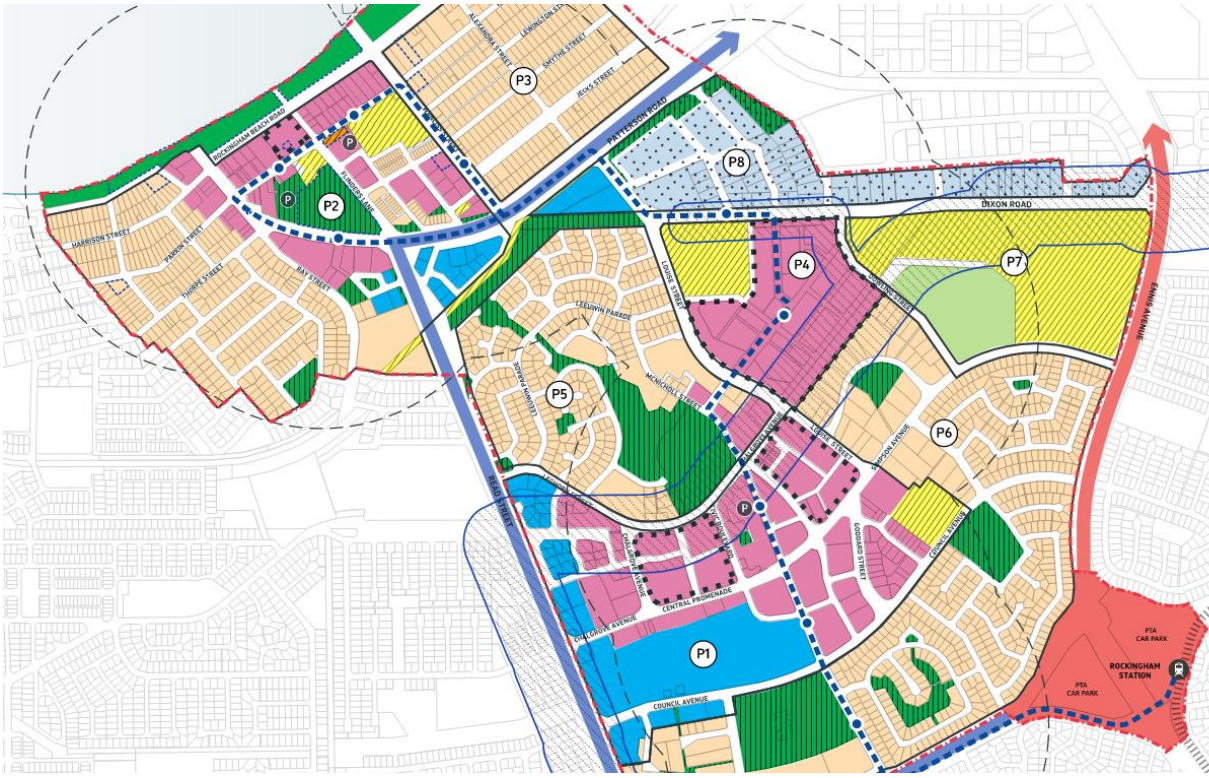
Rockingham City Centre Precinct Structure Plan Local Water Management Plan Addendum

Prepared for: City of Rockingham

Prepared by:
Stantec

Project/File: 300204265



Stantec Australia Pty Ltd

Revision Schedule

Revision No.	Date	Description	Prepared by	Quality Reviewer	Independent Reviewer	Project Manager Final Approval
A	02/07/2025	Issued for Review	SH	JD	SV	JD
B	22/08/2025	Issued for Final	SH	JD	GM	JD
C	30/10/2025	Issued for Final	SH	SV	GM	SV

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1 Introduction and Scope Overview

Stantec Australia Pty Ltd has been engaged to provide a Local Water Management Plan (LWMS) addendum to the previous Water Management Strategy (WMS) for the Rockingham City Centre Precinct Structure Plan (Cardno, 2021). The previous WMS (Cardno, 2021) is included in Appendix A.

The addendum aims to provide technical evidence that satisfies the comments (Appendix B**)** from Department of Water and Environmental Regulation (DWER) and Water Corporation (WC) on the existing WMS. The addendum includes:

- Quantify the existing conditions and post-development peak flow to account for additional runoff from proposed density changes.
- Quantify the amount of additional land required, if any, for drainage/infiltration purposes.
- If required, identify and quantify areas required for future stormwater drainage infrastructure.
- Provide high-level commentary on the impact of proposed changes in land use on groundwater levels.
- Provide evidence that the proposed change in land use will not result in higher peak flows in Water Corporation drains within the precinct.
- Document additional information made available at the time of this study and ensure alignment with State Planning Policy 2.9.

Based on the commentary, this addendum intends to fill the gaps between the Water Management Strategy and provide addendum to the previous document where additional information was available. In summary, this addendum intends to build on the existing water management strategy to a Local Water Management in line with SSP 2.9 Draft Planning guidelines.

The LWMS outlines best practice stormwater infrastructure and water management approaches required to accommodate land use changes resulting from the precinct development. Implementation of the LWMS will maximise opportunities for sustainable long-term use of the precinct, balanced with growth, climate risks and environmental challenges for the site.

Amendments required to update the WMS are detailed in Section 0. Additional modelling to quantify the existing and post-developed modelling is included in Section 7. A development level and Urban Water Management Plan (UWMP) condition is outlined in Section 8.1

2 Amendments to LWMS

The amendments to the previous WMS are informed by several factors:

- New data inputs and baseline information provided by the City of Rockingham (the City) and various other sources
- Updates to the regulatory framework, planning policies, and relevant guidelines.

The summary of the amendments to the LWMS is presented in Table 2-1.

DWER provided comments on the draft LWMS addendum on 03/10/2025. The agreed actions are outlined in Appendix D.

Table 2-1: Summary of Amendments to LWMS

Report Location	Water Management Strategy (WMS) 2021	Proposed Amendment
WMS Section 1.2 Location	The WMS has identified that the total precinct area covers approximately 525 ha	Based on the updated Structure Plan Map (28/03/2025) by Hames Sharley, the precinct area is 534.63 ha. The additional Public Open Space (POS) at the beach and road has been included in the 2025 version as represented in Figure 2-1.
WMS Section 1.4 Policy Framework	Policy Framework includes: • Liveable Neighbourhoods Edition 4 (WAPC, 2009) • Stormwater Quantity Management Manual for WA (DoW, 2007)	Policy Framework updates: • Liveable Neighbourhoods Edition 4 (WAPC, 2015) • Stormwater Management Manual for WA (DWER, 2022) • Draft State Planning Policy 2.9 (DPLH, 2021)
WMS Section 2 Proposed Development	The proposed residential land use for the proposed development is R60, R80, and R100, mixed use, commercial, public purpose etc.	The proposed land use has had minor adjustments since 2021, including: • The proposed development land use includes densification of residential land including R40, R60 and R80. • Some previous POS land use has been changed to Service Commercial, Mixed Use and Public Purpose • The previous report (Cardno, 2021) mentioned that the post-development land use for the Dowling Street Reserve in the middle of the precinct included a variety of land use types: Public Purpose, Public Open Space, Mixed Use-RAC0, Residential R60, R80 and R100., The land use has been updated to Mixed use and Public Purpose use only. The updated proposed land use is represented in Table 2-2 and Figure 2-2. The drainage strategy outlined in this Addendum has been developed in accordance with these revised land uses.
WMS Sections 2.2 Objectives	WMS Objectives: - Stormwater quantity management - Stormwater quality management - Groundwater - Water Conservation	This LWMS includes updated objectives and key details for improved alignment. Refer to Section 4 for details.
WMS Section 3.3 Topography and Soils	The WMS has identified that the study area is generally flat and drains slightly to the west towards Lake Richmond. Spot levels on site range from 7 m AHD in the south-eastern corner near the train station to 3 m AHD along Rockingham Beach	The proposed topography and soil conditions have been updated based on the updated precinct area including: • The topography consideration has been updated based on the updated Precinct Structure Boundary and updated Digital Elevation Model (DEM) to 0.5mAHD at the western boundary of the study area, and up to 8mAHD at the south-eastern corner of the study area near the train station. • City of Rockingham supplied a few Council-identified flooding hotspots: o 3 Rockingham Beach Rd o Patterson Rd o Corner of Chalgrove and Read St o Read St o Bell St Ocean Outlet These flood hotspots have been identified as localised low points with limited drainage infrastructure information available for confirmation of conveyance.
Contaminated Site (to be included in the LWMS)	The Contaminated Site section was not included in the WMS report as it was contained in the Environment Report (Cardno 2022). Five land parcels within a 1km radius of the RSMC have been assigned a contaminated sites classification by the Department of Water and Environmental Regulation (DWER).	The LWMS incorporates the database findings into the design objectives: • The proposal for any sites to be remediated prior to development in line with regulatory requirements for the proposed land use. • Any major Water Sensitive Urban Design (WSUD) infrastructure to be located outside the potentially contaminated site.
WMS Section 3.6 Wetland	The Wetland section was also included in the Environment Report (Cardno 2022). The major wetland is Lake Richmond, which is located outside but downstream of the precinct area. There are a few small Conservation category wetlands identified within the Precinct Area (Section 2.2.6).	Based on the RAMSAR and Wetland Mapping: Swan Coastal (DBCA-019) dataset: • No Wetlands of international importance (RAMSAR) are identified • There are a couple of wetlands within the precinct area proposed for future mixed-use development. Satellite imagery indicates there is a small amount of vegetation within the indicated wetland extent. This area is proposed to be developed based on the proposed precinct structure plan map. Further investigation and assessment is required before the development stage to ensure environmental conditions are met
WMS Section 3.7 Surface Hydrology	The existing surface hydrology catchments have been derived based on the City of Rockingham Council infrastructure and LiDAR DEM.	Catchments have been updated and refined based on the latest drainage network and topography data supplied by the City. The updated sub-catchment flow plan with the drainage network is shown in Figure 2-3.
WMS Section 3.9 Groundwater	The WMS has identified that: • Maximum Groundwater Levels range from 1m AHD to 4m AHD • Existing report on groundwater quality from Bore 8282 Superficial Aquifer sampling point	This LWMS has incorporated additional data provided by the City: • The topography range within the study area is between 0.5m to 8mAHD, with maximum depth to groundwater ranging from approximately 0m (at surface level) at the coastal beach to 4m at the eastern corner of the study area. • The City also supplied the “Soakwells Suitable with Groundwater” layer, which indicates appropriate depths for soakwell installation. This layer helps identify locations where shallower installation is required to maintain functionality due to groundwater presence...

		The "Soakwells suitable with groundwater" database and maximum groundwater levels are presented in Figure 2-4. Perth groundwater map (DWER) stipulates groundwater quality as: • Salinity: 500-1000mg/L (marginal) at the southwest portion of the study area and 1000-1500mg/L (brackish) at the northeast portion of the study area. • Garden Bore Suitability: the study area is Suitable for a garden bore, except the Coastal Area past Kent Street. This may allow for the use of groundwater for irrigation purposes depending on groundwater allocation and reduced dependence targets
Public Drinking Water Source to be included in the LWMS	The Public Drinking Water Source section is not included in the WMS report.	The Public Drinking Water Source Area (DWER 2025) is 13km away from the Precinct Area.
Heritage to be included in the LWMS	The Heritage section is not included in the WMS report. The heritage sites have been identified in the Environment Report (Cardno 2022): • No registered Aboriginal heritage sites are located within the planning envelope. The RSMC is on land within the Gnaala Karla Booja Indigenous Land Use Agreement (ILUA) (Section 2.4). • Several heritage-listed sites under the Heritage Council WA are present within the RSMC (Section 2.4.3)	There are no registered Aboriginal heritage sites located in the study area according to public data sources. However, there are a few European Heritage sites located in the study area which need further investigation before development.
Modelling to be included in the LWMS	The existing report does not include any modelling.	A 1D DRAINS Modelling section (Section 6) to be added with consideration of climate change and coastal inundation with a focus on reporting the peak flow at the Water Corporation drains for pre-development and post-development scenarios. The section also presents the indicative (storage) volumes at the proposed drainage reserves for the post-development scenario.

Table 2-2: Proposed Land Use Zoning (Hames Sharley, 2025)

Post-development Land Use Zoning	Area (ha)	Percentage of Total Area (%)
R40	55.37	10.36%
R60	77.80	14.55%
R80	33.73	6.30%
Mixed Use	68.07	12.81%
Service Commercial	7.96	1.49%
Private Club & Institution	20.56	3.84%
Commercial	28.66	5.36%
Public Open Space	50.79	9.50%
Primary Regional Roads	22.23	4.16%
Public Purposes	38.46	7.19%
Civil & Community	0.19	0.04%
All Other Road reserves	130.83	24.47%
Total	534.63	

