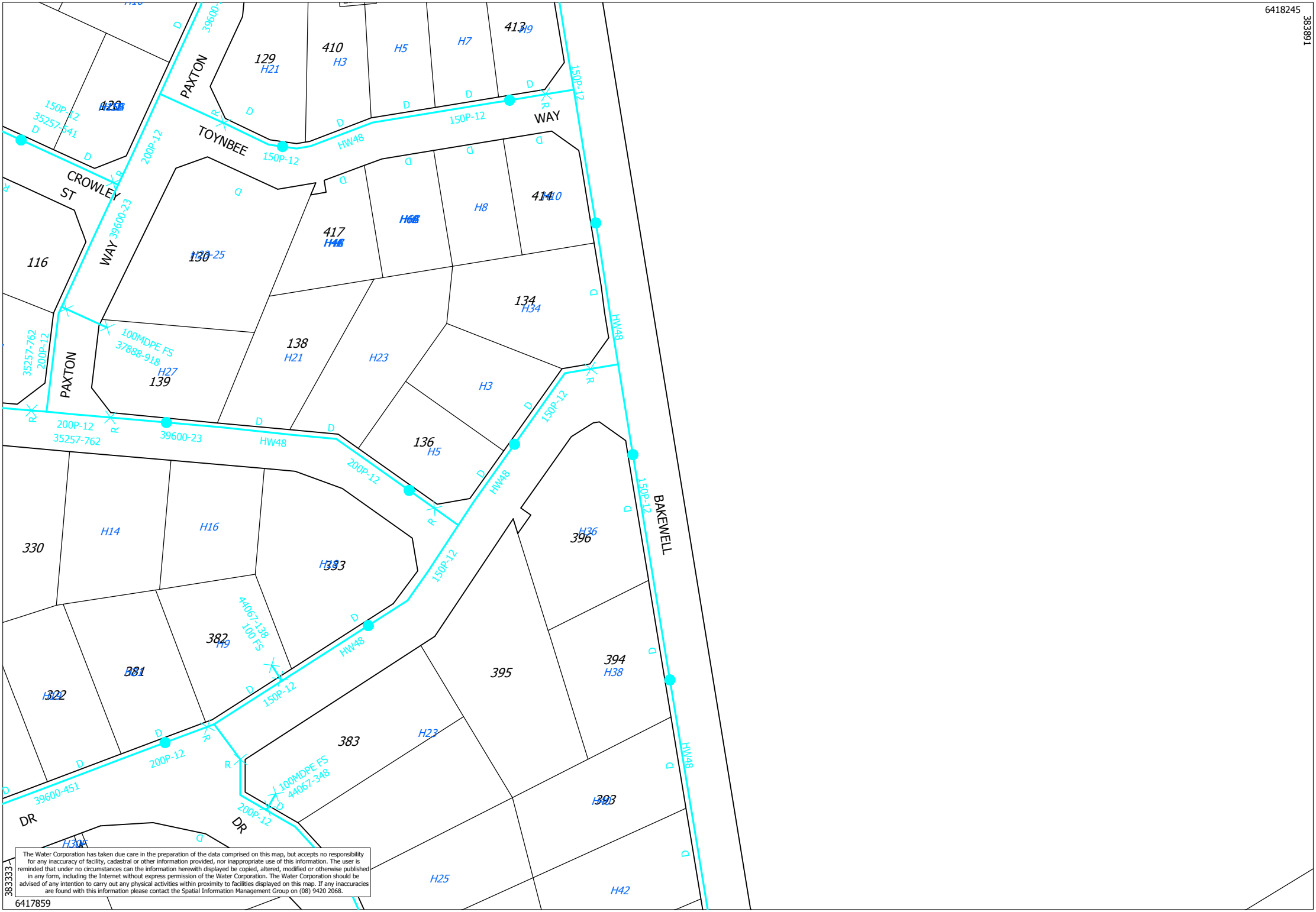
Subdivision Plan - Amended

Lots 4 & 17 Port Kennedy Drive, Port Kennedy

element.

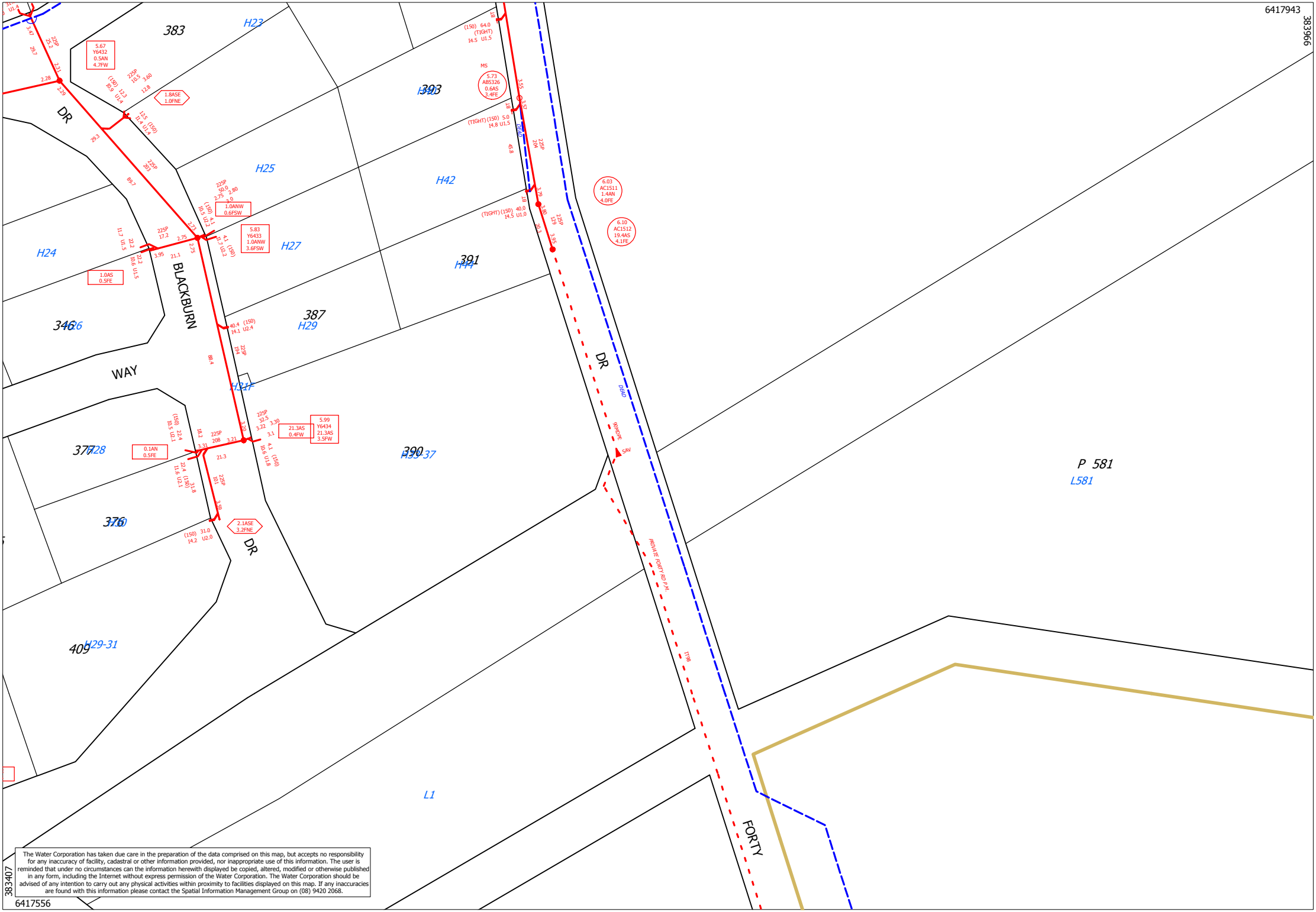
ATTACHMENT 3
Existing Water Reticulation





1_DBYD WATER Screen bg33/08.19 PEEL Date Printed: 14/07/10 10:13:22 Coordinate System: MGA94 Zone 50 Height Datum: AHD