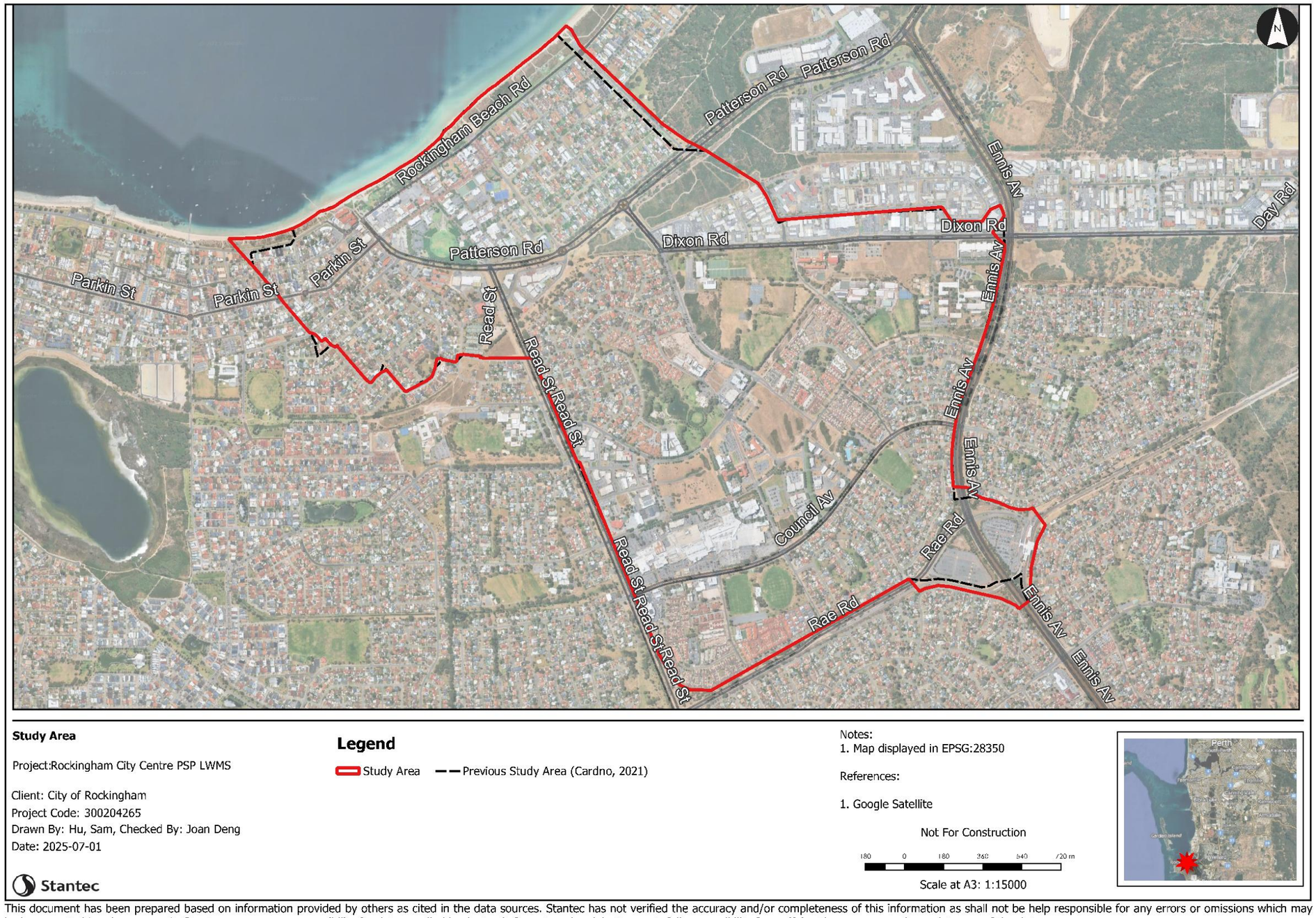
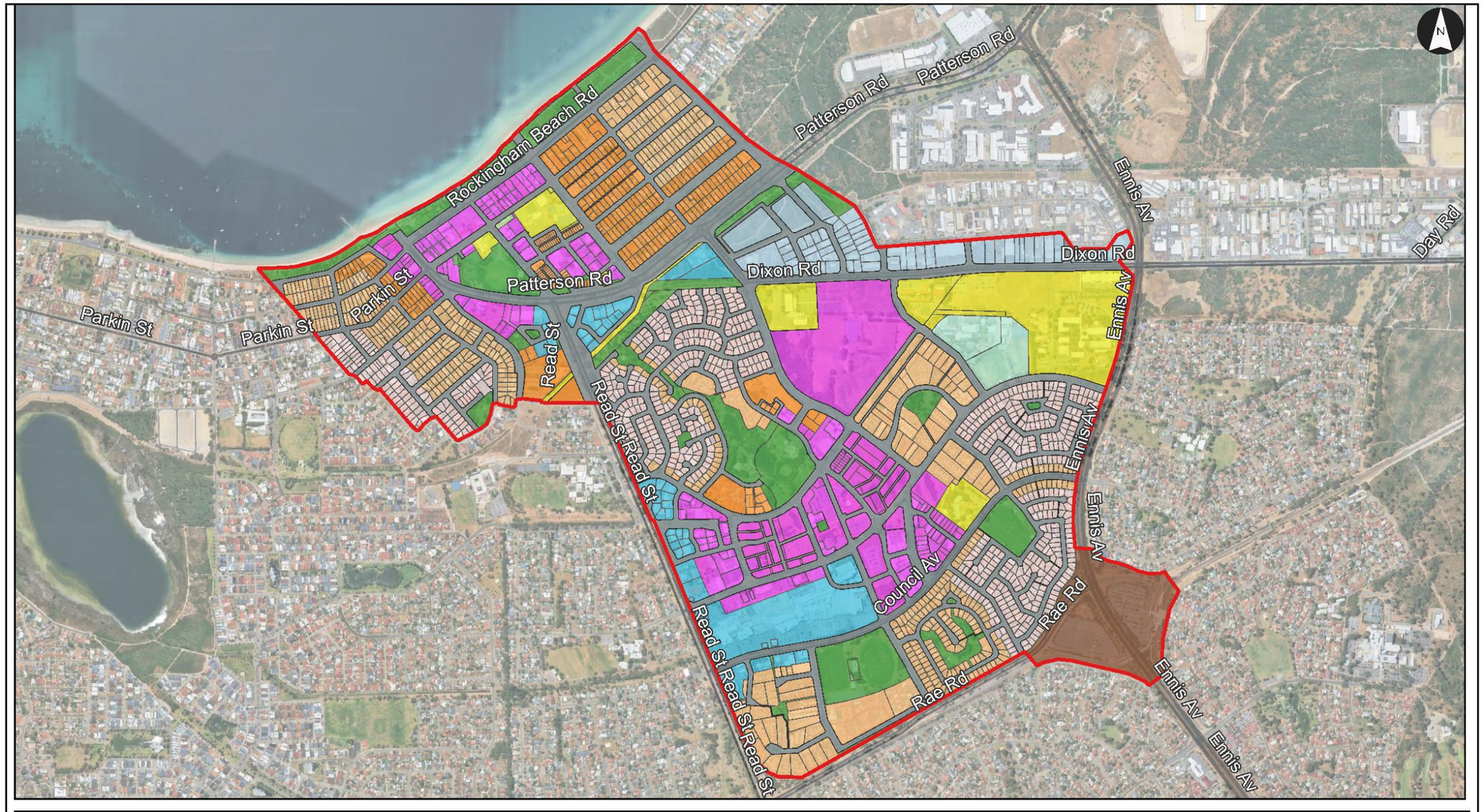


Figure 2-1: Rockingham City Centre Precinct Structure Area (Hames Sharley 2021 & 2025)



Post-development Land Use

Project:Rockingham City Centre PSP LWMS

Client: City of Rockingham
Project Code: 300204265
Drawn By: Hu, Sam, Checked By: Joan Deng
Date: 2025-07-01

Stantec

Legend

- Study Area

Proposed Land Use (Hames Sharley 20250630)

- Commercial
- Mixed Use
- Primary Regional Roads
- Private Club & Institution
- Public Open Space
- Public Purpose
- R40
- R60
- R80
- Service Commercial
- Civic & Coummity
- All Other Road Reserve

Notes:
1. Map displayed in EPSG:28350

References:

1. Google Satellite

Not For Construction

180 0 180 360 540 720 m

Scale at A3: 1:15000

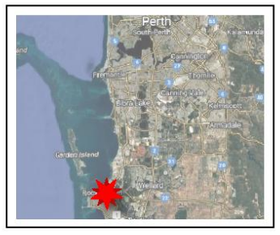


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Figure 2-2: Proposed Land Use (Hames Sharley, 2025)

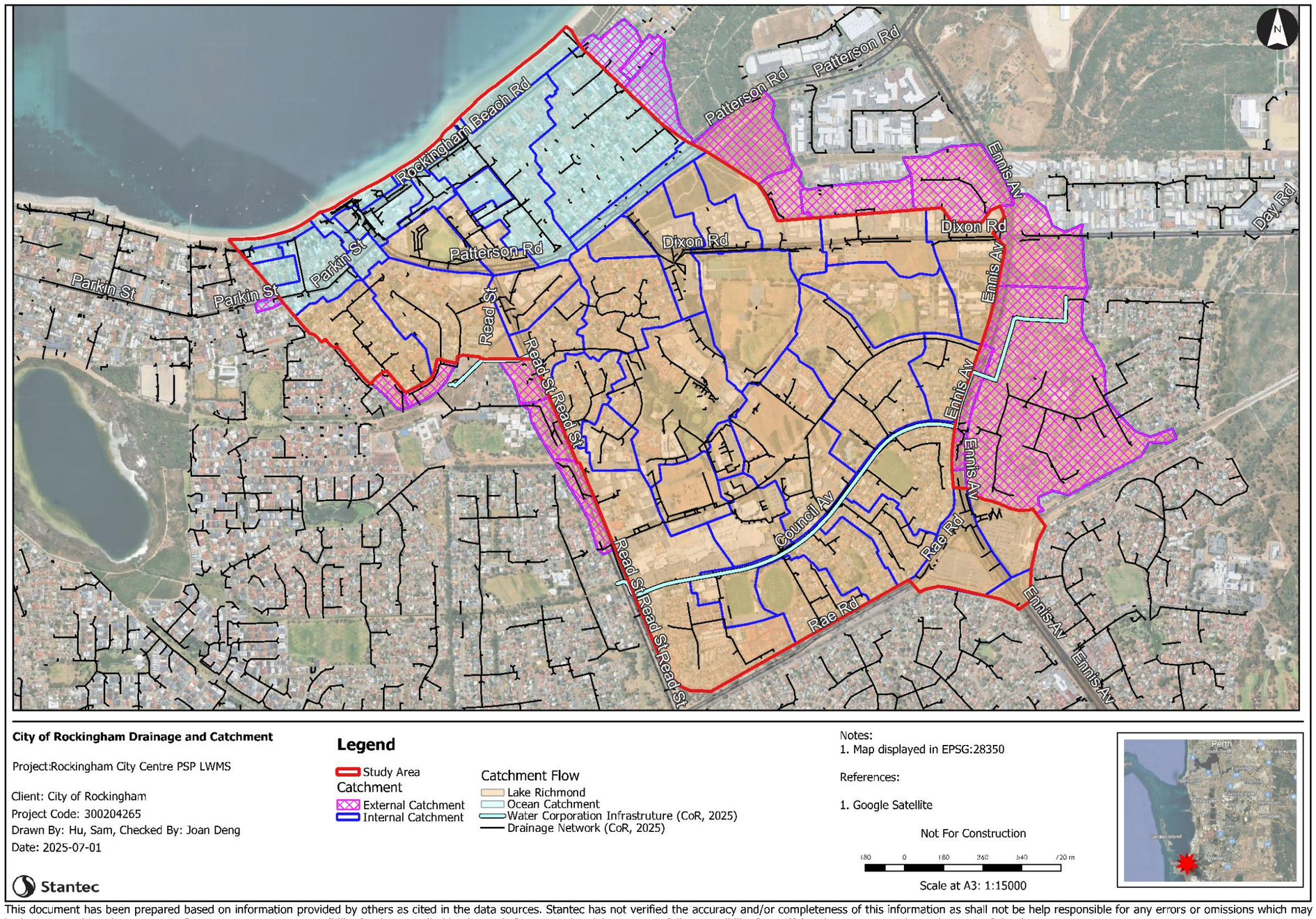


Figure 2-3: City of Rockingham Drainage Infrastructure and Catchment (City of Rockingham (CoR), 2025)

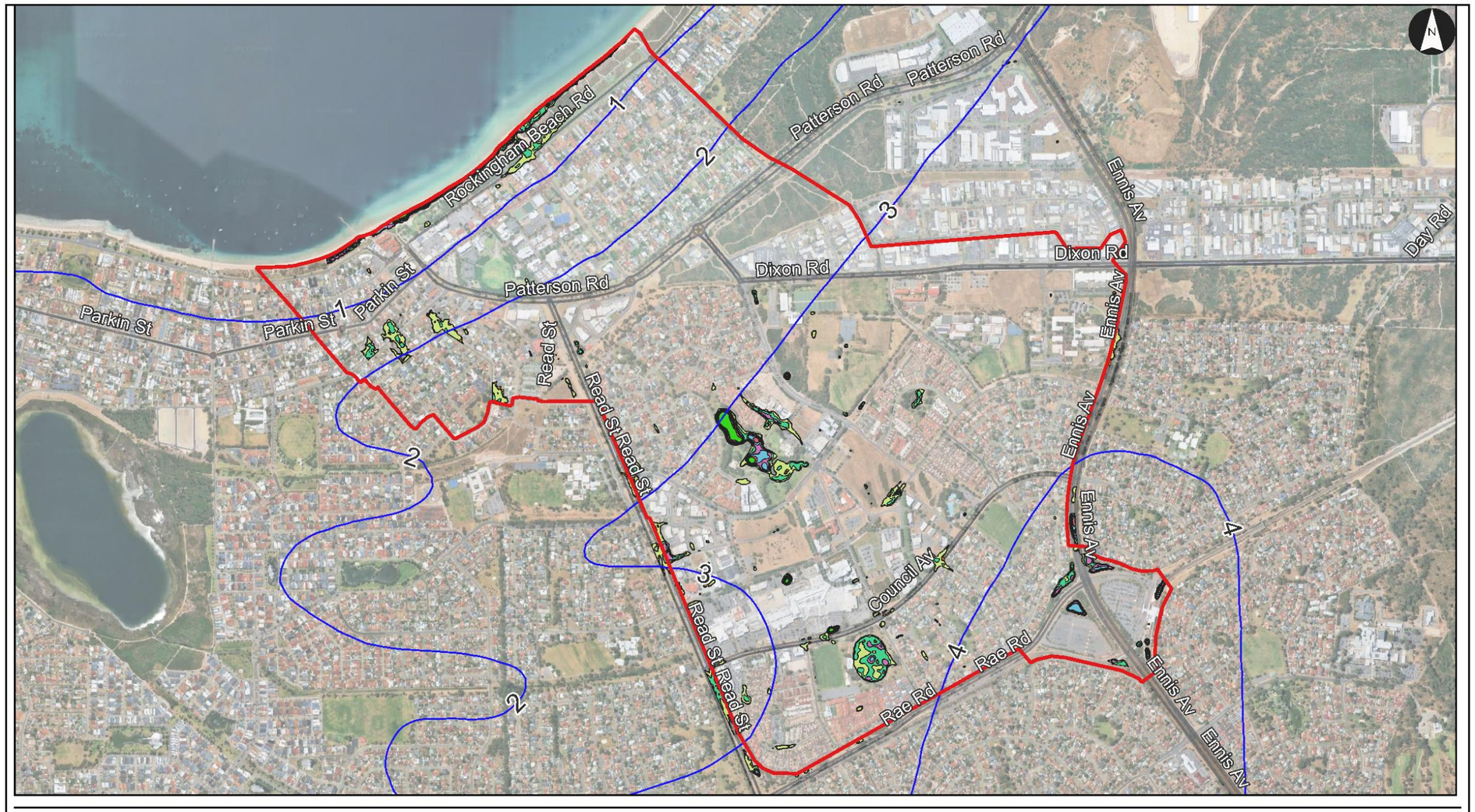


Figure 2-4: Groundwater Soakwells layer and Maximum Groundwater levels

3 Site Visit

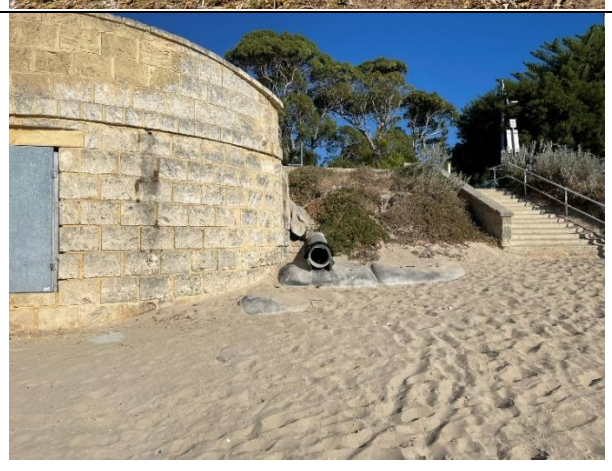
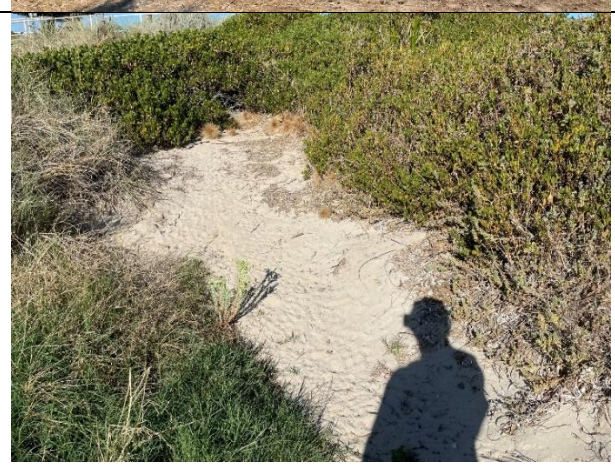
Stantec conducted site visits in April 2024 across key locations to assess existing constraints and determine the suitability of expanding open space areas for drainage purposes. Key findings from these visits include:

- Park areas serve as vital community hubs with high levels of public use. Any proposed drainage infrastructure must be carefully integrated to minimise impacts on amenity and usability.
- The proposed open space locations at Anniversary Park, Careeba Park, and Huston Reserve are generally suitable for dual use as both public open space and drainage reserves, with no major constraints identified.
- Several existing drainage reserves require maintenance to enhance their current performance and offer potential for multifunctional use.
- Ocean outlets were difficult to identify due to overgrown vegetation, underscoring the need to update the drainage infrastructure database.
- Some ocean outlets may require maintenance to ensure they continue to function effectively.

These findings, further detailed in Table 3-1 have informed the development of objectives and the overall water management strategy.

Table 3-1: Key Locations

Local	Description and Notes	Photos
Rockingham Train Station – Infiltration basin	The basins are closed off from public access with significant vegetation within the sites.	 
Careeba Park	The Careeba Park is slightly below road level, with significant public use in the area.	 
Anniversary Park	Anniversary Park has two distinctive levels. The lower level park have some area around the sporting oval, which may allow for some multiple use.	 
Cygnus Street Water Corp Drain	The Water Corporation's infrastructure outlet discharges into a channel with semi permanent standing water.	 
Leghorn Street Basin	The Leghorn Street Basin is shown to have several large trees, and no formalised basin inlet or outlet could be found.	 

Hmas Warramunga Park	The HMAS Warramunga Park functions as a formalised ornamental water storage system. The basin appears to maintain semi-permanent water levels, which are set at approximately the same elevation as the surrounding residential lots. As a result, it provides no additional capacity to protect nearby private properties.		
Dowling Street/Simpson Ave Reserve			
Ocean Outlets	The majority of the ocean outlets are covered in vegetation. Several ocean outlets cannot be located safely due to dense vegetation		
Ocean Outlets	The ocean outlets could be safely found but the greenery/vegetation shows the indicative location.		

4 Design Criteria and Objectives

The water management criteria for this LWMS have been developed with consideration of site-specific constraints and the inputs from City of Rockingham. The details are discussed below.

4.1 Surface Water Management

- **Criteria SW1:** Post-development discharge rate is not to be greater than pre-development discharge at Water Corporation assets to ensure the existing system does not receive increased flow rates for the 1% Annual Exceedance Probability (AEP) critical storm.

- **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains must receive treatment prior to infiltration or discharge for the 15mm of rainfall. This can be achieved with at-source treatment infrastructure (where groundwater allows), including WSUD features such as vegetated swales, rain gardens, or 'leaky' rainwater tank beds. *The City of Rockingham will include incorporating water quality improvements as part of the detailed design for stormwater management within POS areas.*

- **Criteria SW3:** Gross pollutant and/or hydrocarbon traps are to be provided at inlets of detention structures and on any discharge locations from commercial and light industrial lots (subject to lot-specific industry and likely contaminants)

- **Criteria SW4**:
  - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm of rainfall. Additional infiltration will be provided at the Public Open Space (POS) to ensure the 1% AEP post-development flows does not exceed pre-development flows. This can be in the form of underground infiltration storage.
  - New commercial, mixed-use, or other commercial land use will be managed up to 20% AEP1-hour storm events onsite. The owner will also incorporate information on maintenance and cleaning of the proposed infrastructure as part of their development application.
  - All new developments (residential and commercial) within the coastal catchment shall be required to infiltrate all storm events up to and including 20% AEP 1-hour event on the lot, where groundwater conditions allow.

- **Criteria SW5**: Minor drainage pit and pipe system should convey up to and including the 20% AEP storm event runoff in residential areas and 10% AEP storm event runoff in commercial or industrial areas.

- **Criteria SW6:** Major drainage of all storms up to and including the 1% AEP event to be safely conveyed by roads, open drains, and swales where the minor network is surcharged.

- **Criteria SW7:** Post-development flows should pose no negative impacts to downstream receiving waters.

- **Criteria SW8:** Construct residential, commercial, and industrial building finished floor levels at least 0.3 m above the 1% AEP flood level and at least 0.5 m above the 1% AEP flood level of waterways and major drainage systems or otherwise based on advice from the DWER.

- **Criteria SW9:** Adopt regular stormwater asset maintenance to ensure the containment of pollution spills and litter removal.

- **Criteria SW10:** Reduce hardstand areas and encourage at-source infiltration through permeable pavement, adequate hardstand crossfall to adjacent landscaped areas with kerb-cuts to facilitate passive irrigation and treatment.
- **Criteria SW11:** Ensure the stormwater system does not lead to liability for the Council in consideration of coastal inundation.
- **Criteria SW12:** Infiltrate all stormwater in retention devices in less than 36 hours for 20% AEP events, 48 hours for 10% AEP events, and 96 hours for 1% AEP events.
- **Criteria SW13:** Mandate a minimum of 10% of landscape area for Mixed Use, Commercial, and Residential lots (R80), a minimum of 15% of landscape area for Residential lots (R40&R60).

4.2 Groundwater Management

- **Criteria GW1**: Manage groundwater levels to protect properties, infrastructure, and assets. A risk-based decision should be made to identify site-specific groundwater levels for the PSP.
- **Criteria GW2**: Provide 1.2m separation distances for acceptable levels of risk and amenity for critical elements of built form and infrastructure.
- **Criteria GW3**: Minimum critical 63.2% AEP storm event infiltration, or greater up to the 1% AEP event is encouraged where appropriate based on site-specific permeability and groundwater levels.
- **Criteria GW4:** Maintain groundwater regimes for the protection of groundwater-dependent ecosystems.
- **Criteria GW5:** Protect the value of groundwater resources.
- **Criteria GW6:** Achieve nutrient load reduction design objectives for discharges to groundwater
- **Criteria GW7:** Achieve free drainage with a minimum invert level of 150mm above the base of the system into which it discharges for sub-surface drainage outlets under coastal consideration.
- **Criteria GW8:** Achieve separation distances to the phreatic surface if subsoils are utilised in-line with Institute of Public Works Engineering Australia (IPWEA) Specification for separation distances for groundwater-controlled urban development (taking into consideration coastal inundation).

4.3 Water Conservation

- **Criteria WC1:** Mandate water-efficient fixtures for all new developments.
- **Criteria WC2:** Encourage alternative water supplies including rainwater tanks, stormwater harvesting and greywater reuse schemes.
- **Criteria WC3**: Encourage Waterwise native gardens and endemic species, with kerb-cuts or tree pit opportunities to reduce irrigation needs.
- **Criteria WC4:** Achieve consumption target for water use of 100kL/person/yr with no more than 60kL/person/yr of scheme water.
- **Criteria WC5:** Irrigated areas will be watered at a maximum average rate of 7,500kL/ha/yr.

5 Opportunities & Constraints

Summary of the key opportunities and constraints for development in the PSP are outlined in Table 5-1.

Table 5-1: Opportunities & Constraints Summary Table

Characteristic	Opportunity (Strategy)	Constraint	Proposed Management Criteria
Land Use and Built Form	• Increased densification and infill development can provide regenerative and nature-based outcomes by embedding water-sensitive approaches in redevelopment planning. • Multiple uses at the Public Open Space (POS) could enhance community well-being by providing areas for recreation, social interaction, and environmental benefits • Maintain active frontage in public spaces	• Increased densification of development and greenfield area could: - increase the impacts of stormwater runoff and pollution, which need to be managed through development controls. - Reduce groundwater recharge and therefore reduce groundwater levels - Increase the urban heat island effects	• **Criteria SW1:** Post-development discharge is not to be greater than pre-development discharge at Water Corporation assets to ensure the existing system does not receive increased rates of flow for the 1% AEP critical storm. • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains must receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure (where groundwater allows), including WSUD features* such as vegetated swales, rain gardens, or 'leaky' rainwater tank beds, tree pits and other WSUD infrastructure. • **Criteria SW3:** Gross pollutant and/or hydrocarbon traps are to be provided at inlets of detention structures and on any discharge locations from commercial and light industrial lots (subject to lot-specific industry and likely contaminants). This is to be confirmed by the City of Rockingham (CoR). • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to ensure that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • **Criteria SW8:** Construct residential, commercial, and industrial building finished floor levels at least 0.3 m above the 1% AEP flood level and at least 0.5 m above the 1% AEP flood level of waterways and major drainage systems or otherwise based on advice from the DWER. • **Criteria SW13:** Mandate a minimum of 10% of landscape area for Mixed Use, Commercial, and Residential lots (R80), a minimum of 15% of landscape area for Residential lots (R40&R60).
Climate	• Building the resilience of the community and environment is an essential response to climate change through opportunities for education and immersive landscapes. • Waterwise opportunities are to be explored in the final LWMS to manage residual climate-related risks. • Incorporate hydro and ecozoning initiatives to support biodiversity and build climate change resilience. • The use of WSUD may facilitate the creation of a climate resilient community by increasing vegetation coverage, lowering impervious areas and reducing urban heat island effects, etc. • Mandate a minimum landscape area to lower impervious areas and reduce urban heat island effects • Distributed WSUD treatments such as vegetated swales, rain gardens, 'leaky' rainwater tank beds, and tree pits can reduce reliance on irrigation and improve soil moisture for reduced urban heat island effect	• Climate change will likely exacerbate stormwater flooding in high-intensity events, reduce rainfall and groundwater availability and increase urban heat island effects. It may also increase groundwater levels due to sea level rise. • The average annual rainfall is not evenly distributed throughout the year, with most falling from May to October. This may limit stormwater or rainwater capture and require larger storage to meet reliability requirements, however, it is still recommended. • Climate change may also limit the effectiveness of infiltration-based water management due to high intensity rainfall and potential hydrophobic properties of the soil. • The site is near the ocean; coastal inundation may raise in the *climate change impacts.* • Potential increase in groundwater levels, damaging infrastructure, and reducing the functional infiltration	• **Criteria WC1:** Mandate water-efficient fixtures for all new developments. • **Criteria WC2**: Encourage alternative water supplies, including rainwater tanks, stormwater harvesting, and greywater reuse schemes. • **Criteria WC3:** Encourage Waterwise native gardens and endemic species, with kerb-cuts or tree pit opportunities to reduce irrigation needs. • **Criteria WC4:** Achieve consumption target for water use of 100kL/person/yr with no more than 60kL/person/yr of scheme water. • **Criteria WC5**: Irrigated areas will be watered at an average rate of 7,500kL/ha/yr. • **Criteria SW8:** Construct residential, commercial, and industrial building finished floor levels at least 0.3 m above the 1% AEP flood level and at least 0.5 m above the 1% AEP flood level of waterways and major drainage systems or otherwise based on advice from the DWER. • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains must receive treatment before infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure (where groundwater allows), including WSUD features* such as vegetated swales, rain gardens, or 'leaky' rainwater tank beds. • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to facilitate that the 1% AEP post-development

			flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • **Criteria GW1:** Manage groundwater levels to protect properties, infrastructure, and assets. A risk-based decision should be made to identify site-specific groundwater levels for the PSP. • **Criteria GW2:** Provide 1.2m separation distances appropriate for acceptable levels of risk and amenity for critical elements of built form and infrastructure.
Topography	Several public open spaces are situated at the site low points, offering versatile uses that promote community well-being through recreation, social connection, and environmental value	• The site is generally flat and drains slightly to the west towards Lake Richmond, with a maximum elevation of 8m AHD and a minimum elevation of 0.5m AHD. • Localised Low Points: A high-level desktop assessment shows that there is infrastructure located in the low points, which may increase the risk of flooding. • Council-identified flooding hotspots include: - 3 Rockingham Beach Rd - Patterson Rd - Corner of Chalgrove and Read St - Read St - Bell St Ocean Outlet - Victoria St Ocean Outlet • Low-lying ground subject to risk of coastal inundation • The site experiences shallow groundwater conditions due to its low-lying coastal topography • Many of the stormwater management basins do not have a designated outlet and overland flow path. In the event that the storms exceed the design, storms may result in localised flooding in the surrounding areas: - Warramunga Reserve - Waterfront Village Green drainage reserves	• **Criteria GW1:** Manage groundwater levels to protect properties, infrastructure, and assets. A risk-based decision should be made to identify site-specific groundwater levels for the PSP. • **Criteria SW1:** Post-development discharge is not to be greater than Pre-development discharge at Water Corporation assets to ensure the existing system does not receive increased rates of flow for the 1% AEP critical storm. • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains are to receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure, including soak wells (where groundwater allows), and/or WSUD features including but not limited to vegetated swales, raingardens, or 'leaky' rainwater tank beds. • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to facilitate that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • **Criteria SW8:** Construct residential, commercial, and industrial building finished floor levels at least 0.3 m above the 1% AEP flood level and at least 0.5 m above the 1% AEP flood level of waterways and major drainage systems or otherwise based on advice from the DWER.
Geology	Calcareous deep sands in parts of the catchment may assist infiltration where possible.	• Calcareous deep sand exists over the entire Rockingham District, which is generally prone to wind erosion, and is characterised by high pH levels and low water-holding capacity, potentially constraining vegetation growth. The site may be variable in permeability, with limited information available to confirm	• **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains are to receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure, including soak wells (where groundwater allows), and/or WSUD features, including but not limited to vegetated swales, rain gardens, or 'leaky' rainwater tank beds. • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to facilitate that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • Onsite infiltration testing and investigation need to be done prior to construction • Engage a geotechnical specialist for further assessment if issues are identified within high-risk area