ATTACHMENT 4
Existing Sewer Reticulation



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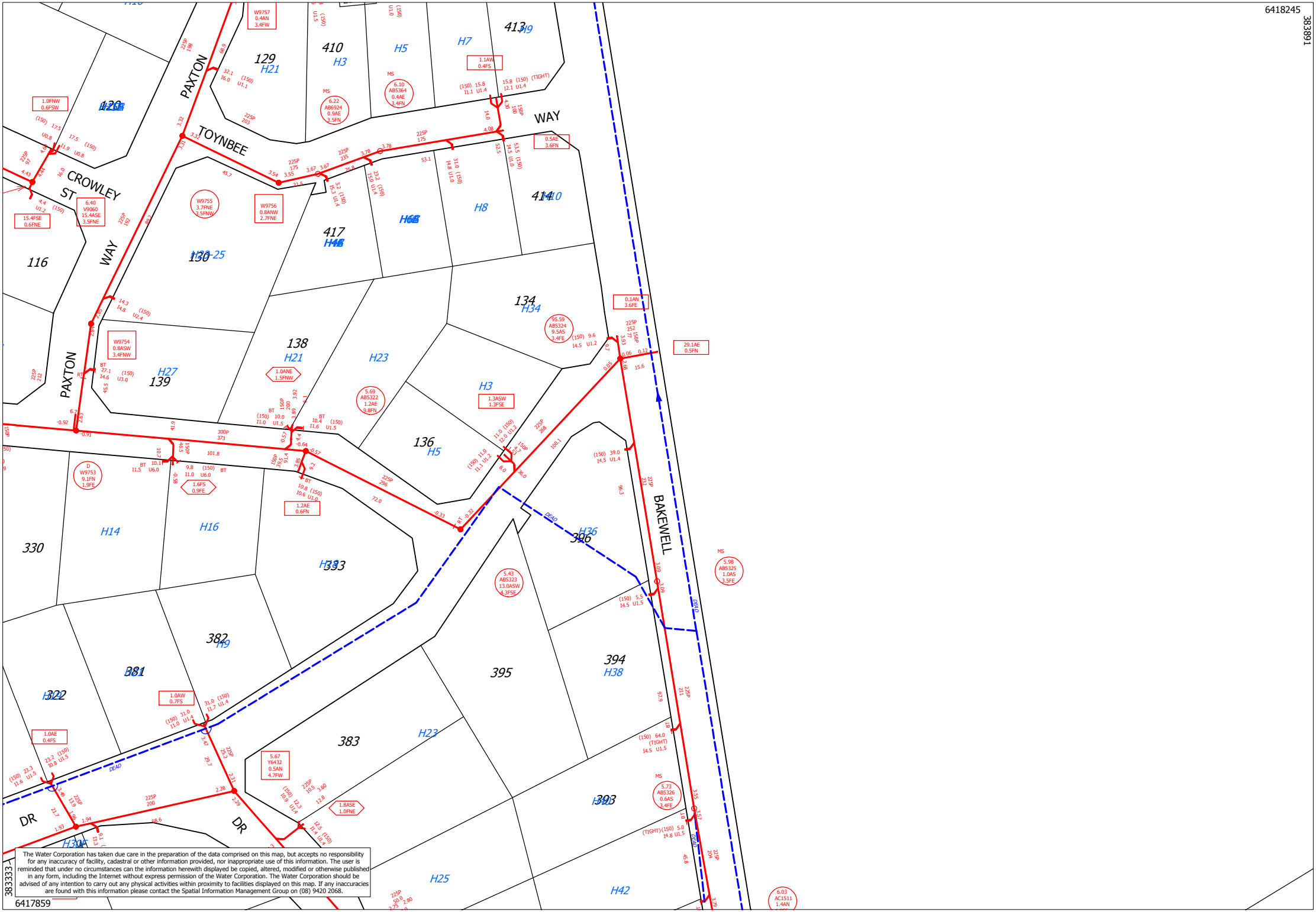

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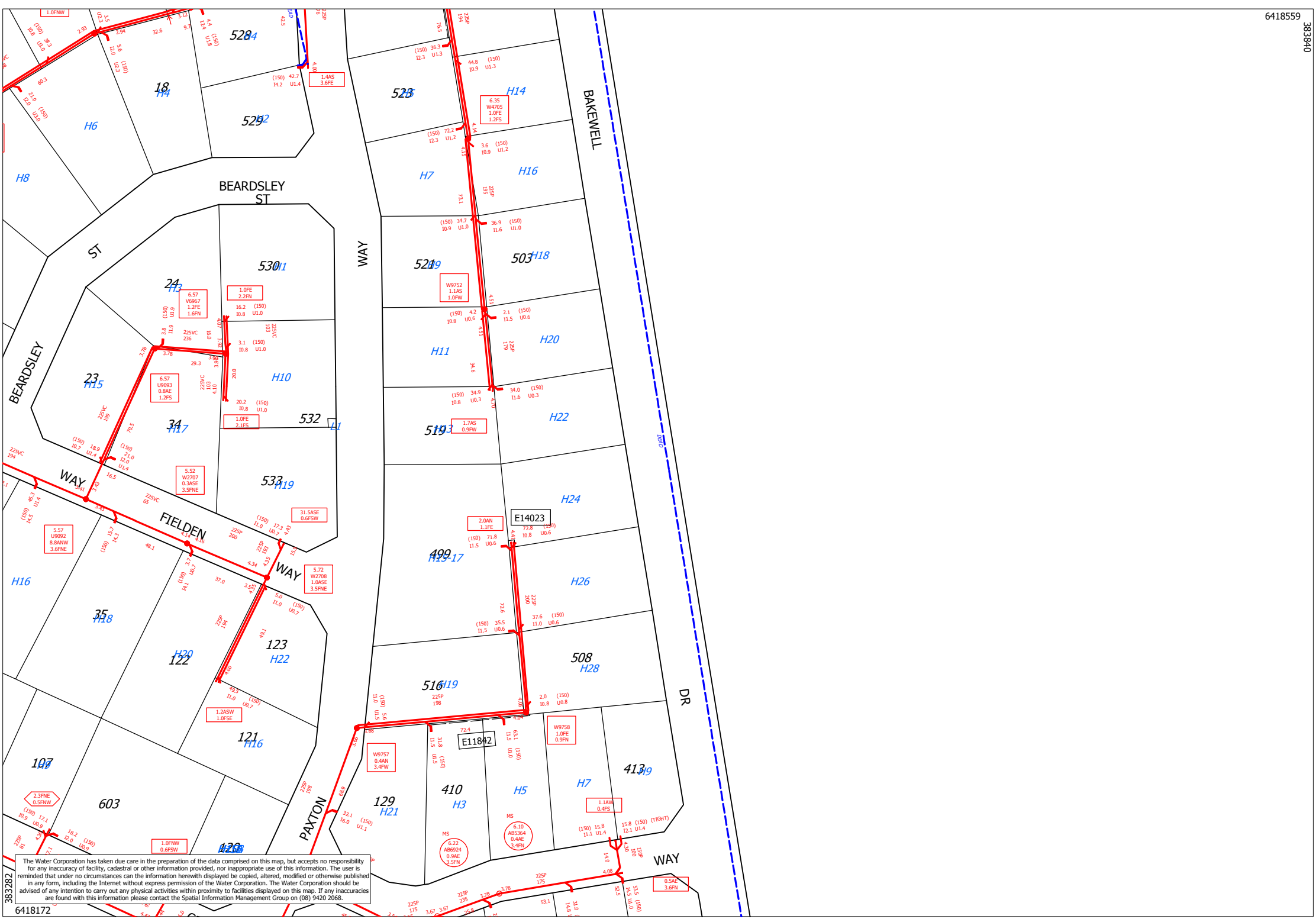
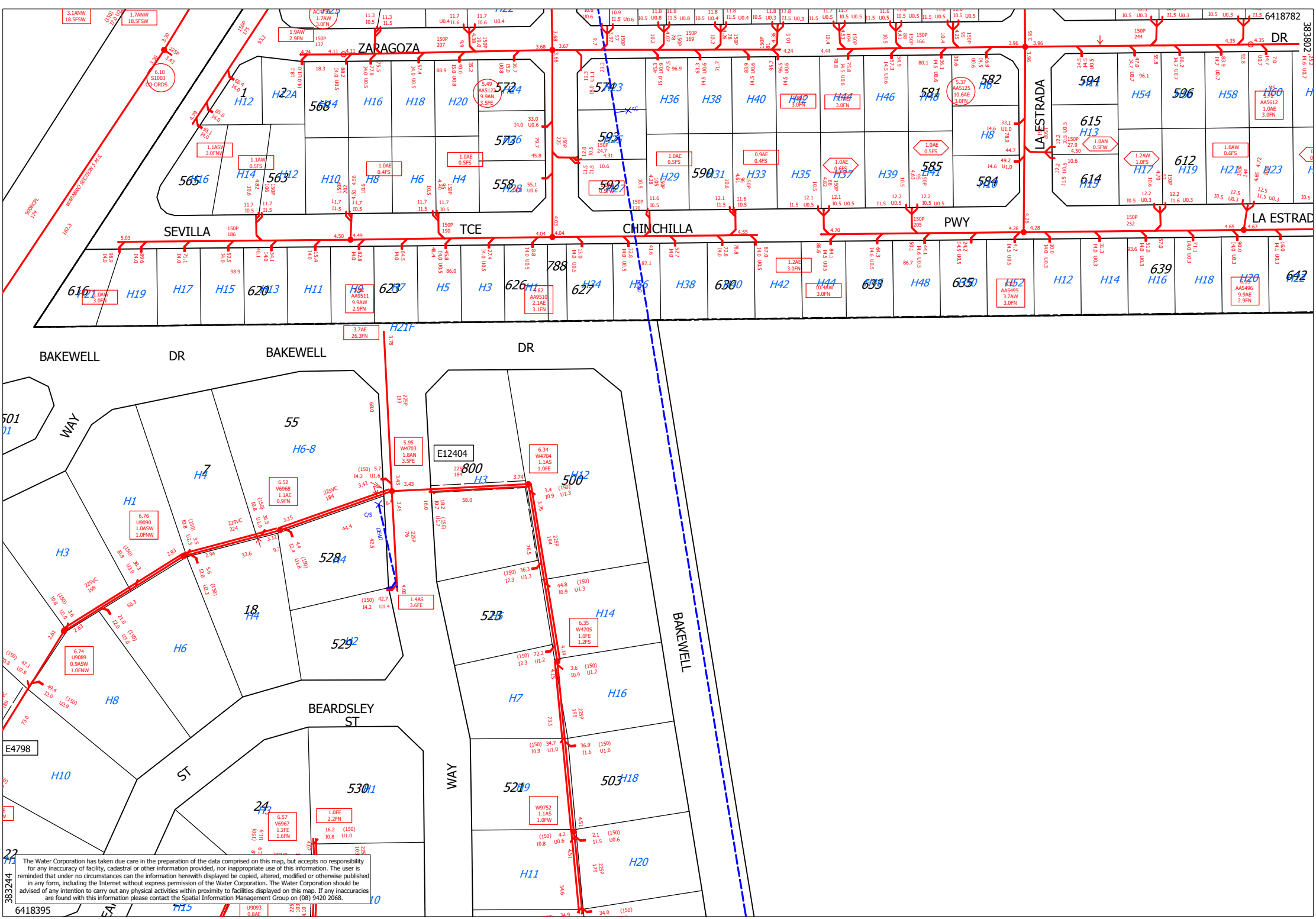