Surface Water	• Any future development should preserve water flows to prevent downstream flooding and reduce nutrient loads. Development controls will be necessary to decrease the proportion of impervious surfaces. • Formalise Water Sensitive Urban Design within the PSP area, including but not limited to lot-specific development controls (soakwells, rainwater tanks etc), tree pits for passive irrigation, drainage swales for conveyance and treatment and infiltration basins/beds to facilitate integrated water management. • Opportunity to increase the functionality of the existing open space for multiple use and drainage reserves.	• There is no District Water Management Plan to guide overall water management principles; however numerous other strategies are in place. • Surface Water Management will need to be in line with Stormwater Manual WA 2022 for management objectives. • Based on the information provided, the capacity of the Water Corporation infrastructure to convey flows is not quantified. • The densification of the proposed land use is expected to increase peak flow and volumetric assessment. • There are several potential wetlands in the precinct area in the same location as the proposed mixed-use. The satellite image shows that the area still has vegetation aligning with the wetland shape. This should be investigated and assessed further to ensure compliance to environmental regulations. • Refer to Lake Richmond Requirement from Lake Richmond Management Plan (2020) Stormwater management strategies, which are outlined to reduce pollutants entering the lake from nearby urban areas, ensuring that runoff is properly filtered and treated before it reaches the wetland.	• **Criteria SW1:** Post-development discharge is not to be greater than pre-development discharge at Water Corporation assets to ensure the existing system does not receive increased rates of flow for the 1% AEP critical storm. • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains must receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure (where groundwater allows), including WSUD features* such as vegetated swales, rain gardens, or 'leaky' rainwater tank beds. • **Criteria SW3:** Gross pollutant and/or hydrocarbon traps are to be provided at inlets of detention structures and on any discharge locations from commercial and light industrial lots (subject to lot-specific industry and likely contaminants). This is to be confirmed by the City of Rockingham (CoR). • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to facilitate that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • **Criteria SW5:** Minor drainage pit and pipe system should convey up to and including the 20% AEP storm event runoff in residential areas and 10% AEP storm event runoff in commercial or industrial areas. • **Criteria SW6:** Major drainage of all storms up and to and including the 1% AEP event to be safely conveyed by roads, open drains and swales where the minor network is surcharged. • **Criteria SW7:** Post-development flows should pose no negative impacts to downstream receiving waters. • **Criteria SW10:** Reduce hardstand areas and encourage at-source infiltration through permeable pavement, adequate hardstand crossfall to adjacent landscaped areas with kerb-cuts to facilitate passive irrigation and treatment. • **Criteria SW13:** Mandate a minimum of 10% of landscape area for Mixed Use, Commercial, and Residential lots (R80), a minimum of 15% of landscape area for Residential
Existing Services	• A majority of the site is captured and conveyed by City of Rockingham (CoR) underground stormwater network and Water Corporation drains. The Water Corporation drains convey flows westward into an overland flow channel that ultimately discharges into Lake Richmond. • The northern portion of the site is collected by CoR stormwater network and discharged to Rockingham Beach to the north via ocean outfalls.	• The capacity of the Water Corporation's open drain is not known. • A review of the CoR drainage pit and pipe network indicates that several existing basins lack outlet pipes, increasing vulnerability to groundwater rise and more extreme weather events associated with climate change.	• **Criteria SW1:** Post-development discharge is not to be greater than pre-development discharge at Water Corporation assets to ensure the existing system does not receive increased rates of flow for the 1% AEP critical storm. • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains are to receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure, including soak wells (where groundwater allows), and/or WSUD features, including but not limited to vegetated swales, rain gardens, or 'leaky' rainwater tank beds. • **Criteria SW4:** - Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm. Additional infiltration will be provided at Public Open Space (POS) to facilitate that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage. - New commercial, mixed-use, or other commercial land use will manage up to 20% Annual Exceedance Probability (AEP) 1-hour storm events onsite. The owner will also manage to incorporate maintenance and cleaning of the proposed infrastructure as part of their development application. - All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1 hour on the lot, where groundwater conditions allow. • **Criteria SW5**: Minor drainage pit and pipe system should convey up to and including the 20% AEP storm event runoff in residential areas and 10% AEP storm event runoff in commercial or industrial areas. • **Criteria SW9:** Adopt regular stormwater asset maintenance to ensure the containment of pollution spills and litter removal. Accumulation of litter and

			sediment impacts the capacity and performance of the asset and may result in increased overland flows.
Groundwater	• Calcareous deep sands and yellow sand have high permeability and potential for infiltration. • No Public Drinking Water Source Areas at risk of contamination. • Groundwater quality is suitable for garden bore use for most areas of the site except those near or within the coastal area. • The maximum groundwater level at the site is from 1m AHD to 4m AHD, southeast to northwest towards the coast. The topography ranges from 7m AHD in the southeastern corner near the train station to 3m AHD along Rockingham Beach. Therefore, Rockingham Beach has a shallow depth to groundwater between 0-2m AHD; the rest of the site has a depth to groundwater between 2-4mAHD, which suitable for soakwell uses.	• The shallow depth to groundwater at and along Rockingham Beach may limit infiltration.	• **Criteria GW1:** Manage groundwater levels to protect properties, infrastructure, and assets. A risk-based decision should be made to identify site-specific groundwater levels for the PSP. • **Criteria GW2:** Provide 1.2m separation distances appropriate for acceptable levels of risk and amenity for critical elements of built form and infrastructure. • **Criteria GW3:** Minimum 15mm infiltration, or greater up to the 1% AEP event is encouraged where appropriate. • **Criteria GW4:** Maintain groundwater regimes for the protection of groundwater-dependent ecosystems. • **Criteria GW5:** Protect the value of groundwater resources. • **Criteria GW6:** Achieve nutrient load reduction design objectives for discharges to groundwater. • **Criteria GW7:** Achieve free drainage for sub-surface drainage outlets under coastal consideration. • **Criteria GW8**: Achieve separation distances to the phreatic surface if subsoils are utilised in-line with Institute of Public Works Engineering Australia (IPWEA) Specification for separation distances for groundwater-controlled urban development (taking into consideration coastal inundation). Groundwater levels should be confirmed at the development stage to confirm the proposed water management strategies • **Criteria SW2:** All flows from constructed impervious surfaces and subsoil drains must receive treatment prior to infiltration or discharge for the 15mm. This can be achieved with at-source treatment infrastructure (where groundwater allows), including WSUD features* such as vegetated swales, rain gardens, or 'leaky' rainwater tank beds, tree pits and other WSUD infrastructure. • The City of Rockingham will include incorporating water quality improvements as part of the detailed design for stormwater management within POS areas.
Flora and Fauna	• No Bush Forever site is located in the site • Based on the Wetland Mapping: Swan Coastal (DBCA-019) there might be some wetlands within the precinct boundary.	• Based on the Rockingham Strategic Centre Environment Report (2021), priority and Threatened species are likely to occur within the site. • Based on the Rockingham Strategic Centre Environment Report (2021), most of the site is within an ESA due to the presence of TECs and a conservation-significant wetland across the area	• **Criteria WC3**: Encourage Waterwise native gardens and endemic species, with kerb-cuts or tree pit opportunities to reduce irrigation needs. • Manage as per the appropriate regulation and management with relevant stakeholders. • To be confirmed with the environmental specialist to conduct a site-specific assessment
Contaminated Sites and ASS	• Based on publicly available database, there is no Acid Sulphate Risks (ASS) at and near the site	• Contaminated soil classification and spoil removal will likely be necessary for excavation. • The lot near Churchill Park in the site has been identified as a registered contamination site with remediation required • There are 5 lots along Goddard St and close to Hmas Warramunga Park in the site have been identified as remediated for restricted use	• **SW9**: Adopt regular stormwater asset maintenance to ensure the containment of pollution spills and litter removal. • A risk-based investigation of Contaminated Sites and ASS is required during future design stage. • Manage as per the appropriate regulation, including site-specific assessment by qualified and experienced personnel if required. • Engagement with relevant regulatory authorities and/or contamination and ASS specialist to conduct site-specific assessment at high-risk areas.
Heritage	• Based on the publicly available database, no Aboriginal Heritage Site registered within the site	• Lake Richmond is located downstream of the site (outside) as the final discharge point, which is mapped as a registered Aboriginal Heritage Site which may require further investigation • Scarred & Modified trees and Rings of stones at the upstream of the site (outside) are mapped as registered Aboriginal Heritage Sites which may require further investigation • There is a Native Title on the site as identified in the Rockingham Strategic Centre – Environment Report • A couple of European Heritage sites have been identified in the site, which may require further investigation	• Manage as per the appropriate regulation, including conducting site-specific assessment by qualified and experienced personnel if required. • Engagement with relevant regulatory authorities • Information requests need to be submitted to the DLPH Native Title Branch if further information is required. • Heritage specialist to conduct site-specific assessment at high-risk areas.

6 Water Balance

A high-level water balance has been completed for the precinct area with the following assumptions:

- Daily rainfall records for Station 9258 have found:
    1. Approximately 50% of daily rainfall within is less than 15mm.
    2. Approximately 70% of the annual rainfall is less than 30.44mm (20% AEP 1 hour storm)
- The evapotranspiration rate has been sourced from BOM for the Perth Area, approximately 900mm per square meter per year.
- Only 5% of the rainfall is retained on an impervious surface to be evaporated every year.
- Criteria SW13: Mandate a minimum of 10% of landscape area for Mixed Use, Commercial, and Residential lots (R80), a minimum of 15% of landscape area for Residential lots (R40&R60).

The results of the water balance are shown in Table 6-1. The water balance shows that there is an expected increase in recharge in the groundwater of approximately 800,000 kl/year.

Davidson Yu has estimated average recharge in the Perth region to be around 8–10%. However, the use of 15mm or 20% AEP 1-hour soakwells or underground basins has led to reduced evapotranspiration and more concentrated infiltration, which can result in higher groundwater recharge under proposed conditions. Nevertheless, this does not necessarily translate into increased groundwater levels due to several factors:

- Higher groundwater levels are expected to increase coastal discharge, which may establish a new equilibrium and maintain the existing groundwater levels.
- Future climate scenarios predict reduced rainfall, leading to lower overall recharge.
- Rising sea levels from climate change may reduce coastal discharge capacity and potentially increase groundwater levels.
- During high-intensity rainfall events induced by climate change conditions, infiltration capacity is reduced, causing more runoff to reach the coast rather than recharging the aquifer.

The net impact on groundwater levels remains uncertain, as it involves complex, interrelated factors that require further modelling and specialised assessment.

Table 6-1: Water Balance Summary Table

Existing Conditions	**Use**	**Area (ha)**	**Quantity (mm/year)**	**Total kL/year**	**%**
Inputs					
Rainfall		534.63	789	4,217,994	100%
Input Total				4,217,994	100%
Outputs					
Evapotranspiration	Developed Area	339.5	39.45	133,921	3%
	Pervious Area (open space, vegetated spaces, garden, road reserves)	195.1	900	1,756,161	42%
Superficial Aquifer		339.5	394.5	1,339,213	32%
Surface Runoff				977,997	23%
Outputs Totals				4,217,994	100%
Balance				0	
Post-development	**Use**	**Area (ha)**	**Quantity (mm/year)**	**Total kL/year**	**%**
Inputs					
Rainfall		534.63	789	4,217,994	100%
Input Total				4,217,994	100%
Outputs					
Evapotranspiration	Developed Area	386.5	39.45	152,480	4%
	Pervious Area (open space, vegetated spaces, garden, road reserves)	148.1	900	1,332,758	32%
Superficial Aquifer		386.5	552.3	2,134,727	51%
Surface Runoff				598,029	14%
Outputs Totals				4,217,994	100%
Balance				0	0

7 Stormwater Modelling

The drainage system is to be designed to manage stormwater runoff from both minor and major storm events, up to and including the 1% AEP rainfall event. This includes designing for the minor 20% AEP event for drainage in residential areas, the minor 10% AEP event for drainage in commercial and public purpose areas, and the 1% AEP major storm event for major flow paths.

The post-development scenario has been modelled to demonstrate the functionality of the proposed design criteria and to inform the sizing of the required storage areas. The assessment indicates that post-development peak flows at Water Corporation drainage outlets are not expected to increase compared to existing conditions.

Key assumptions included in the modelling are as follows:

- Catchments are based on the topography information rather than the drainage infrastructure.
- Localised low points have not been modelled.
- Overland flow paths and directions are based on topography data.
- Rockingham City Centre area consists predominantly of sandy soils with sandy dune like topography based on a desktop assessment.

Predevelopment:

- All existing residential lots are assumed to have soakwells with 15mm storage capacity as per the discussion with City of Rockingham.
- No existing commercial/mixed lot infiltration requirement has been implemented in City of Rockingham.

Post Development:

- Residential Development located in the Lake Richmond Catchment:
  - On-site infiltration to be provided for all storm events up to and including the first 15mm.
  - For the Residential Development located in the Lake Richmond Catchment: On-site infiltration for the first 15mm of runoff Additional infiltration will be provided at the Public Open Space (POS) to ensure that the 1% AEP post-development flows do not exceed pre-development flows. This can be in the form of underground infiltration storage.
- All new commercial, mixed-use, or other commercial land use, will manage up to 20% AEP 1-hour storm events onsite.
- All new developments (residential and commercial) within the coastal catchment: Infiltrate all storm events up to and including 20% AEP 1-hour event on the lot, where groundwater conditions allow.
- The existing City of Rockingham (CoR) basins have been modelled to represent the most realistic closed conditions within the study area.
- The existing Water Corporation (WC) infrastructure has been modelled as open channels, as the actual culvert dimensions and invert levels are unknown. The capacity of the culverts are unknown and outside the scope of this assessment.
- Local stormwater drainage has not been included in the model due to the current development stage and is not usually required as part of the local water management planning process.
- The major drainage system uses overland flow paths for conveyance to the main discharge location downstream of the PSP

This assessment is intended as a high-level identification of key areas where additional storage may be required and provides a comparative analysis between existing and proposed land use conditions. An additional 2D assessment should be conducted to confirm storage values and considerations.

7.1 Methodology

Preliminary stormwater modelling was performed using a 1D DRAINS model to assess the hydrology for the site in line with Australian Rainfall and Runoff (ARR2019 4.2) and the Bureau of Meteorology Computerised Design Intensity Frequency and Duration Rainfall System (CDIRS) (Geoscience Australia, 2019).

Recommended loss rates, temporal patterns, areal reduction factors and rainfall pre-burst information were downloaded from the ARR Data Hub.

The rainfall temporal patterns were assumed to be spatially uniform across the catchment with a site less than 20 km^2.

Storm durations modelled range from 10 min to 24 hours for the 1%, 10% and 20% AEP storm events. The critical duration and median temporal patterns for design event selection were assessed in line with best practice industry standards.

The 1D assessment has several limitations that warrant a more detailed 2D hydraulic analysis, including consideration of coincidental coastal conditions, to better understand the potential flood risks within the Precinct Structure Area. Key limitations of the current assessment include:

- **Localised low points** with no clearly defined overland flow paths, which may lead to ponding and localised flooding.
- **Basins lacking formal outlets**, relying solely on infiltration as the primary drainage mechanism. These basins are at risk of overtopping during large storm events or when infiltration capacity is compromised, particularly those located near buildings or private properties.
- **Limited data on subsurface drainage infrastructure**, including potential gaps where connections may be missing. In locations where infrastructure does exist, critical information such as invert levels is unavailable, limiting the accuracy of the model.
- **Low invert levels at ocean outlets**, which could result in backflow during high tide or storm surge events, reducing system capacity and increasing the risk of flooding and site inundation.

To address these complexities and develop a more robust understanding of flood risk across the site, it is recommended that detailed 2D hydraulic modelling be undertaken. The City of Rockingham has committed to undertaking a detailed 2D drainage capacity assessment at the next stage of planning to confirm network capacity, overland flow paths, and localised flooding risks. This approach enables more accurate simulation of overland flow paths, ponding behaviour, and potential inundation areas which are elements that cannot be reliably assessed through 1D modelling alone.

7.2 Climate Change Considerations

Climate change will likely exacerbate stormwater flooding in high-intensity events, reduce rainfall and groundwater availability, increase localised groundwater mounding and urban heat island effects. As the rainfall becomes more intense, the ability to infiltrate will be reduced. A site-specific geotechnical investigation would allow for improved characterisation of the sub-surface conditions to inform modelling parameters.

This model incorporates near-term climate projections, which are now considered the new baseline conditions. Rainfall depths and loss parameters have been adjusted using data from the ARR Data Hub using the 2030 SSP2-4.5 scenario.

7.3 Model Parameters

7.3.1 Rainfall and Storm Duration

The modelling incorporates near term moderate emissions climate change estimates by adjusting ARR2016 rainfall depths to the 2030 SSP2-4.5 scenario. The uplifted rainfall depths are presented in Table 7-1.

Table 7-1: Climate Change SSP2-4.5 2030 Intensity Frequency Duration for Location (-32.28, 115.742)

Duration (mins)	63.20%	50%	20%	10%	5%	2%	1%
10	10.42	11.49	14.99	17.35	19.71	23.01	25.61
15	12.63	13.92	18.05	20.89	23.84	27.73	30.80
20	14.28	15.69	20.30	23.60	26.79	31.15	34.57
25	15.58	17.11	22.18	25.72	29.26	33.98	37.64
30	16.76	18.41	23.84	27.49	31.27	36.34	40.24
45	19.59	21.48	27.49	31.86	36.11	42.01	46.61
60	21.83	23.84	30.44	35.16	40.00	46.49	51.68
90	25.04	27.38	34.87	40.25	45.75	53.47	59.67
120	27.49	30.04	38.28	44.20	50.46	59.16	66.12
180	31.12	33.97	43.43	50.39	57.68	68.06	76.72
270	35.48	38.65	49.72	57.97	66.78	79.44	90.06
360	38.53	42.22	54.54	63.84	73.81	88.26	100.46
540	43.79	48.05	62.61	73.70	85.46	102.93	117.60
720	47.18	51.95	68.04	80.25	93.35	112.11	128.76
1080	52.36	57.75	76.01	89.87	104.61	126.50	144.10
1440	56.43	62.26	82.06	97.02	112.20	135.30	154.00

7.3.2 Initial and Continuing Loss

Regional loss values for the initial loss and continuing loss model were sourced from the ARR2019 Data Hub. Climate change considerations were incorporated into the modelling by adjusting these loss values based on the near term 2030 SSP2-4.5 scenario.

As the regional loss values are derived from rural forested areas, ARR recommends that 60-80% of the initial loss be adopted to reflect an urbanised pervious area.

Loss assumptions are shown in Table 7-2 for all modelled areas.

Table 7-2: Climate Change SSP2-4.5 2030 Initial and Continuing Loss Setup

	Impervious Area		Remaining Pervious Area	
	Initial Loss (mm)	Continuing Loss (mm/hr)	Initial Loss (mm)	Continuing Loss (mm/hr)
Road (Impervious) and Verge (Pervious)	1	0	25.2	2.48

Pre-development Residential Lot	15	0	25.2	2.48
Pre-development Industrial, Commercial and Mixed Use	1*	0	25.2	2.48
Post-development Residential Lot at Ocean Catchment	30.44	0	25.2	2.48
Post-development Residential Lot at Lake Catchment	15	0	25.2	2.48
Post-development Industrial, Commercial and Mixed Use	30.44	0	25.2	2.48

**Assuming there is no on-lot infiltration at the industrial, commercial and mixed-use area in the Pre-Development Condition.*

It is acknowledged that existing properties in the peri-urban setting will likely have disconnected downpipes and assumptions for comparison between pre-development and post-development are required to be confirmed in future design stages

7.4 Permeability

Explicit infiltration has only been adopted at the infiltration basin locations in the pre-development and post-development models. however, the loss assumptions outlined above consider the imperviousness of the entire catchment.

An infiltration rate of 2 m/day was assumed for the infiltration basins in the DRAINS model. Due to the variability of the permeability of Calcareous sand and other geological units, the permeability of the underlying soils should be verified and confirmed with on-site testing before construction.

7.5 Coastal Tailwater Considerations

As the Rockingham City Centre PSP is located near the coast, tailwater conditions would be a factor in the potential flood risks on land as it will introduce a tailwater effects and reduce the capacity of the existing drainage infrastructure.

A sensitivity have been applied to all ocean outlets in the DRAINS model based on the City of Rockingham's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) Technical Assessment (Cardno, 2018). The tailwater levels for 1%, 10% and 20% AEP storm events have been represented in Table 7-3.

Table 7-3: Tailwater Level

DRAINS Model Event (AEP)	Tailwater Event ARI* (years)	Tailwater Level (mAHD)
1%	10 years	1.74
10%	1 years	1.44

**Average Recurrence Interval (ARI) refers to the average time (in years) between events of a certain magnitude*

The aim of this assessment is to quantify peak flows. Based on existing literature, there is a low correlation between peak flows and coastal conditions in the Rockingham area. As such, Stantec has

excluded coastal tailwater effects from this assessment. The recommendation to consider coincident tailwater and fluvial flooding is based on Australian Rainfall and Runoff (Project 18); however, given the low correlation locally, this should be confirmed through a coincident analysis incorporating coastal levels in future CHRMAP or future flood risk review.

7.6 Boundary Conditions (Print Out Locations)

There are a total of seventeen locations that have been schematised as boundary conditions. Six of them are the ocean outlet point locations, five of them are the Water Corporation print point locations, and the final six are general catchment outlet locations. The adopted boundary conditions are presented in Table 7-4 and Figure 7-1.

Table 7-4: Boundary Conditions

Print Out Locations	Type	Modelled
O1O	Ocean Outlet	Free-flowing outlet
O2O	Ocean Outlet	Free-flowing outlet
O3O	Ocean Outlet	Free-flowing outlet
O4O	Ocean Outlet	Free-flowing outlet
O5O	Ocean Outlet	Free-flowing outlet
O6O	Ocean Outlet	Free-flowing outlet
O7G	General Catchment Outlet	Free-flowing outlet
O8W	Water Corporation Infrastructure Print Point	Based on the water level within the Water Corporation drain
O9G	General Catchment Outlet	Free-flowing outlet
O10G	General Catchment Outlet	Free flowing outlet
O11G	General Catchment Outlet	Free flowing outlet
O12G	General Catchment Outlet	Free flowing outlet
O13W	Water Corporation Infrastructure Print Point	Based on the water level within the Water Corporation drain
O14W	Water Corporation Infrastructure Print Point	Based on the water level within the Water Corporation drain
O15W	Water Corporation Infrastructure Print Point	Based on the water level within the Water Corporation drain
O16W	Water Corporation Infrastructure Print Point	Based on the water level within the Water Corporation drain
O17G	General Catchment Outlet	Free flowing outlet

7.7 Catchment Delineation

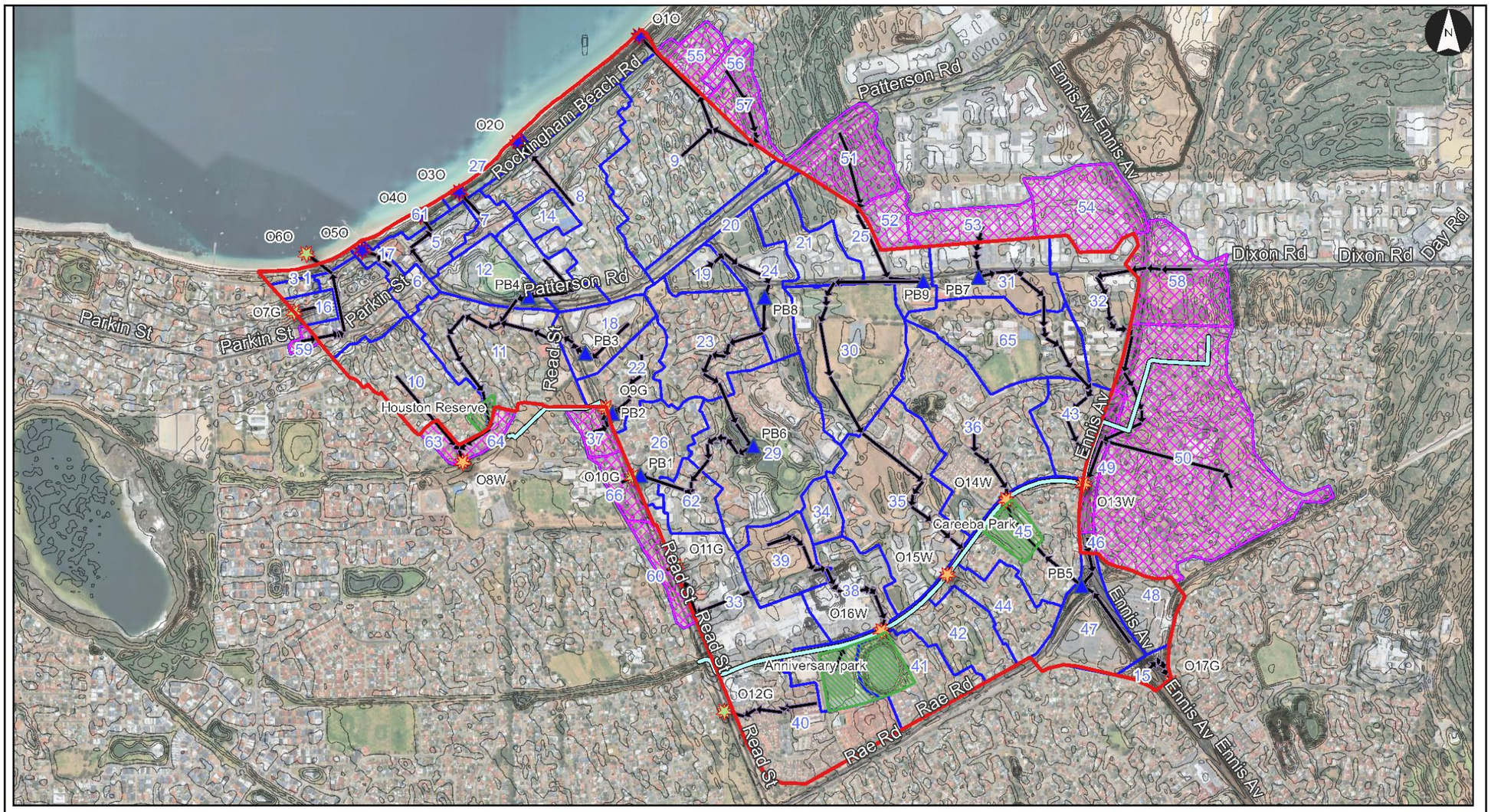
Since the sub-catchments and flow paths remain the same between existing and post-developed conditions, a combined existing and post-development catchment setup is presented in Table 7-5 and Figure 7-1. The existing condition is based on aerial imagery while the post developed conditions are based on proposed land use and mandatory landscape and vegetated areas.