2_DBYD SEWER Screen bg33/08.19 PEEL Date Printed: 14/07/10 10:13:12 Coordinate System: MGA94 Zone 50 Height Datum: AHD



2_DBYD SEWER Screen bg33/08.19 PEEL Date Printed: 14/07/10 10:13:24 Coordinate System: MGA94 Zone 50 Height Datum: AHD

ATTACHMENT 5
Existing Power Supply

SEVILLA TCE
CHINCHILLA PWY
LA ESTRADA WY
MERIDA LP
BURGES L
MONTILLA CR
TOLEDO CCT
N
S2888
PAXTON WY
BAKEWELL DR
18
1698
S2561
MS012061
24
3
8044
PAXTON
34
8046
PAXTON WY
518
15
BAKEWELL DR
S3221
28 BAKEWELL DR
122
20
123
17
4
120
15
L417 TOYNBEE WAY
TOYNBEE WY
130
138
21
137
MS011771
1 BESSEMER RD
331
14
333
7
396
36
382
381
21
394
38
383
BESSEMER RD
393
40
385
25
392
42
386
391
44
347
33
BLACKBURN 1
390
37
581
582
583
765
PORT KENNEDY DR
ENNIS 2
ENNIS AVE
WARNBRO SOUND AVE
BLACKBURN

Windows DFIS Map Printed: Fri Aug 05 16:34:41 2011 User: dtwyman
32ø22'00"S, 115ø46'03"E MGA (Zone 50): (38406590,641822514) Scale: 1:3412 Profile: ALL

ATTACHMENT 6
Proposed Development Concept

Legend

Structure Plan Boundary

MRS Reserves

Parks and Recreation

Local Reserves

Public Open Space and Drainage

Local Zones

Port Kennedy Enterprise Zone

Other

Local Distributor Road

Local Access Road

Pedestrian Path

Dual Use Path

Principal Shared Path

Wetland

Wetland Buffer (50m)

Notes

1. Proposed drainage basins (refer to LWMS)
2. Vegetation screening as part of road reserve
3. No vehicle access to Ennis Avenue

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.1

Area affected by City of Rockingham Local Planning Scheme No. 2 Clause 4.9.4.2

Structure Plan

Lot 4 and 17 Port Kennedy Drive, Port Kennedy

Date: 27 Sep 2023 Scale: 1:4000 @ A3 1:2000 @ A1 File: **717-278 ST-1** Staff: MR GW Checked: MR

0 40 80m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

ATTACHMENT 7
Drainage

CCW

RESERVE

BAREWELL DRIVE

ENNIS AVENUE

PORT KENNEDY DRIVE

4.0 GWL

3.0 GWL

583

582

581

LEGEND

- SITE BOUNDARY
- 7.60 FINISHED LOT LEVEL
- PROPOSED KERB
- PROPOSED DRAINAGE
- —2.0m AAGWL— ANNUAL AVERAGE GROUND WATER LEVEL
- 50m ENVIRONMENTAL BUFFER
- AT SOURCE DISPOSAL AT LOW POINT
- AT SOURCE DISPOSAL VIA LINEAR OPEN DRAIN
- AT SOURCE DISPOSAL VIA BELOW GROUND LINEAR SYSTEM
- AT SOURCE DISPOSAL LEADING TO OPEN AIRED BASIN FOR LARGER EVENTS
- OPEN AIRED BASIN

1:2000 0 20 40 80 120
Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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TUSMO Pty Ltd ACN 070 097 168 as trustee for The Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 626 396 385

CLIENT: DevelopmentWA

DRAWING:
CONCEPT DRAINAGE DISPOSAL PLAN

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/904**

REV No. **D**

ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-904.dwg

BAREWELL DRIVE

ENNS AVENUE

PORT KENNEDY DRIVE

CCW

RESERVE

4.0 GWL

3.0 GWL

3.5 GWL

583

582

581

LEGEND

- SITE BOUNDARY
- 7.40 FINISHED LOT LEVEL
- PROPOSED KERB
- PROPOSED DRAINAGE
- PROPOSED DRAINAGE BASIN
- 2.0m AAGWL ANNUAL AVERAGE GROUND WATER LEVEL
- 6.70 PROPOSED ROAD LEVELS
- PROPOSED DRAINAGE FLOW
- CATCHMENT BOUNDARY
- 50m ENVIRONMENTAL BUFFER

1:2000 0 20 40 80 120
Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 117-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

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TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **CONCEPT DRAWING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/905**

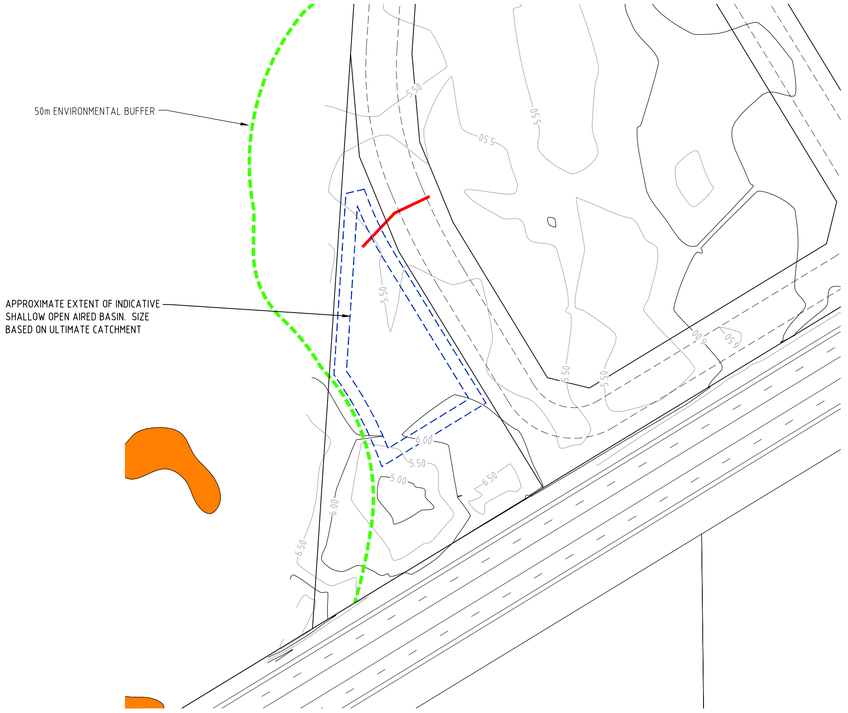
REV No. **D**

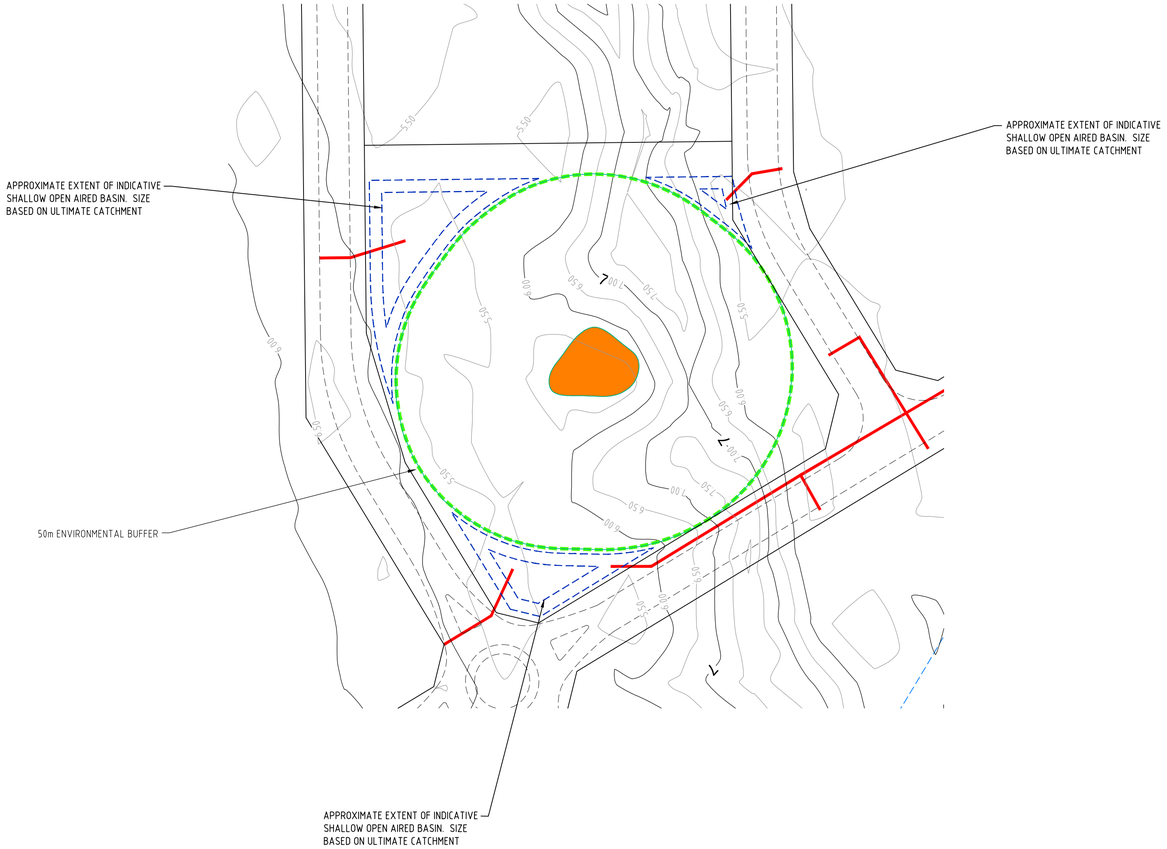
ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-905.dwg

LEGEND

- EXISTING CONTOURS
- PROPOSED KERB
- PROPOSED DRAINAGE
- PROPOSED OPEN AIRED DRAINAGE BASIN
- 50m BUFFER





BEFORE YOU DIG www.byda.com.au

1:1000 0 10 20 40 60
Half Size 1:2000 - SCALE (m)

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No	DATE	REVISION	BY
C	10-10-2023	UPDATED STRUCTURE PLAN 7117-278 ST01A 2023-09-27	MEG
B	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
A	30-12-2021	CONCEPT	MEG

Porter Consulting Engineers
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Canning Bridge 6153 WA
Tel (08) 9315 9955
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www.porterseng.com.au

CLIENT: DevelopmentWA

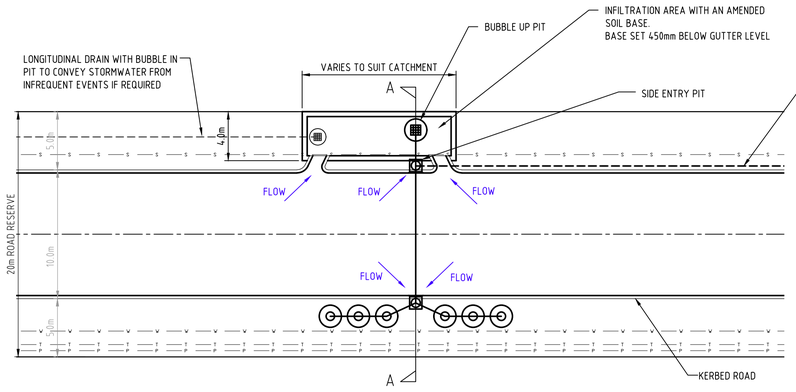
DRAWING: **PROPOSED DRAINAGE BASINS**

STATUS: **CONCEPT**

SCALE	1:1000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 18-6-73/906 | REV No. C | ORIGINAL DRAWING SIZE A1

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-906.dwg



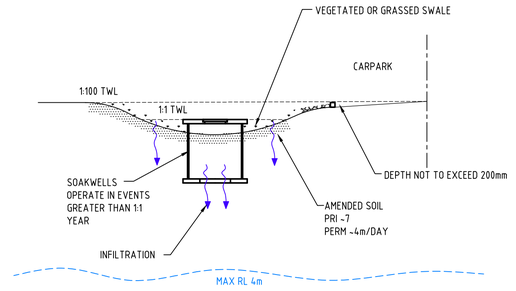
TYPICAL LOW POINT DRAINAGE ARRANGEMENT MAY INCLUDE
- 2 x INLET PITS
- 1 x BUBBLE UP PIT
- 6 x SOAKWELLS
- 4m WIDE INFILTRATION AREA APPROX 15m LONG

ALL CHAMBERS ARE Ø1.8m x 1.2m DEEP WITH SOAKAGE BASES

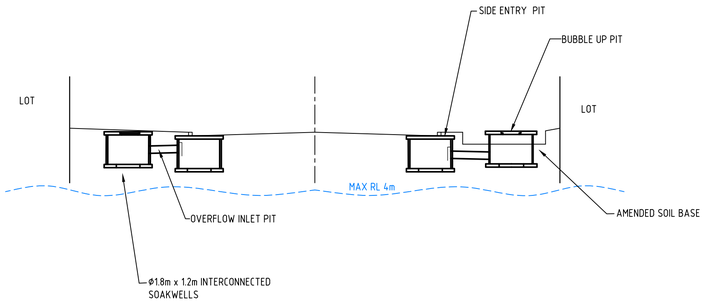
THIS WILL HOLD RUNOFF FROM 14.0m OF ROAD RESERVE (c=0.8) FOR THE 10% AEP EVENT WITH 100mm FREEBOARD TO GUTTER LEVEL

RUNOFF FROM THE 1% AEP EVENT IS HELD LOCALLY WITH ONLY MINOR FLOODING AT THE KERBLINE (70mm).

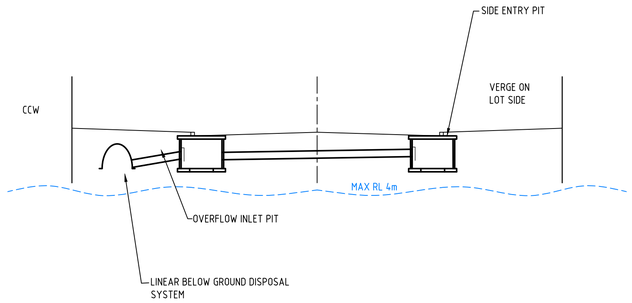
ROAD RESERVE- TYPICAL LOW POINT DRAINAGE
1:250



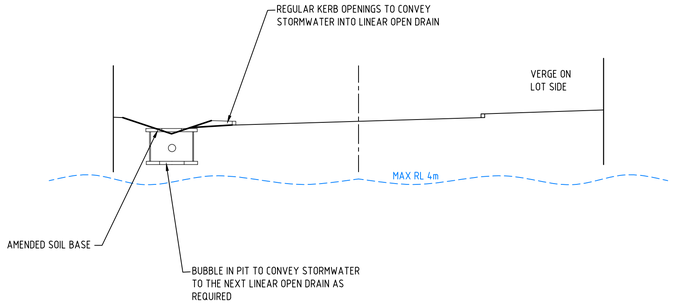
LOT STORMWATER DRAINAGE
1:100



ROAD RESERVE- TYPICAL LOW POINT DRAINAGE
1:125
SECTION A-A



ROAD RESERVE- TYPICAL BELOW GROUND LINEAR SYSTEM
1:125



ROAD RESERVE- TYPICAL LINEAR OPEN DRAIN
1:125

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PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers
Level 2 Kisborn Court
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Email office@porterenq.com.au
www.porterenq.com.au
TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **DRAINAGE DETAILS**

STATUS: **CONCEPT**

SCALE	AS ABOVE
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/907**
REV No. **A**
ORIGINAL DRAWING SIZE **A1**
FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-907.dwg

ATTACHMENT 8
Water Corporation Sewer Catchment Planning

WARNBRO

SD072

CATCHMENT 'V2713 - 072'
SEWER DESIGN FLOW - 11.3L/s

CATCHMENT 'W9839 - 072'
SEWER DESIGN FLOW - 3.0L/s

CATCHMENT 'W9771 - 072'
SEWER DESIGN FLOW - 4.5L/s

WARNBRO P.S. 4-
ST RAPHAEL CR
PUMP STN 4 - 072'
REDUCTION 'S0993 - 072'
SEWER DESIGN FLOW - 24.5L/s
EXISTING PUMP RATE - 49.9L/s
LONG TERM PUMP RATE - 32.6L/s

CATCHMENT 'W4912 - 072'
SEWER DESIGN FLOW - 4.5L/s

CATCHMENT 'W9848 - 072'
SEWER DESIGN FLOW - 1.9L/s

CATCHMENT 'W9826 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V2432 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V9675 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'V4706 - 072'
SEWER DESIGN FLOW - 2.4L/s

CATCHMENT 'A6685 - 072'
SEWER DESIGN FLOW - 1.9L/s

CATCHMENT 'V9811 - 072'
SEWER DESIGN FLOW - 3.5L/s

CATCHMENT 'A6692 - 072'
SEWER DESIGN FLOW - 6.9L/s

CATCHMENT 'A0600 - 072'
SEWER DESIGN FLOW - 8.2L/s

CATCHMENT '72 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT '71 - 072'
SEWER DESIGN FLOW - 2.6L/s

CATCHMENT 'X0957 - 072'
SEWER DESIGN FLOW - 2.9L/s

CATCHMENT '40 - 072'
SEWER DESIGN FLOW - 2.3L/s

CATCHMENT '35 - 072'
SEWER DESIGN FLOW - 2.0L/s

CATCHMENT '34 - 072'
SEWER DESIGN FLOW - 2.0L/s

CATCHMENT 'X8841 - 072'
SEWER DESIGN FLOW - 1.5L/s

CATCHMENT 'S0901 - 072'
SEWER DESIGN FLOW - 4.2L/s

CATCHMENT 'V4931 - 072'
SEWER DESIGN FLOW - 3.9L/s

CATCHMENT 'U3600 - 072'
SEWER DESIGN FLOW - 4.3L/s

CATCHMENT 'U3596 - 072'
SEWER DESIGN FLOW - 2.8L/s

CATCHMENT '50 - 072'
SEWER DESIGN FLOW - 5.5L/s

CATCHMENT '51 - 072'
SEWER DESIGN FLOW - 9.9L/s

CATCHMENT 'V4368 - 072'
SEWER DESIGN FLOW - 14.9L/s

WARNBRO P.S. 13-
ENDEAVOUR DR
PUMP STN '13 - 072'
REDUCTION 'S0995 - 072'
SEWER DESIGN FLOW - 56.6L/s
EXISTING PUMP RATE - 33.0L/s
LONG TERM PUMP RATE - 89.6L/s