Table 7-5: Existing and Post-development Catchment Information

Print Out Locations	Contributing Catchment	External Catchment	Pre-development Fraction of Impervious	Post-development Fraction of Impervious	Catchment Area (ha)	Flow Path Length (m)	Flow Path Slope (%)
O1O	55+56+57*	External	0.41	0.41	10.86	514.60	0.33
	9+20		0.75	0.81	37.53	654.70	0.59
O2O	8+14+2		0.61	0.69	33.86	344.70	1.26
O3O	27+7		0.43	0.43	5.20	167.80	2.26
O4O	5+61		0.64	0.64	7.83	271.10	1.49
O5O	17		0.74	0.84	1.53	138.30	1.67
O6O	59	External	0.74	0.84	0.70	183.00	0.17
	6+4+3+1		0.62	0.72	13.99	398.30	0.85
O7G	16		0.80	0.84	2.08	91.20	0.36
O8W	63+64	External	0.53	0.53	3.34	51.20	0.53
	10		0.67	0.78	15.22	393.60	0.20
	11		0.77	0.83	21.48	846.60	0.10
	12+13		0.62	0.62	14.53	346.50	0.27
	18		0.63	0.63	8.22	245.20	0.15
O9G	37	External	0.60	0.60	2.86	179.90	0.19
	22		0.58	0.64	8.16	302.10	0.35
O10G	66	External	0.60	0.60	3.26	53.00	0.77
	19+24		0.51	0.71	14.49	438.30	0.12
	23+29+34		0.56	0.63	48.82	451.30	0.07
	62+26		0.72	0.83	14.97	220.80	0.47
O11G	60	External	0.64	0.64	3.51	42.70	1.15
	33		0.92	0.88	19.52	441.00	0.53
O12G	40		0.83	0.79	20.50	403.90	0.37
O13W	54+58	External	0.57	0.57	25.56	250.00	0.32
	50+49	External	0.73	0.73	61.25	777.00	0.15
	32		0.76	0.76	13.71	862.00	0.07
	53	External	0.85	0.85	7.10	298.70	0.08
	31+65		0.67	0.83	30.02	859.20	0.01
	43		0.64	0.75	8.42	297.10	0.39
O14W	46	External	0.75	0.75	0.51	214.90	0.76
	36+45		0.62	0.71	45.71	283.20	0.68
	47+48		0.85	0.85	18.56	309.10	0.73
O15W	51+52	External	0.40	0.40	14.28	329.40	0.12
	25		0.63	0.83	11.63	339.00	0.02
	21+30+35+44		0.45	0.84	68.29	1311.00	0.15
O16W	28+41		0.49	0.51	18.39	267.40	1.14
	39+38+42		0.50	0.79	29.81	762.00	0.41
O17G	15**		0.70	0.70	2.07	163.30	2.69
Total					667.77		

**Catchments with similar flow paths that flow into the same printout point have been combined together*

***Catchment 15 is located at the Rockingham Train Station. The model has assumed the catchment will flow to an individual print out location based on the topography and DEM information*



This document has been prepared based on information provided by others as cited in the data sources. Stantec has not verified the accuracy and/or completeness of this information as shall not be help responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 7-1: DRAINS Model Catchment Plan

7.8 Existing Basins

The existing City of Rockingham (CoR) basins have been modelled based on topography and the basin database provided by City of Rockingham. A summary of the DRAINS model basin inputs is presented in Table 7-6 and the basin locations are presented in Figure 7-1. The basin parameter assumptions in the DRAINS model include:

- All basins are designed with an infiltration rate of 2 m/day.
- Basin geometry and configuration are based on typical design parameters and the available area at each POS, with the following assumptions:
  - Basins are assumed to have a flat base.
  - Basin dimensions have been estimated based on the CoR supplied GIS layer

The basin dimensions and infiltration rates are indicative only and will need to be confirmed in future stages.

Table 7-6: DRAINS Model Basin Setup

Basin	Basin Location and Description	Assumed Infiltration Area (m^2)
PB1	Diamantina Reserve South	790
PB2	Diamantina Reserve North	168
PB3	Beacon Reserve	1,220
PB4	A combination of The Village Green and Patterson Reserve	1,500
PB5	A combination of Rockingham Train Station Basins	8,500
PB6	City Park	11,238
PB7	Dixon/Rogers	720
PB8	Lot 1306 Dixon Rd	862
PB9	Dixon/Dowling	244

7.9 Water Corporation Infrastructure Setup

The existing Water Corporation (WC) infrastructure has been modelled based on the following assumptions:

- Due to the lack of available data on culvert numbers, invert levels, and other details, the WC infrastructure has been represented as open channels rather than piped systems.
- A minimum cover of 600 mm has been assumed for all modelled WC infrastructure.
- The open channels have been modelled with a standard width of 10 metres and a depth of 2 metres.
- A slope of 0.1%, derived from the site topography, has been applied.

This modelling approach aims to estimate the timing and water levels of potential discharges, allowing assessment of any tailwater effects on the drainage pipe systems that discharge into the Water Corporation infrastructure; however, it cannot provide capacity estimates for the WC drains themselves.

7.10 Validation of Peak Flows

The modelled peak flows have been validated against the Rational Method described in Book IV Clause 1.3.2 of AR (2001) for the Eastern External Catchment 49 and 50, as it does not have tailwater impacts, that would limit validation. The results are presented in Table 7-7.

Although a 15-minute critical storm duration in the DRAINS model appears short when compared to the Rational Method, the following factors may justify and help explain this discrepancy:

- The upstream catchment is fully developed, as evidenced by aerial imagery. Consequently, flow estimates derived from the Rational Method may differ from modelled flows, which are typically calibrated against undeveloped rural catchment gauge data.
- While observed flow patterns resemble sheet flow, much of the runoff is likely conveyed via the pit and pipe system and along the road network.

Table 7-7: Peak Flow Validation

Method	Peak Flow (m^3/s)	Critical Duration (Minutes)
Rational Method	10.56	45
DRAINS model	21.2	15
Rational Method for 15 minutes	21.0	15
Results Difference (%)	0.01%	

7.11 Model Results

The model results indicate that post-development flows at the reporting locations generally remain within pre-development conditions, primarily due to:

- An increase in lot-level infiltration from 15 mm to 30.44 mm across residential lots in the coastal catchment, as well as in mixed-use and commercial lots.
- Purpose-built infiltration storages within proposed open space areas.

At location O8W, the post-development peak flow is slightly higher than pre-development conditions. However, this increase is considered acceptable based on the following:

- The increase is minor, with only a 2.4% rise under the 1% AEP median temporal pattern.
- The time of concentration has been adjusted by changing the catchment characteristics (proposed change in land use) from 30 minutes to 15 minutes. Given that this site discharges into a Water Corporation drainage system with a large upstream catchment where peak flows are likely to occur later, the risk of peak flow alignment is low.
- There is no suitable open space or available land nearby for additional detention or flood storage.

As such, the minor increase in flow to Water Corporation assets is considered acceptable, subject to confirmation through detailed capacity assessments of the receiving drainage infrastructure.

In the 1% AEP event, there is no significant decrease in post-development flows to Lake Richmond to maintain environmental values. In the more frequent events, a minor reduction occurs. However, the

water balance indicates increased groundwater recharge. This may contribute to Lake Richmond to offset the minor reduction in stormwater inflows for environmental purposes. The proportion and effects of this recharge are outside the current scope.

The modelled results for each of the print locations are summarised in Table 7-8 below.

Table 7-8: Peak Flow Rate Comparison Table

Print Out Locations	1% AEP Flow Rate (m^3/s)		10% AEP Flow Rate (m^3/s)	
	Pre	Post	Pre	Post
O1O	12.20	9.87	5.26	3.97
O2O	10.20	8.4	5.37	3.41
O3O	1.55	1.31	0.807	0.594
O4O	2.54	1.9	1.34	0.782
O5O	0.53	0.37	0.311	0.155
O6O	3.45	2.64	1.79	0.992
O7G	0.69	0.50	0.365	0.123
O8W	5.89	6.03	3.37	2.08
O9G	2.39	2.01	1.29	0.839
O10G	3.60	3.27	1.94	1.41
O11G	10.90	6.13	6.68	2.29
O12G	7.27	5.88	3.65	2.48
O13W	15.70	10.9	8.72	4.55
O14W	10.60	9.07	6.11	4.67
O15W	15.80	14.6	8.74	6.29
O16W	11.80	11.4	6.03	4.48
O17G*	0.76	0.76	0.37	0.357

7.12 Storage Sizing

This assessment has provided an indicative storage sizing for each of the proposed open spaces. The respective storage size and location is presented in Table 7-9 and Figure 7-1. Additional considerations for freeboard may be required to meet public safety objectives.

Table 7-9: DRAINS Model Proposed Drainage Storage Setup

Basin	Servicing Catchments	Basin Location and Description	Assumed Infiltration Area (m^2)	Indicative Storage Volume (m^3)
Anniversary Park	41	Drainage Storage at Anniversary Park	790	850
Careeba Park	36,45	Drainage Storage at Careeba Park	1185	2,020
Huston Reserve	11	Drainage Storage at Huston Reserve	2370	3,000
PB2	22,26	Enlarge or put extra drainage storage at the Diamantina Reserve North	252	1,350

These storage solutions can take various forms, including but not limited to:

- Aboveground basins;
- Underground storage systems that allow for multi-functional use of open space and minimise seasonal waterlogging leading to turf deterioration;
- Vegetated swales integrated within or surrounding key sports fields and public spaces; Or
- A combination of these approaches may be implemented to achieve optimal outcomes.

8 Conclusion and Discussion

This Local Water Management Strategy (LWMS) addendum has been prepared in support of the Rockingham City Centre Precinct Structure Plan (Cardno, 2021). The purpose is to provide the technical evidence required to address comments from the Department of Water and Environmental Regulation (DWER) and the Water Corporation (WC) regarding the existing Water Management Strategy (WMS), as included in Appendix B.

- Existing and post-development flow conditions have been quantified using 1D hydrological modelling. Due to the relatively flat topography of the precinct, this assessment serves as a high-level screening tool to evaluate performance of the existing and whether the proposed systems will perform adequately.

- In addition to lot-scale infiltration across the precinct, additional storage requirements have been quantified and allocated to proposed open space areas at Anniversary Park, Careeba Park, Huston Reserve, and to an increased capacity at PB2 basin.

- While the modelling identifies some opportunities for additional basins and storage areas, there are limitations, and further assessment is required to confirm the capacity of the downstream drainage infrastructure.

- The proposed land use changes and associated water management measures are expected to increase groundwater recharge. However, predicting the resultant groundwater levels involves complex modelling and may require further analysis, particularly under climate change scenarios.

- Post-development peak flows are lower than existing conditions at all reporting points, except for O8W, where a 2.4% increase is observed. This increase should be considered acceptable to the City of Rockingham and the Water Corporation, as the peak flow is unlikely to coincide with the time of concentration of the main WC drainage system, thereby minimising potential impacts.

- In the 1% AEP event, there is no significant decrease in post-development flows. In the more frequent events, a minor reduction occurs. However, the water balance indicates increased groundwater recharge. This may contribute to Lake Richmond, though the proportion and effects are outside the current scope.

In summary, this assessment addresses the key concerns raised by the Water Corporation and DWER, demonstrating that the proposed land use and water management measures are not expected to adversely impact drainage capacity or performance. However, the 1D assessment has several limitations that warrant a more detailed 2D hydraulic analysis, including consideration of coincidental coastal conditions to better understand the potential flood risks within the Precinct Structure Area. Key limitations of the current assessment include:

- **Localised low points** with no clearly defined overland flow paths, which may lead to ponding and localised flooding.

- **Basins lacking formal outlets**, relying solely on infiltration as the primary drainage mechanism. These basins are at risk of overtopping during large storm events or when infiltration capacity is compromised, particularly those located near buildings or private properties.

- **Limited data on subsurface drainage infrastructure**, including potential gaps where connections may be missing. In locations where infrastructure does exist, critical information such as invert levels is unavailable, limiting the accuracy of the model.
- **Low invert levels at ocean outlets**, which could result in backflow during high tide or storm surge events, reducing system capacity and increasing the risk of flooding and site inundation.

To address these complexities and develop a more robust understanding of flood risk across the site, it is recommended that detailed 2D hydraulic modelling be undertaken. This approach enables more accurate simulation of overland flow paths, ponding behaviour, and potential inundation areas, which when combined dynamically are elements that cannot be reliably assessed through 1D modelling alone.

8.1 Development Level and Urban Water Management Plan (UWMP) Conditions

Given the conceptual and high-level approach of this LWMS, it is recognised that additional detail will be necessary at later stages to enable a thorough evaluation of the feasibility, functionality, and performance of the proposed drainage infrastructure. This information will be provided through the preparation of a comprehensive Urban Water Management Plan (UWMP) and/or detailed flood risk assessment at a lot scale, ensuring that the drainage system meets both practical requirements and relevant regulatory standards. At the next stage of the project, the UWMP and/or detailed flood risk assessment will include the following:

- Geotechnical and groundwater conditions, which identifies the site-specific infiltration and groundwater design levels.
- The identified contaminated site will need specialised assessment, including recommendations for any remedial measures. If contamination has not been adequately managed, proposed soak wells may not be suitable for on-lot management. Alternative management strategies, such as leaky rainwater tanks may be suitable.
- Where conservation category wetlands within the precinct are proposed to be developed. Development of these wetland areas should be managed in line with regulatory guidelines.
- Where heritage sites have been identified, although the proposed open spaces to be used as drainage reserves have been selected to avoid any disturbance to the heritage areas. Any onsite management will need to be tailored to minimise disturbances and negative impacts.
- **Detailed assessment of existing drainage infrastructure** – Undertake a comprehensive review of the current drainage network, including capacity, condition, and performance under a range of conditions (e.g., peak rainfall events). This will include mapping existing infrastructure, identifying potential bottlenecks, and assessing the network's capability to accommodate current and projected stormwater volumes.
- **Identification of required modifications or upgrades** – Based on the above assessment, the UWMP should outline any necessary improvements or expansions to the existing drainage system. This may involve upgrades to pipes, culverts, or detention basins, and consideration of sustainable drainage measures such as green infrastructure to enhance efficiency and resilience.
- **Demonstration of effective stormwater management** – the UWMP must provide clear evidence that the proposed stormwater drainage system will operate effectively and meet regulatory and performance requirements. This should outline how runoff will be managed, flood risks mitigated, and water quality protected, while accounting for future development and potential

climate change impacts. Compliance with relevant stormwater retention and treatment policies should be demonstrated.

- **Confirmation of LWMS assumptions** – Verify that the assumptions and modelling parameters adopted in this LWMS remain applicable at the detailed design stage.
- **Confirmation of required storage volumes** – Establish the storage requirements for both individual lots and proposed public open spaces.
- **Water Quality Improvements** – The City of Rockingham will include incorporating water quality improvements as part of the detailed design for stormwater management within POS area.

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Appendices

Appendix A Rockingham City Water Management Strategy (Cardno, 2021)

Rockingham City Centre

Precinct Structure Plan

CW1181500

Prepared for
City of Rockingham

7 April 2022

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B	04/04/2022	Client Comments	SK	RD

Executive Summary

This Water Management Strategy (WMS) has been prepared by Cardno on behalf of City of Rockingham (CoR) in support of the development of the Rockingham Strategic Centre (RSC) located approximately 37km south of Perth Central Business District.

The study area is approximately 525 ha in size which includes city centre zoning, residential areas, commercial lots, and public open spaces. There are a portion of lots within the study area that are currently zoned for development but remain undeveloped.

This WMS provides the framework for the application of total water cycle management to the RSC, consistent with Department of Water (DoW) guiding document, City of Rockingham Policies and the WAPC (2008) Better Urban Water Management framework.

The WMS has been developed to address the following project objectives;

- Present Water Sensitive Urban Design (WSUD) options that could be applied to the precinct;
- Determine the proposed drainage parameters and existing flood capacity of the development site;
- Consider stormwater management options which could be utilised, including reuse opportunities;
- Consider precinct level, total water cycle management options and provide a multi-criteria analysis for consideration including economic, environmental and other constraints; and
- Consider alternative water sources to be used within the development (potable and non-potable).