ATTACHMENT 9
Concept Sewer Layout

LEGEND

- RETICULATION AREA BOUNDARY
- 7.90 FINISHED LOT LEVEL
- Φ225P PROPOSED SEWERS & ACCESS CHAMBER (AC) OR MAINTENANCE SHAFT (MS)
- SEWER INSTALLED VIA TRENCHLESS TECHNIQUES
- Φ225P @300 DN225 SEWER @1:300
- EXISTING GRAVITY SEWER
- PM EXISTING SEWER PRESSURE MAIN
- 2.0m GWL ANNUAL AVERAGE GROUND WATER LEVEL
- 1.70 PROPOSED SEWER FLOW
- IL 4.00 INDICATIVE SEWER LEVEL

LOT HAS MULTIPLE SEWER JUNCTIONS TO MANAGE FILLING REQUIREMENTS DUE TO THE SHAPE OF THE LOT

SECTION OF MAIN TO BE INSTALLED USING TRENCHLESS TECHNIQUES

CCW

RESERVE

BAKEWELL DRIVE

ENNIS AVENUE

PORT KENNEDY DRIVE

1.15ha SITE LOT SERVICED VIA GRAVITY AT 1:80

1.15ha SITE LOT SERVICED VIA GRAVITY AT 1:80

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:

PORT KENNEDY BUSINESS PARK
PORT KENNEDY

No	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
B	13-4-2021	CHANGES MADE TO CCW CROSSING AS PER WCWA EMAIL DATED 9-2-2021	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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TUSMO Pty Ltd ACN 070 097 948 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **CONCEPT WASTEWATER SERVICING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/901** REV No. **D** ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-901.dwg

ATTACHMENT 10
Concept Water Main Layout

CCW

RESERVE

ENNS AVENUE

BAKEWELL DRIVE

PORT KENNEDY DRIVE

DN200 TEE CONNECTION 3.0m TO THE WEST OF THE EXISTING HYDRANT

583

582

581

LEGEND

- RETICULATION AREA BOUNDARY
- 60 — FINISHED LOT LEVEL
- 150P-16 — PROPOSED 150mm WATER MAIN, PIPE SIZE AND MATERIAL DESIGNATION
- 200P-16 — PROPOSED 200mm WATER MAIN, PIPE SIZE AND MATERIAL DESIGNATION
- EXISTING WATER MAIN, HYDRANT & SLUICE VALVE

BEFORE YOU DIG www.byda.com.au

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
C	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
B	31-1-2023	LOT LAYOUT UPDATED- OPTION 4A	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

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Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@porterenq.com.au
www.porterenq.com.au

TUSMO Pty Ltd ACN 070 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 626 396 385

CLIENT: DevelopmentWA

DRAWING:

CONCEPT WATER SERVICING PLAN

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/902**

REV No. **C**

ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-902.dwg

ATTACHMENT 11
Western Power Feasibility Study and Concept Power Layout

Feasibility Study

Project Name:	MF010087 – Port Kennedy Business Park
Customer Ref:	SAA2011127
Number of lots:	106
Date:	June 2011

1. INTRODUCTION

Porter Consulting Engineers on behalf of the developer has requested a Feasibility Study for power supply to the proposed Port Kennedy Business Park development in Port Kennedy. The following information has been provided to us for conduct this study. Please refer to the Appendix for more information.

Number of lots	106 Lots
Number of stages	Not available at this stage
Load take-up	1 to 2 years for start of Stage 1, other Stages unknown
Proposed Load	Approximately 7MVA load based on 200kVA /ha.

2. EXISTING INFRASTRUCTURE

Figure 1 and Figure 2 below show the 22kV network and zone substations around the proposed Port Kennedy Business Park. Based on the current network configuration and feeders loads, there are insufficient spare capacities available on these networks to supply the 7MVA load in Port Kennedy Business Park.

With the size of the proposed development, a new feeder is likely to be required to supply the entire 7MVA load.

Figure 1: Existing 22kV Network around the Proposed Port Kennedy Business Park

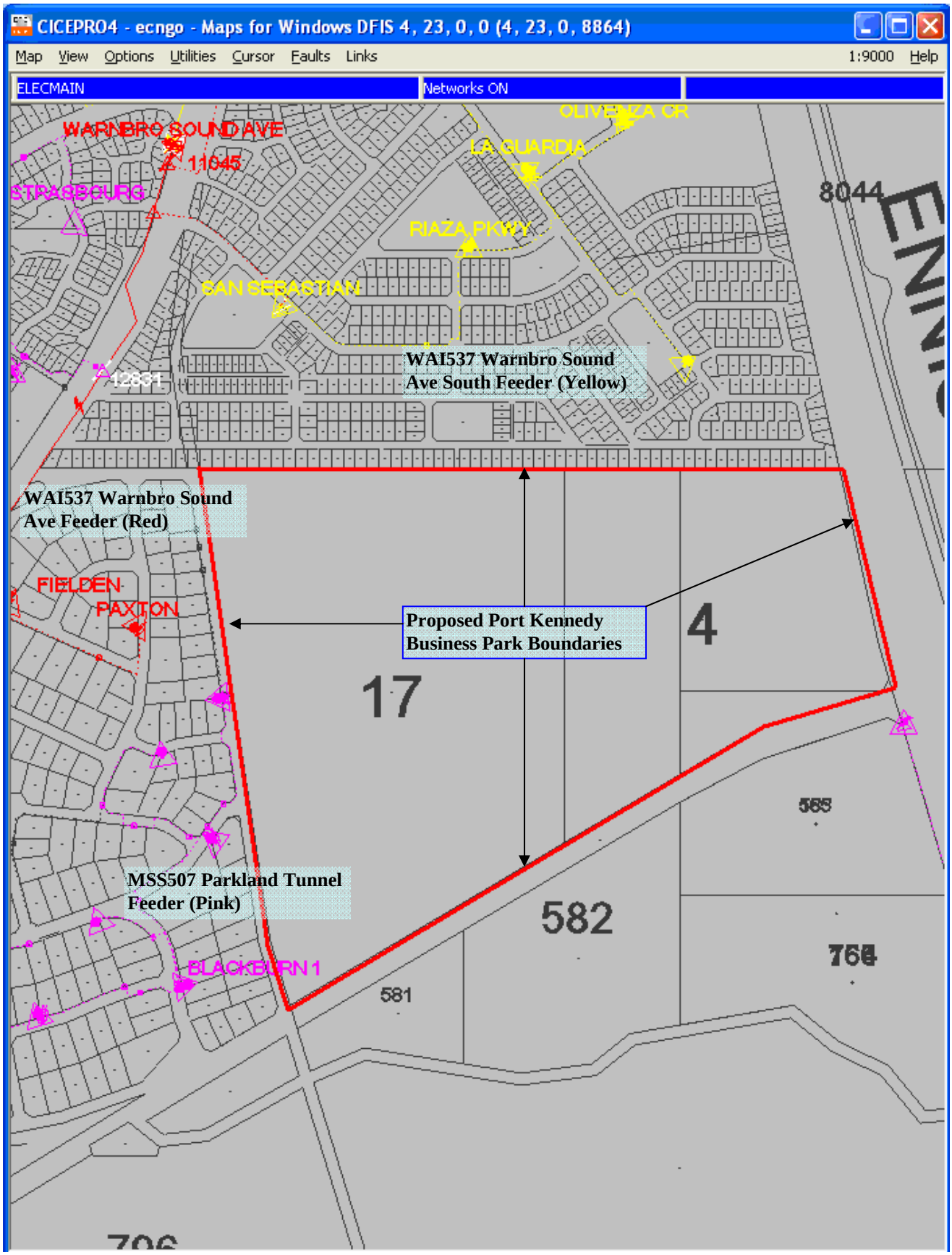


Figure 2: Extended MV network including Zone substations around the Proposed Development