The proposed Rockingham Strategic Centre indicates an intensification of development when compared to current development and zoning, with a reduction in pervious areas and an increase in density within city centre areas. In order to preserve the existing environment and ensure no adverse impacts to surface and ground water within the study area, objectives have been established for water quality, water quantity, water conservation and ground water management.

The options which were developed and deemed most suitable to be embedded into the Rockingham Strategic Centre Precinct Structure Plan and achieve project objectives include;

- Soakage well systems on lot level
- Regional bioretention/ detention basins
- Bio-swales along road frontage
- Rainwater tanks
- Treated stormwater and wastewater for irrigation
- Aquifer re-injection

The MCA assessment indicated that options 1, 2 and 3 provided the highest ranking, suggesting that these methods are most suitable in addressing project objectives while achieving reasonable cost outcomes. It is noted that most options only address some components (i.e. water quality and groundwater) of the total water cycle, and it will likely be a combination of different options that will provide a holistic, practical approach for managing water within the study area.

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Figures

1 Introduction

1.1 Background

Rockingham is situated within the South Metropolitan Peel Sub-Regional Planning Framework area. The framework recognises the benefits of a consolidated and connected city utilising the region's previous historic patterns of urban growth.

To align with Western Australia's contemporary state planning policy framework, the City of Rockingham (CoR) is in the process of preparing an updated *Rockingham Strategic Centre Precinct Structure Plan* (RPSP) to provide guidance for future development within the region. The RPSP is intended to supersede the *Rockingham Strategic Regional Centre – Centre Plan* (2009) which previously underpinned planning and development within the Rockingham city area.

As part of the RPSP, a multidisciplinary approach has been adopted for the strategic planning, by setting out broad land-use zones, setting aside areas for regional open space, protection of environmental values and other regional infrastructure purposes, and assisting in coordinating the provision of major infrastructure.

This report provides a Water Management Strategy (WMS) for the RPSP that makes recommendations for solutions which consider best practice water management principles, to be embedded into the precinct planning. The WMS will outline stormwater infrastructure and water management approaches required to accommodate land use changes resulting from the precinct development. Implementation of the WMS will maximise opportunities for sustainable long-term use of the precinct, balanced against the growth, climate and environmental challenges for the site.

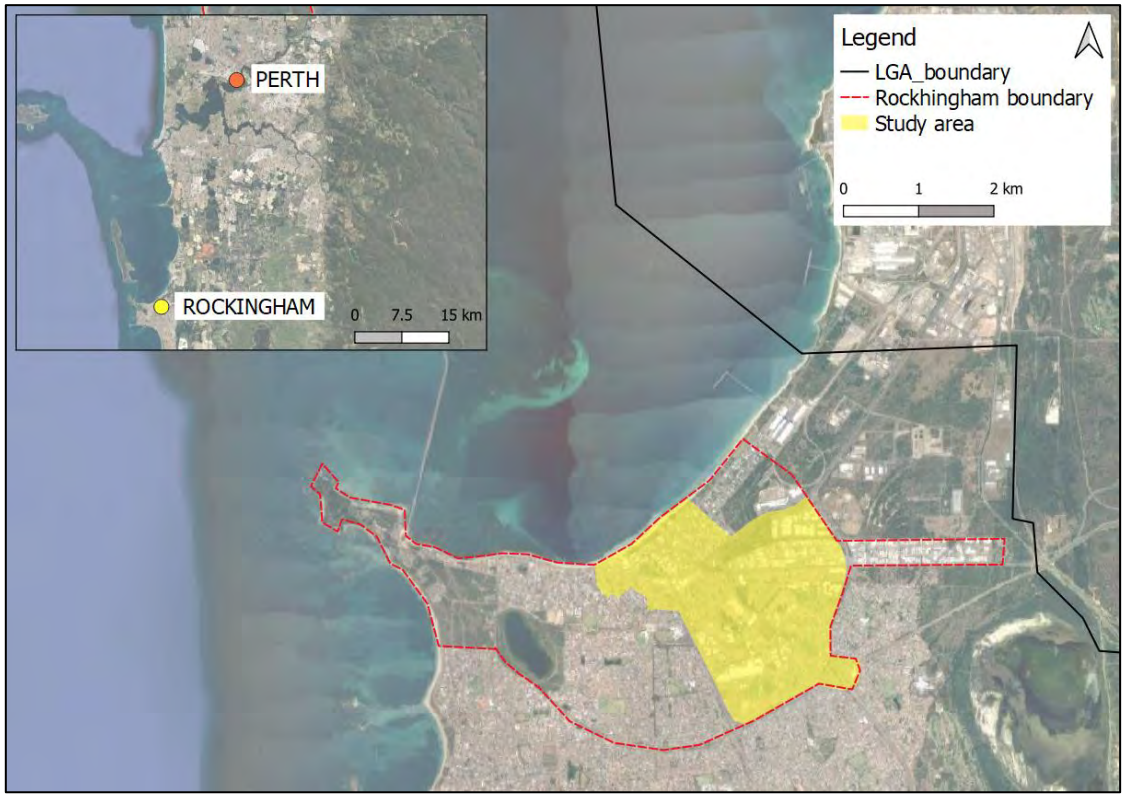
1.2 Location

The Rockingham Strategic Centre (RSC), referred to as the Study Area herein, is located in the City of Rockingham (CoR), located approximately 37km south of the Perth CBD.

Within the City of Rockingham, the Study Area is situated within the suburb of Rockingham, in the northern area of the City of Rockingham as illustrated within Figure 1-1.

The Study Area covers approximately 525 ha and is bounded by Ennis Avenue to the east, Rae Road to the south, Read Street to the west and Rockingham Beach Rd to the north.

Figure 1-1 Rockingham Location Plan



1.3 Report Purpose

This Water Management Strategy (WMS) has been developed to accompany the RPSP to ensure that relevant water management objectives are incorporated into the plan's development. This WMS will outline stormwater infrastructure and water management approaches required to accommodate land use changes resulting from the precinct development. This WMS has been developed to achieve the following project objectives;

- Present Water Sensitive Urban Design (WSUD) options that could be applied to the precinct;
- Determine the proposed drainage parameters and existing flood capacity of the development site;
- Consider stormwater management options which could be utilised, including reuse opportunities;
- Consider precinct level, total water cycle management options and provide a multi-criteria analysis for consideration including economic, environmental and other constraints; and
- Consider alternative water sources to be used within the development (potable and non-potable).

1.4 Policy Framework

The WMS provides the framework for the application of total water cycle management to the proposed urban structure. The WMS has been prepared to be consistent with the following guidance documents from the Western Australian Planning Commission (WAPC), Department of Water (DoW) and City of Rockingham (CoR) in defining its key principles and objectives as summarised in Section 2.2:

- Better Urban Water Management Framework (WAPC, 2008);
- Liveable Neighbourhoods Edition 4 (WAPC, 2009);
- Stormwater Quantity Management Manual for WA (DoW, 2007);
- Planning Bulletin 92 – Urban Water Management (WAPC, 2009);
- Planning Policy No. 3.4.3 – Urban Water Management (CoR);
- Lake Richmond Management Plan (CoR, 2020); and
- Rockingham Lakes Regional Park Management Plan (CoR, 2010).

A summary of the guidance obtained through key design principles and objectives from these documents is outlined in the following sections.

1.4.1 Better Urban Water Management (WAPC, 2008)

The guideline document *Better Urban Water Management* (BUWM) (WAPC, 2008) focuses on the process of integration between land use and water planning and specifying the level of investigations and documentation required at various decision points in the planning process.

1.4.2 Liveable Neighbourhoods (WAPC, 2009)

The WMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM) established in the guideline document, *Liveable Neighbourhoods* (WAPC,2009).

IUWM (also known as total water cycle management) is defined 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 also promotes water conservation measures, reuse and recycling of water and best practice in stormwater management. The objectives in this WMS are consistent with *Liveable Neighbourhoods*.

1.4.3 Stormwater Quality Management Manual for WA (DoW, 2007)

The Water and Rivers Commission released A Manual for Managing Urban Stormwater Quality in Western Australia in 1998 to define Best Management Practices (BMP) necessary to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also provides guidelines for the incorporation of water sensitive design principles into urban planning and design, to promote the improvement of water quality from urban development.

The document was released to provide a guideline for best planning and management practices for use by the Water and Rivers Commission, other State and Local Government Authorities and sectors of the urban development industry.

The Department of Water (DoW, now the Department of Water and Environment Regulation, DWER) completed a major review of the Manual in consultation with a working team comprising industry and government representatives, published in August 2007. Principal objectives for managing urban water in Western Australian are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within the Study Area relative to pre-development conditions;
- Water Quantity: To maintain the total water cycle balance within the Study Area relative to the predevelopment 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 social, aesthetic and cultural values are recognised and maintained when managing stormwater; and
- 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.

1.4.4 Planning Bulletin 92 – Urban Water Management

The document *Planning Bulletin 92* provides guidance on urban water management principles to be adopted by the Western Australian Planning Commission (WAPC) and local governments when preparing planning proposals. The aim of the document is to ensure that relevant and appropriate information is utilised when making decisions for water planning.

The bulletin outlines which policies and framework documents are to be considered in the planning process for different phases and different types of development work. The information presented within this WMS adheres to the advice within *Planning Bulletin 92- Urban Water Management.*

1.4.5 City of Rockingham policies and guidance

Planning Policy No. 3.4.3 Urban Water Management

The intent of this Planning Policy is to ensure that the processes outlined within *Better Urban Water Management (WAPC, 2008)* are applied throughout the planning process in a consistent manner. More specifically, the policy provides guidance on appropriate measures to manage catchments to maintain or improve groundwater and surface water resources and promote water sustainability practices. The methods for water management outlined within *Planning Policy No. 3.4.3* have been incorporated into this WMS.

Lake Richmond Management Plan This management document provides key direction for the protection and enhancement of the conservation and recreation values within the Lake Richmond reserve. It has been ensured that the guiding principles of the *Lake Richmond Management Plan* were aligned with the recommendations made within this WMS.

Rockingham Lakes Regional Park Management Plan

The purpose of this management plan is to provide the overarching approach for the protection and enhancement of the conservation, recreation and landscape values of Rockingham Lakes Regional Park. The strategies for conserving the features of the park were considered in the water management approaches for this study.

1.5 Data Sources

The information and data sources used to guide the recommendations of this WMS have been obtained from local, state and national organisations. At the time of preparing this report it has been assumed that the data represents the most up to date and accurate version available. Where practicable, Cardno has undertaken due-diligence to review the data provided by external sources.

The key sources of data which have informed this study are summarised below.

- Concept planning advice from Water Corporation;
- Current catchment and drainage information from City of Rockingham;
- Precinct planning data received by Hames Sharley (Dated 26-11-2021 Revision B); and
- Coastal Hazard Risk Management and Adaption Plan (CHRMAP), City of Rockingham (2019).

A full range of reference are detailed within Section 7 of this report.

2 Proposed Development

The proposed RSC covers an area of approximately 525ha and incorporates a range of land uses.

There are residential areas situated in the south, central and northern areas with a range of lot sizes and characters. Two main mixed used regions exist, the City Centre and Waterfront Village, which are anticipated to provide a range of retail, food and beverage and commercial uses. The industrial zoned region is in the north east corner, with the Campus situated on the southern side of Dixon Road.

Compared to current land use planning, there has been an increase in areas zoned as residential and open spaces. However, it is noted that review of the latest aerial imagery reveals that there are some lots which are currently undeveloped and do not reflect current zoning potential.

The pre-development and post-development land uses have been summarised in Table 2-1 and Table 2-2 respectively, and illustrated in Figure 2-2.

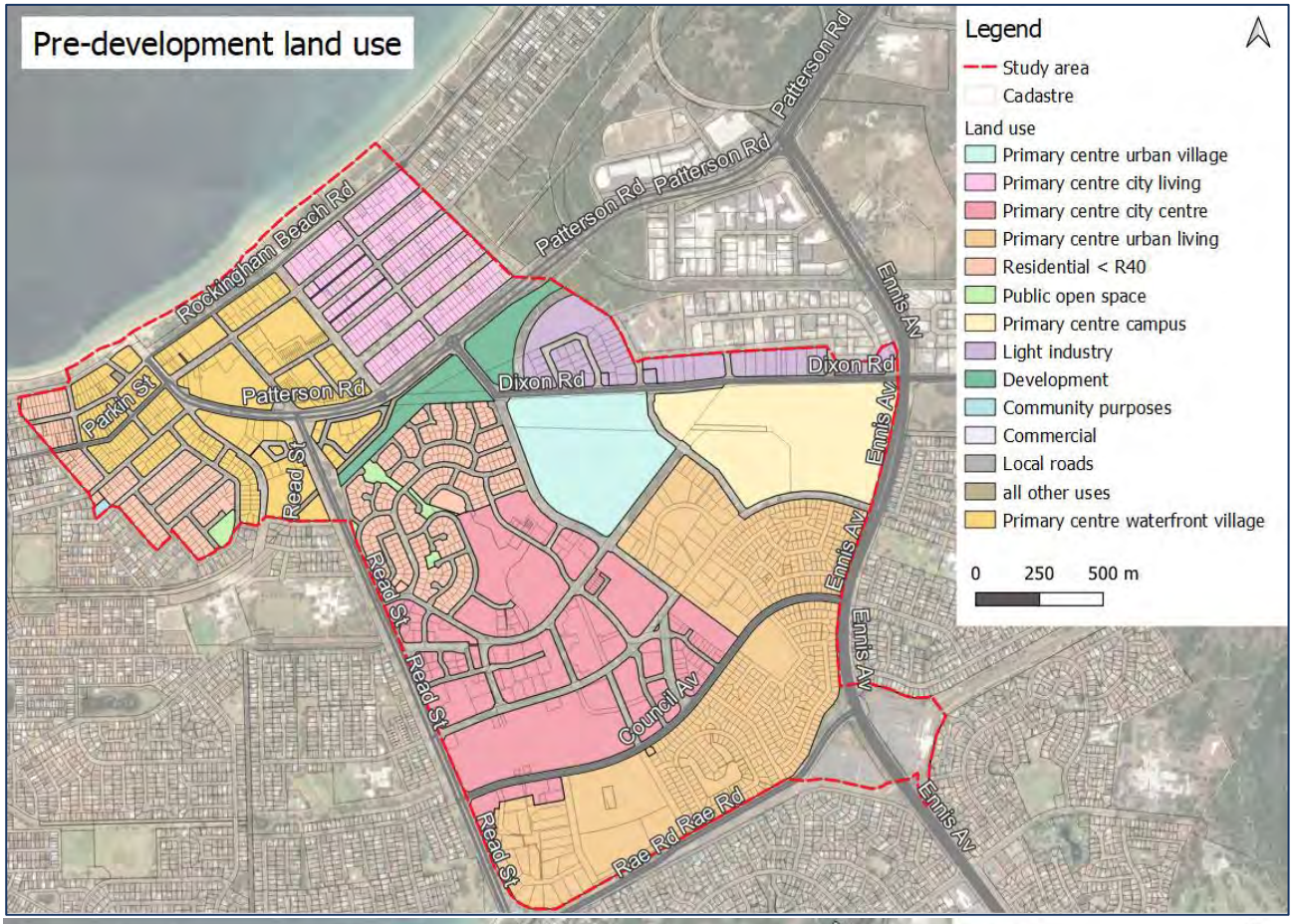
Table 2-1 Pre-development land use zoning