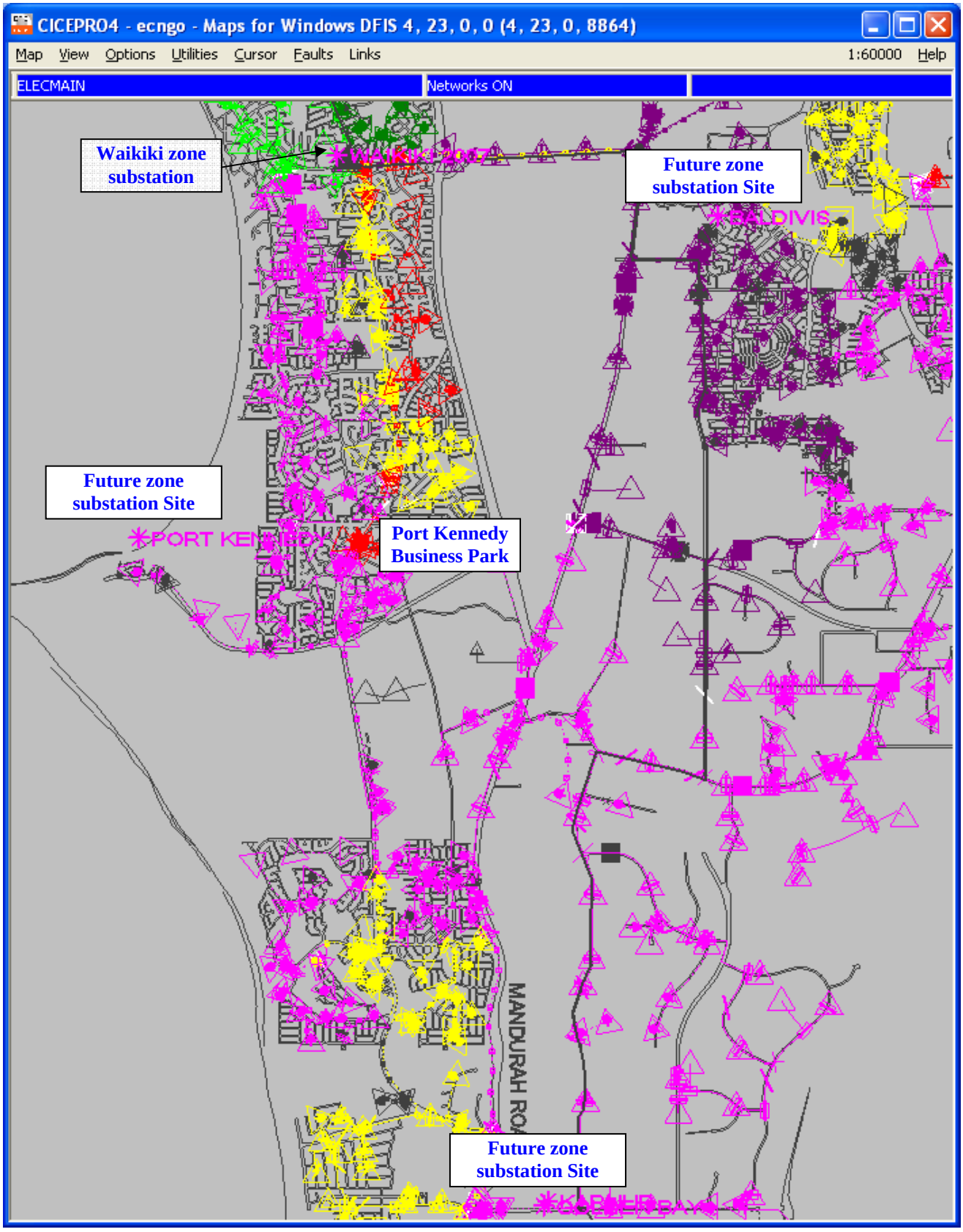
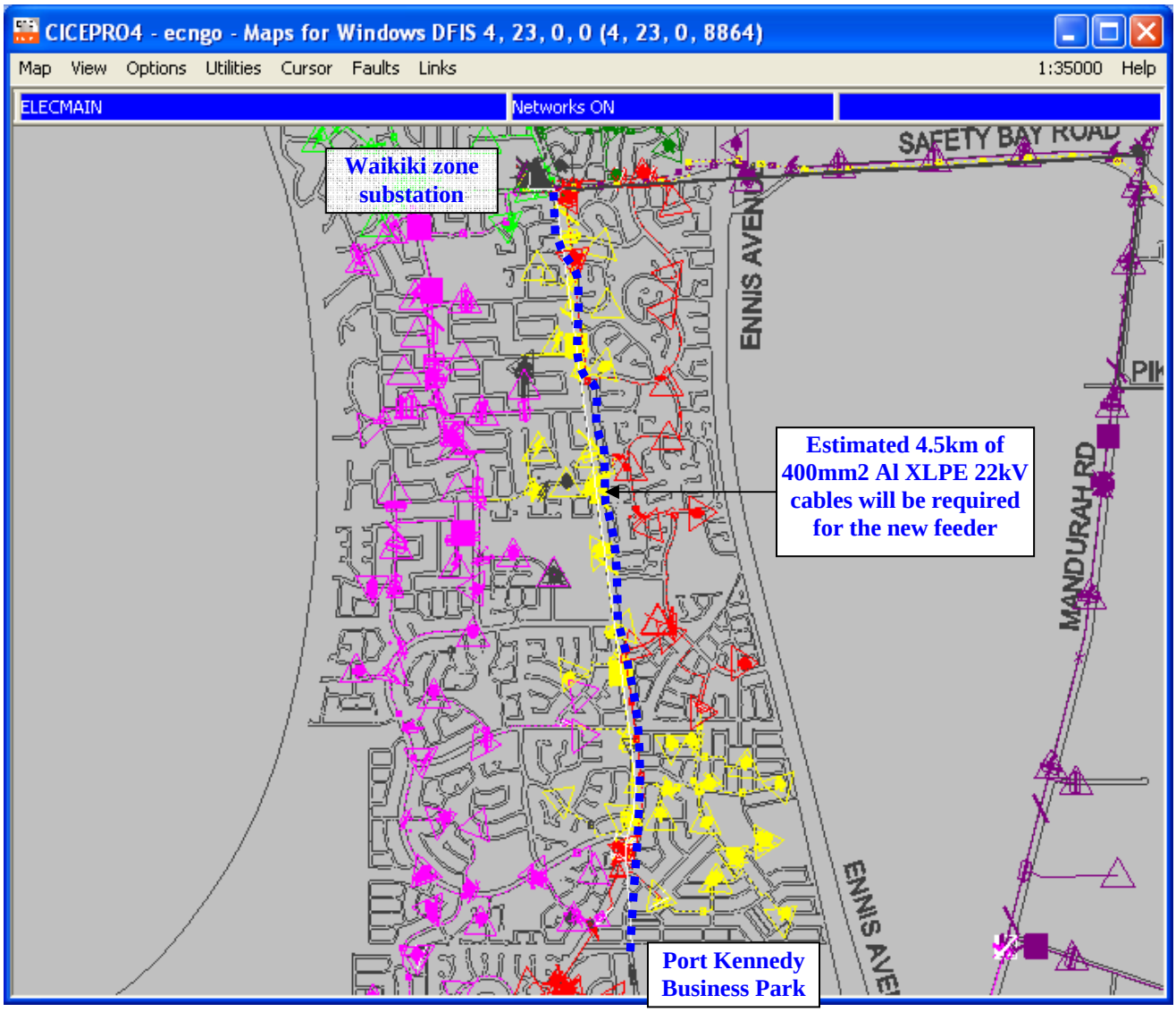


Figure 3: One option to supply the 7MVA Port Kennedy Business Park Load



3. STUDY DETAILS

Analysis of the proposed loads was conducted considering other load requests and predicted load growth in the surrounding region. Consideration was also given to the substation capacity shortfall in the surrounding area, as well as the distribution feeder capacity. The analysis indicates that reinforcements are required to cater for the proposed developments.

4. REINFORCEMENT ESTIMATE

Based on the present network configuration and feeders load, there are some spare network capacities available on the WAI 536 Warnbro Sound Ave South feeder and WAI 537 Warnbro Sound Ave feeder to supply around 2MVA of new loads in this area.

Once the spare network capacities are used up, one network reinforcement option is to install a new feeder from Waikiki zone substation which may require up to 4.5 km of 400mm2 Al XLPE 22kV cables. Please refer to Figure 3 for an indicative feeder route. The requirement and timing of this new feeder is dependant on the load growth of this and other surrounding developments in the area. It might also be possible to extend from a future feeder which has spare capacity.

Please note that the network reinforcement outlined above does not include any work within the development boundary.

5. GENERAL ASSESSMENT

The details in this feasibility study report are only indicative. Further in-depth study and analysis will be required to determine the exact requirement of the reinforcement works once a formal application to Western Power has been lodged. It would be appreciated that at the time of the initial application, a staging plan with expected takeoff dates be provided to Western Power.

Western Power can neither reserve capacity nor guarantee supply to this development without a formal request being lodged. In order to provide a firm connection proposal and cost, a formal application to Western Power will have to be made, in accordance with our connection policies.

Appendix: Customer Completed Feasibility Request Form

westernpower

Electricity Networks Corporation ABN 18 540 492 861

Part A - Application type

☐ Feasibility Enquiry ☑ Feasibility Study

Applicant details - for tax invoice

Title (e.g. Mr, Mrs)	Mr	Surname	Porter
Given name(s)	David		
Company or busines name	Porter Consulting Engineers		
		ABN	N/A
Postal address	PO Box 1036		
Suburb or town	Canning Bridge	Post code	6153
Email (optional)	david@portereng.com.au		
Mobile (optional)	N/A	Telephone	(08) 93159955
Fax (optional)	(08) 93159959		
Western Power reference number (if applicable)	N/A		

Part B - Land use

Residential	☐	Commercial/Industrial	☑	Special Rural	☐
Other (please describe)					
Number of lots	120	Number of stages	N/A	Number of lots per stage	N/A
Approximate commencment date for each stage.	12 months to 24 months for start of stage 1. Other stages unknown.				
Comments					

Part C - Project details

Please attached Stage Plan with this document.

Project name	Port Kennedy Business Park
Your project reference number	SAA2011127

Part D - Site address/location plan

Please attach a location plan or concept plan with this document.

Site address	Lots 4 & 17 Port Kennedy Drive
Suburb or town	Port Kennedy — Post code: 6172
Nearest cross street	Port Kennedy Drive between Ennis Ave and Bakewell Drive
Map number	N/A
Grid reference	N/A — From street directory

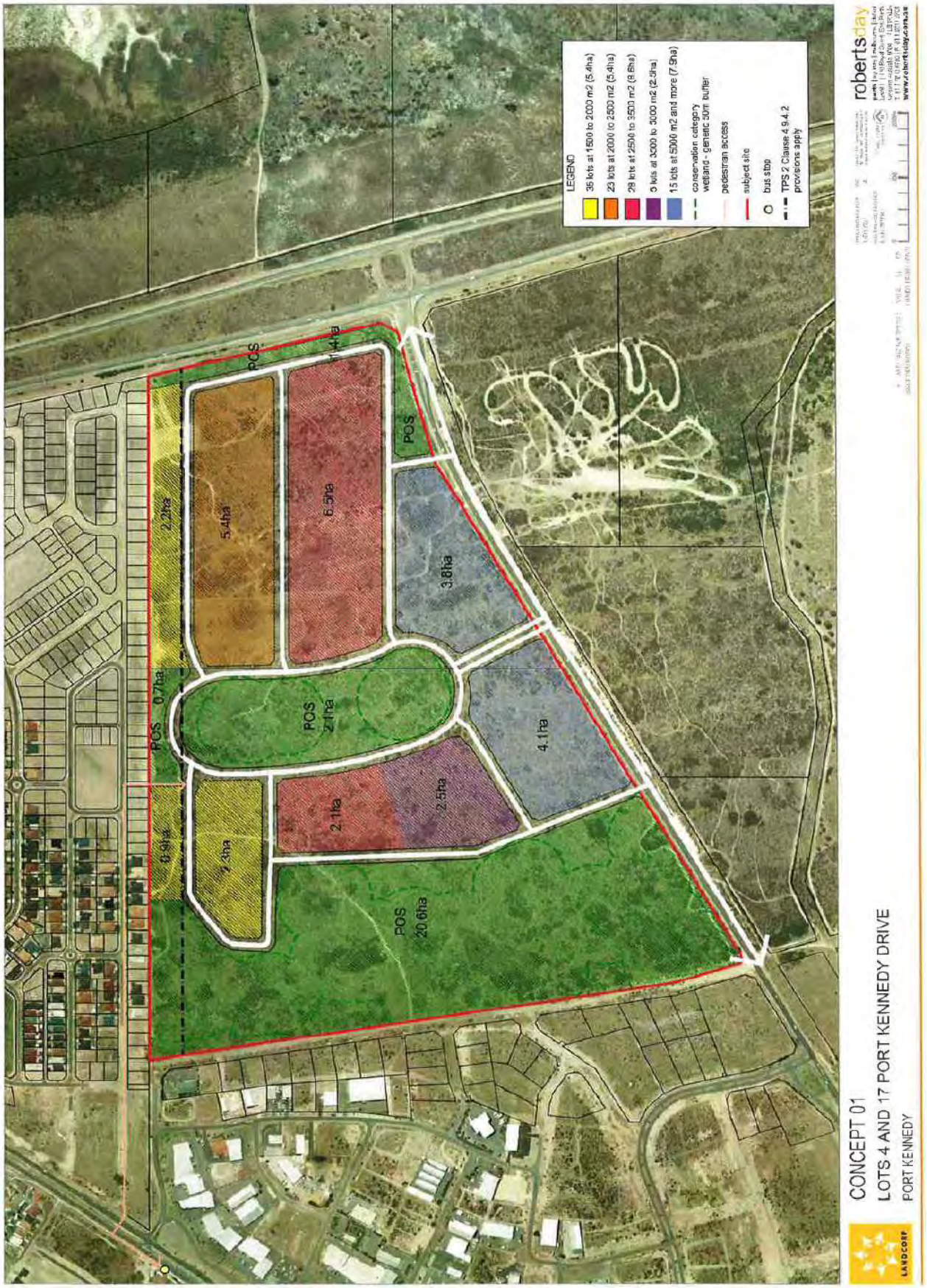
Part E - Proposed loading

ADMD per lot	200kVA/ha
Comments	Total usable area is 34.5ha equating to approximately 7MVA.

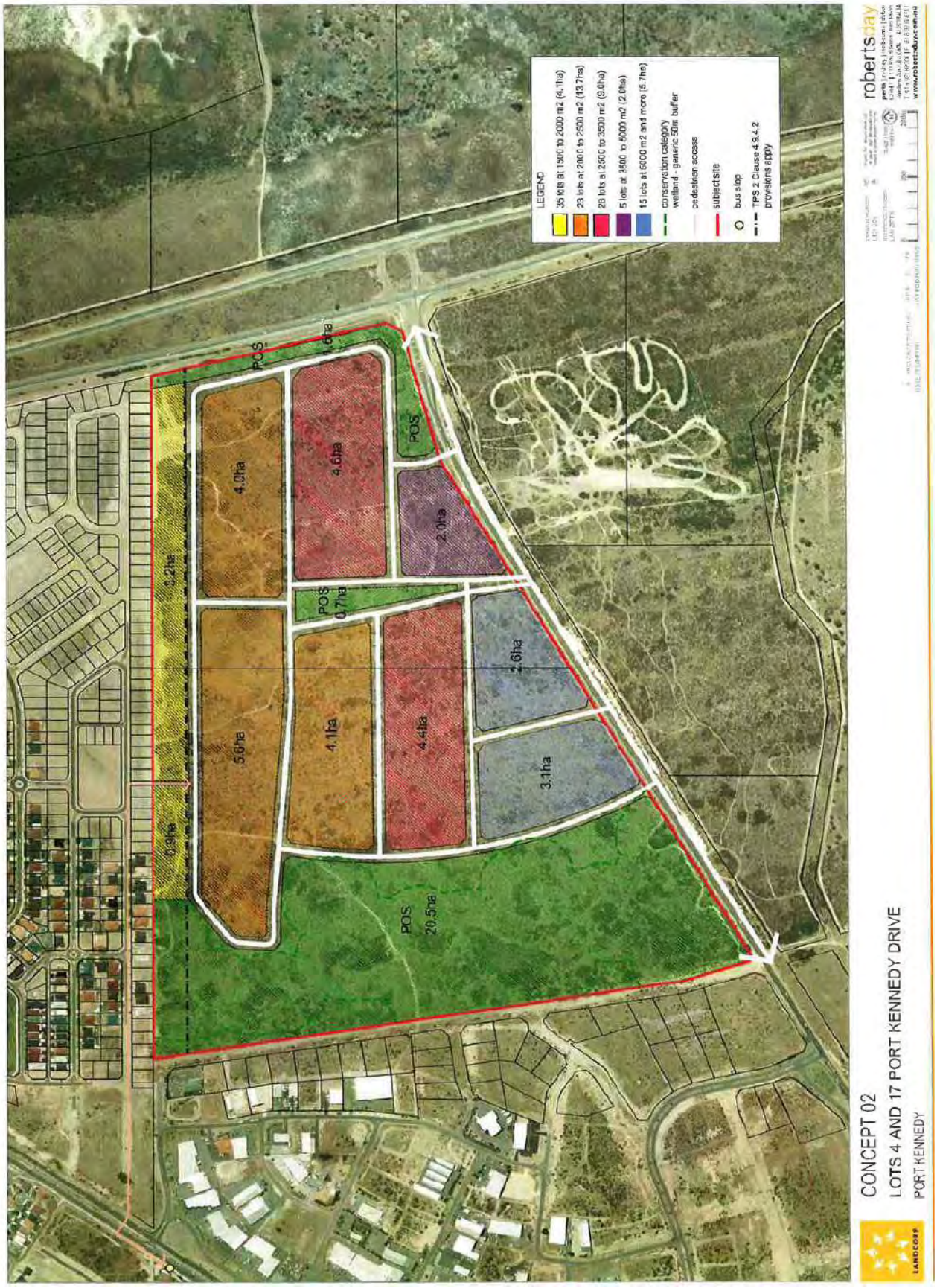
Part F - Approval

On signing this form as the duly authorised representative, the signatory accepts liability for payment of $315.00 (inc GST) for a Feasibility Enquiry or $775.00 (inc GST) for a Feasibility Study. Please refer to 'Terms & Conditions'.

Name	David Porter
Mobile (optional)	Telephone ([redacted]) 93159955
Signature	Date 27 / 05 / 2011



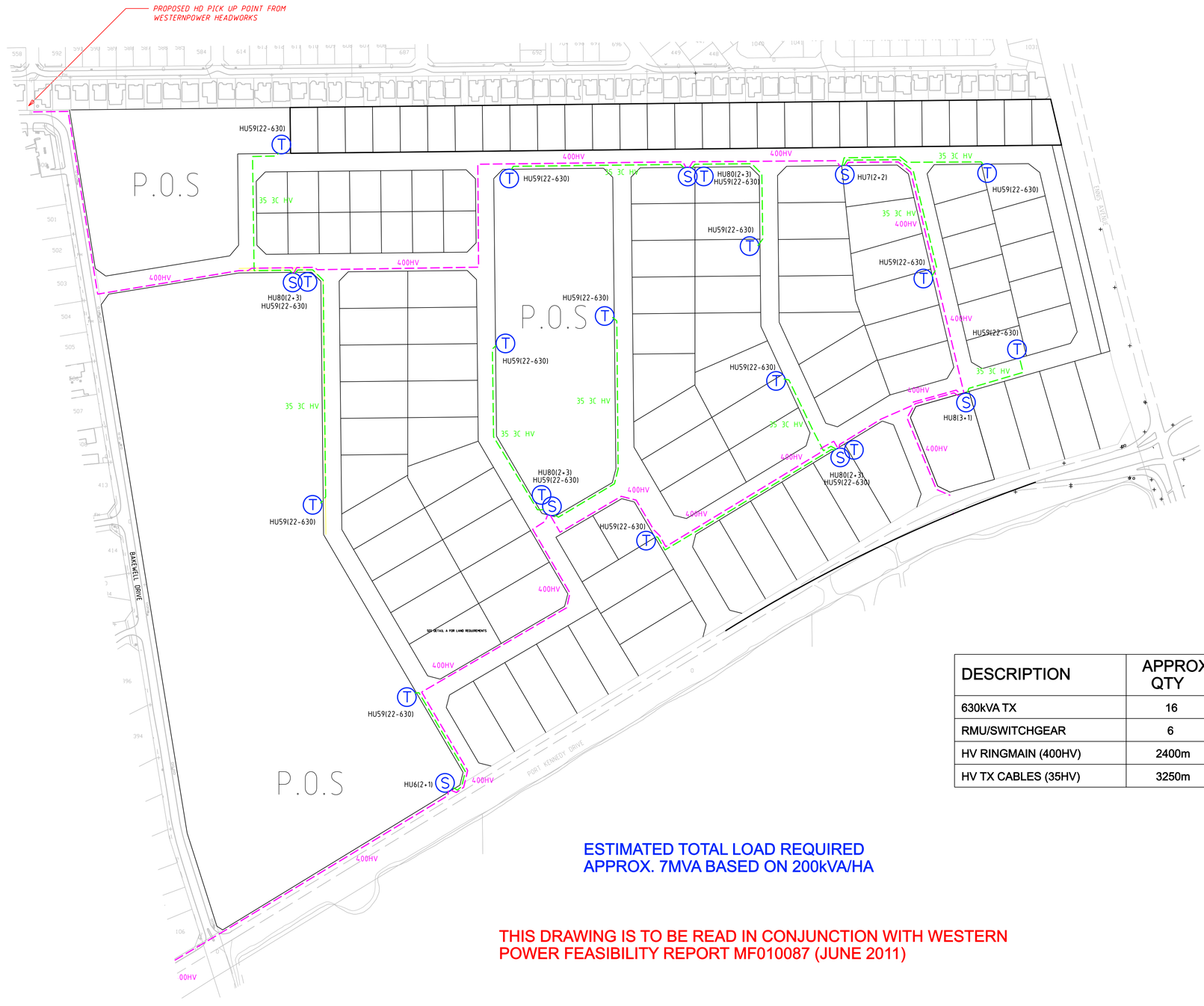
Proposed Development Plan – Concept 01



Proposed Development Plan – Concept 02

NOTES:

1. INSTALLATION TO BE IN ACCORDANCE WITH WESTERN POWER UNDERGROUND DISTRIBUTION SCHEMES POLICY AND INSTALLATION MANUALS, WAER, AS3000 AND ANY OTHER REGULATORY REQUIREMENTS.
2. ALL TRANSFORMER LAND REQUIREMENTS (IF REQUIRED) ARE TO BE LOCATED IN THE ROAD RESERVE OR P.O.S.
3. CABLE JOINTS SHOWN IN NOMINAL POSITIONS. TO BE INSTALLED IN REQUIRED LOCATION AND ONLY IF NECESSARY. FINAL LOCATIONS TO BE SHOWN ON 'AS CON' WITH DIMENSIONS FROM NEAREST PEG.



DESCRIPTION	APPROX QTY
630kVA TX	16
RMU/SWITCHGEAR	6
HV RINGMAIN (400HV)	2400m
HV TX CABLES (35HV)	3250m

ESTIMATED TOTAL LOAD REQUIRED
APPROX. 7MVA BASED ON 200kVA/HA

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH WESTERN POWER FEASIBILITY REPORT MF010087 (JUNE 2011)

CABLE		CONDUIT SIZE
400mm2	HV	160mm
240mm2	HV	150mm
185mm2	HV	150mm
95mm2	HV	150mm
50mm2	HV	150mm
35mm2	HV	100mm
240mm2	LV	100mm
185mm2	LV	100mm
120mm2	LV	100mm
25mm2	LV	50mm
16mm2	SL	50mm
10mm2	SL	50mm
40 C PILOT		50mm

STREET LIGHTS: 70W HPS, 150W HPS, 250W HPS, 70/75W MH, 150W MH, 250W MH, EXISTING, 42W CF

AERIAL CONDUCTORS AND POLES: NEW POLE (ANY TYPE AS INDICATED); EXISTING POLE (ANY TYPE AS INDICATED); EXISTING AERIAL CONDUCTORS (SIZE AND TYPE AS INDICATED)

PILLARS: UNIVERSAL, MINI, MINI -WORKING END, LINK, UMS PIT, 100AMP CUTOUT, 200AMP CUTOUT

TRANSFORMERS (T); SWITCHGEAR (S)

SCHEME BOUNDARY; RETAINING WALLS

DUCTS: ARROW DENOTES ALIGNMENT TO PEG; EXISTING DUCTS

DUCTS TO BE LAID TO WPC SPECIFICATION ES 3/16/84

METRES 125 0 125 250

LOCAL SHIRE: CITY OF ROCKINGHAM

Stapleton and Associates Pty. Ltd.
Consulting Electrical & Control Engineers
A.B.N. 50 008 949 755
Level 4, 524 Hay Street, Perth, Western Australia 6000.
Phone (08) 9325 4588 / Fax (08) 9221 3934
Email: info@stapletons.net.au

SHEET SIZE A1

REFERENCES

DRG. No.	DESCRIPTION

REVISIONS

No	DR'N	CHK'D	DATE	DESCRIPTION
0	D.E.T.	D.E.T.	05-08-11	ISSUED FOR CLIENT COMMENTS

SCALE 1:2500

0 10 20 30 40 50

DRAWN	D.E.T.	04-08-11
DESIGNED	D.E.T.	04-08-11
CHECKED	D.E.T.	04-08-11
PROJECT ENGINEER		
APPROVED		

CLIENT
PORTER CONSULTING ENGINEERS / LANDCORP

TITLE
PORT KENNEDY BUSINESS PARK
WPC U/G ELECTRICAL DEVELOPMENT
PROPOSED HIGH VOLTAGE RETICULATION

DRG. No. 2011127-E-001

REVISION 0

...\Microstation\2011127001.dgn 5/08/2011 4:42:28 PM

ATTACHMENT 12
Indicative Bulk Earthwork Re-contouring Plan

LEGEND

- EARTHWORKS AREA BOUNDARY
- 7.90 FINISHED LOT LEVEL
- — 2.0m AAGWL — ANNUAL AVERAGE GROUND WATER LEVEL
- PROPOSED KERB

NOTE:
EARTHWORKS ARE NOT TO ENCROACH INTO THE CCW OR RESERVE LOTS

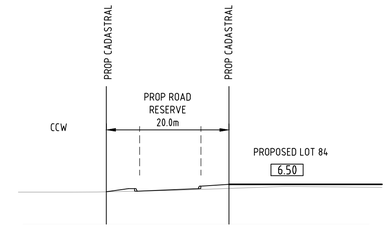
CCW

RESERVE

BAKEWELL DRIVE

PORT KENNEDY DRIVE

ENNIS AVENUE



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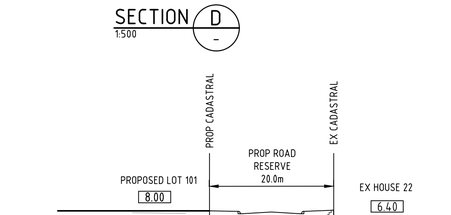

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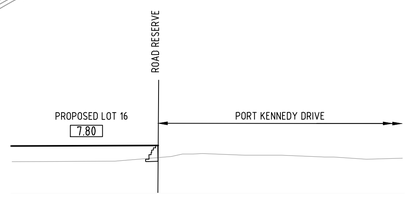
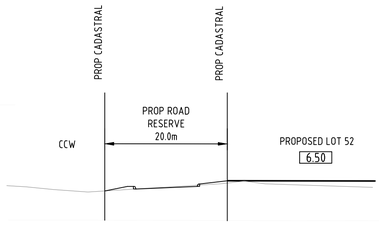


SECTION B 1:500

SECTION E 1:500



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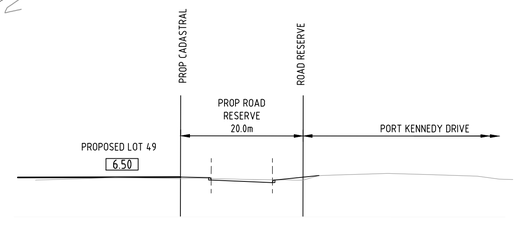

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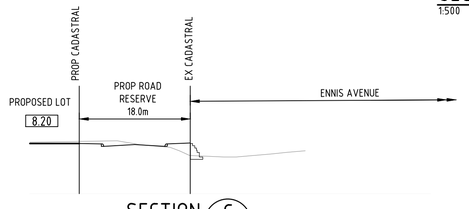

SECTION C 1:500

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1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)

BEFORE YOU DIG www.byda.com.au

PROJECT:
PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No	DATE	REVISION	BY
D	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
C	31-1-2023	LOT LAYOUT UPDATED- OPTION 6A	MEG
B	15-4-2021	TURNING POCKET ADDED ON PORT KENNEDY DRIVE	MEG
A	17-12-2020	CONCEPT	MEG

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Email office@portereng.com.au
www.portereng.com.au

TUSMO Pty Ltd ACN 070 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: CONCEPT EARTHWORKS PLAN

STATUS: CONCEPT

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 18-6-73/903

REV No. D

ORIGINAL DRAWING SIZE A1

FILE NAME S:\ACTIVE PROJECTS\18-06-073\ACAD_PLANNING\18673-903.dwg

ATTACHMENT 13
Staging Plan

DIAL BEFORE YOU DIG www.1100.com.au

PROJECT:

PORT KENNEDY ENTERPRISE PARK
PORT KENNEDY

No.	DATE	REVISION	BY
B	10-10-2023	UPDATED STRUCTURE PLAN 717-278 ST01A 2023-09-27	MEG
A	17-12-2020	CONCEPT	MEG

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TUSMO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: DevelopmentWA

DRAWING: **STAGING PLAN**

STATUS: **CONCEPT**

SCALE	1:2000
DATE	DEC 2020
DESIGN	SCH
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. **18-6-73/900** | REV No. **B** | ORIGINAL DRAWING SIZE **A1**

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Consulting Engineers

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T. (08) 9289 8300 – **E.** hello@elementadvisory.com.au
elementadvisory.com.au