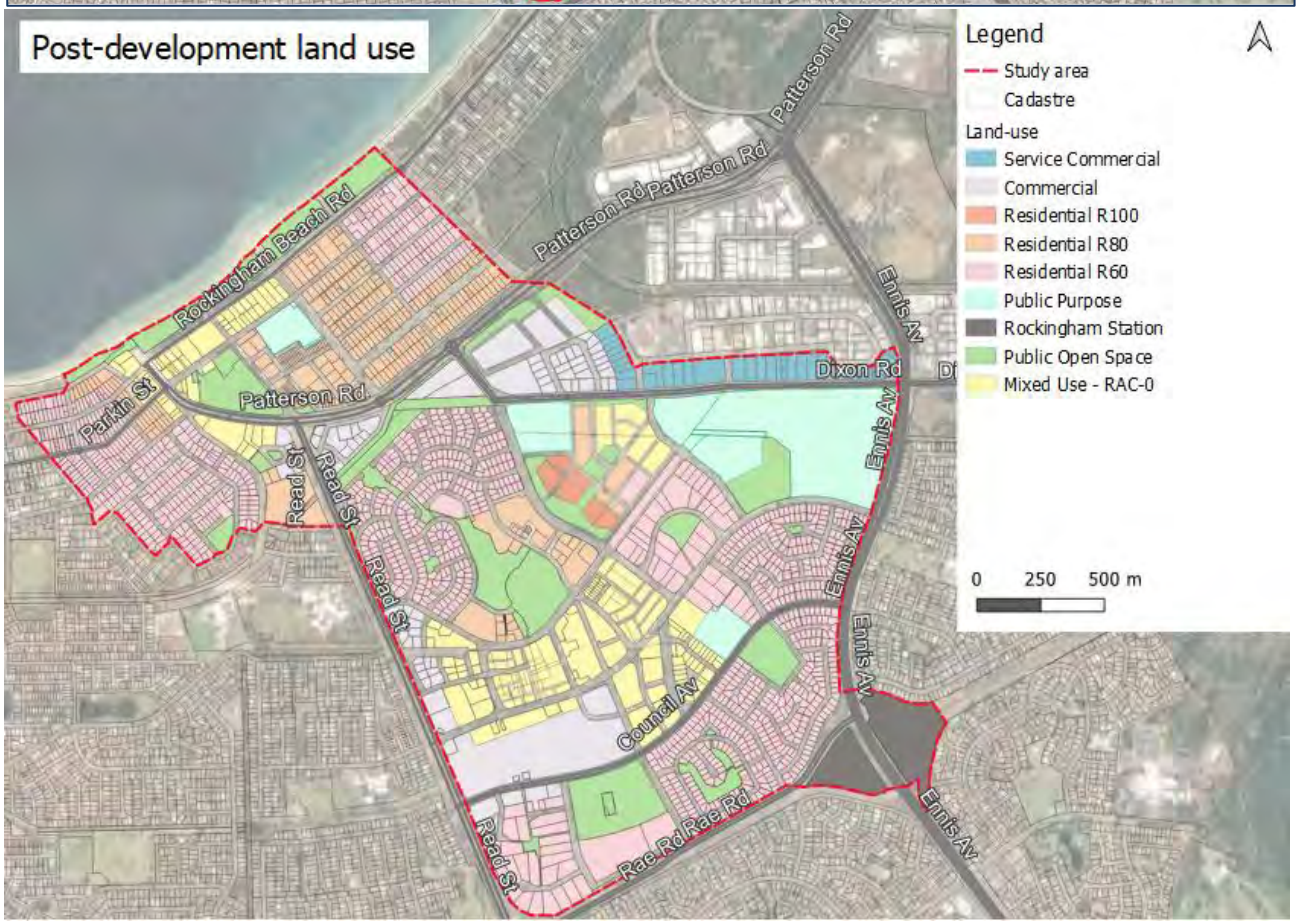
Land Use	Area (ha)
Special use	0.5
Residential	40
Public purposes	1
Public open space	3
Primary centre waterfront village	49
Primary centre urban village	25
Primary centre urban living	104
Primary centre city living	31
Primary centre city centre	78
Primary centre campus	35
Local roads	1
Light industry	20
Development	11
Community purposes	0.5
Other	126
TOTAL	525

Table 2-2 Post-development land use zoning

Land Use	Area (ha)
Residential R60	133
Residential R80	44
Residential R100	3
Mixed Use	47
Commercial	40
Public Purpose	40
Service Commercial	11
Public Open Space	60
Other	147
TOTAL	525

Figure 2-2 Land use comparison for Study Area





2.2 WMS Objectives

The key guiding principles for this WMS are to:

- Facilitate implementation of sustainable best practice urban water management practices;
- Provide integration with planning processes and clarity for agencies involved with implementation;
- Minimise public risk, including risk of injury or loss of life;
- Protect infrastructure and assets from flooding and inundation;
- Encourage environmentally responsible development; and
- Facilitate adaptive management responses to the monitored outcomes of development.

The above principles have been applied to all aspects of this WMS and are described in Table 2-3.

Table 2-3 Summary of WMS Principles and Objectives

Category	Objective	Criteria
Stormwater Quantity Management *Refer note 1,2**	> Prevent impacts on receiving environments from changes to catchment hydrology. > Protect infrastructure and assets from major storm and flooding events. > Protect people and property from flooding. > Give consideration to future Sea Level Rise (SLR)	> Manage first 15mm of lot runoff within road reserves > Maintain peak flow rates to the pre-development condition in the critical 1 in 1-year annual exceedance probability event. > The post-development peak flow rates from the Study Area should not exceed the pre-development 1% AEP storm event. There is no specific requirement on peak flow rates for 1EY storm event and catchment runoff for 1% AEP event. > Construct residential, commercial and industrial building habitable floor levels at least 0.3 m above the 1% AEP flood level of the urban drainage system and at least 0.5 m above the 1% AEP flood level of waterways and major drainage systems, or otherwise based on advice from the Department of Water and Environmental Regulation. > Ensure stormwater system does not lead to liability for the City in consideration of SLR scenarios.
Stormwater Quality Management *Refer note 1,2**	> Protect the downstream receiving environment through the application of WSUD principles and nutrient load reduction design objectives for stormwater runoff.	> Treat all stormwater captured in the drainage infrastructure prior to discharge to the receiving environment. > Achieve water quality improvement in scenario where the pollutant outputs exceed the catchment ambient conditions by meeting reduction targets of: – 80% total suspended solids – 60% total phosphorus – 45% total nitrogen – 70% gross pollutants > Implement structural treatment measures (infiltration storages, bio-retention/treatment structures sized to minimum 2% of connected impervious area. > Infiltrate all stormwater in retention devices in less than 96 hrs. > Maintain or restore desirable environmental flows and hydrological cycles as specified by DoW.

Category	Objective	Criteria
Groundwater *Refer note 1,2**	> Managing and minimising changes in groundwater levels and groundwater quality following development. > Protect infrastructure and assets through management of groundwater levels. > Protect groundwater-dependent ecosystems by maintaining groundwater regimes within the catchment. > Protect the value of groundwater resources. > Give consideration to future SLR.	> Achieve nutrient load reduction design objectives for discharges to groundwater. > Sub-surface drainage (subsoils) and drainage infrastructure set at or above the groundwater. > Provide sufficient separation distances appropriate to acceptable levels of risk and amenity for critical elements of built form and infrastructure. > Achieve free drainage for sub-surface drainage outlets under an SLR scenario; and > Achieve separation distances to the phreatic surface if subsoils are utilised inline with IPEWAs Specification for separation distances for groundwater-controlled urban development (taking into consideration SLR).
Water Conservation *Refer note 1**	> Preserve natural resources through the development of a water conservation strategy that considers factors such recycling, re-use, reduction. > Progress the water supply and sewage disposal strategy.	> Implement alternative fit-for-purpose water sources where appropriate and cost-effective. > Achieve consumption target for water use of 100 kL/person/yr with no more than 60 kL/person/yr of scheme water. > Irrigated areas will be watered at an average rate of 7500 kL/ha/yr.

Note 1: Information sourced from *Western Australian Planning Commission (WAPC). (2008). Better Urban Water Management.* Perth: WAPC.

Note 2: Information sourced from City of Rockingham (CoR). *Planning Policy No. 3.4.3 – Urban Water Management, (LUP/1265-05; D19/204775)*

3 Pre-Development Environment

3.1 Existing Land Use

City of Rockingham's Planning & Development mapping was used to define the existing land uses for the Study Area. Mapping indicates that the majority of the Study Area comprises of various city centre zoning, with residential, public open spaces and parks/recreation areas becoming more prominent towards Rockingham Beach Road in the north. It is noted that a portion of lots within the current Study Area remain undeveloped lots. Refer to Figure 2-2 for the land uses currently comprising the Study Area.

3.2 Climate

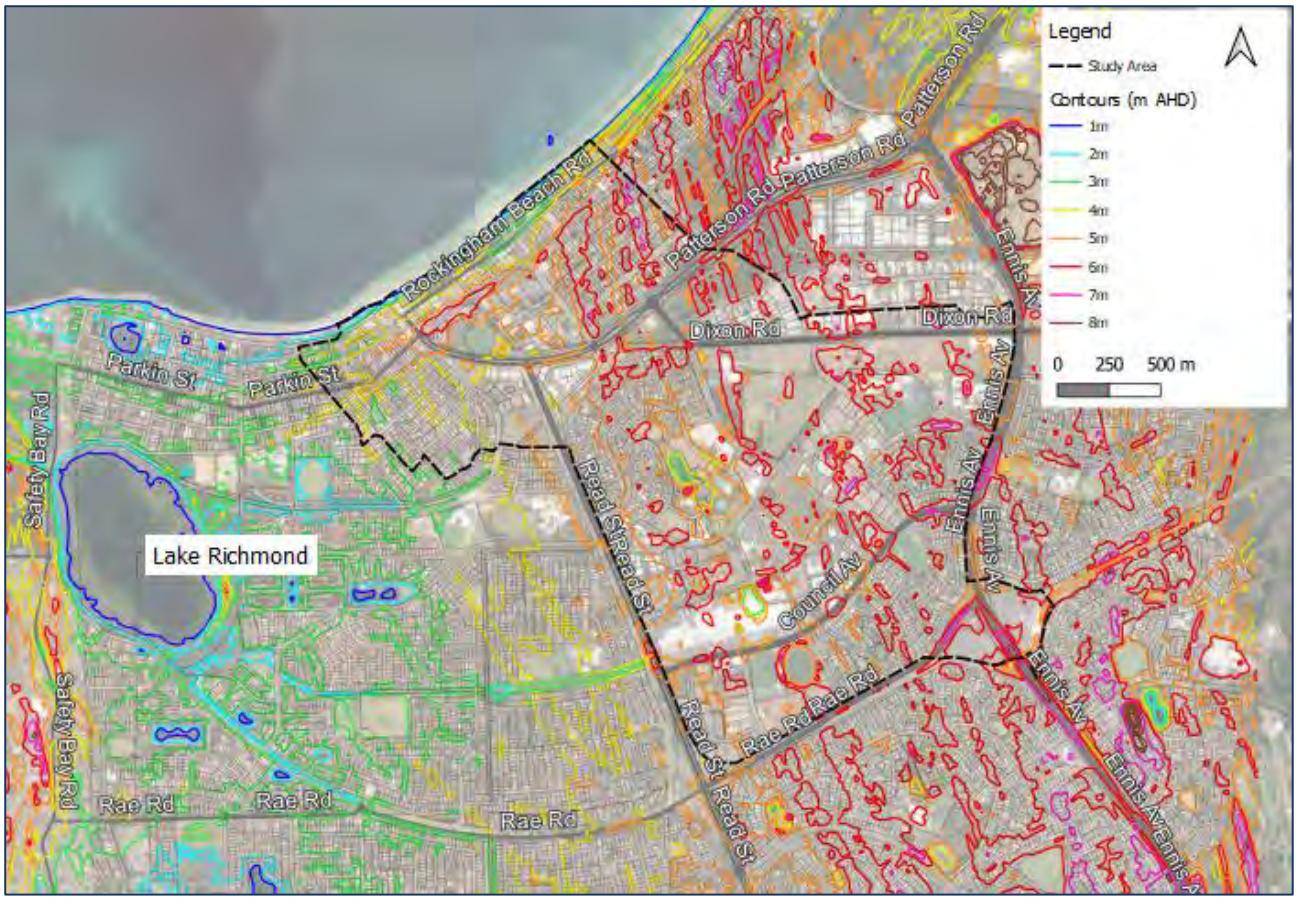
The Rockingham area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Mean daily temperatures vary from 30˚C in summer to 18˚C in winter. The mean annual rainfall is 788mm, with most falling from May through to October (Bureau of Meteorology).

3.3 Topography and Soils

The landforms that occur within the City of Rockingham are all relatively young with the majority of the region located upon Aeolian (wind-blown soils) that have been laid down relatively recently. Remnants of linear dunes that lay perpendicular to the south west winds are still evident throughout the Rockingham City Centre and are a key characteristic of the region.

A majority of the Study Area has been levelled and developed and no longer represents the natural landform of the region. The Study Area is generally flat and drains slightly to the west towards Lake Richmond. Spot levels on site range from 7 m AHD in the south-eastern corner near the train station to 3 m AHD along Rockingham Beach as illustrated in Figure 3-1.

Figure 3-1 Study Area Topography



Mapping published from the Department of Primary Industries and Regional Development has indicated that calcareous deep sand exists over the entire Rockingham District. This type of soil type is generally prone to

wind erosion and contains high airborne salt loads. The soil is generally characterised by high pH levels and low water-holding capacity and may therefore influence the growth potential for vegetation.

3.4 Surface Geology

The Study Area exhibits characteristics typical of coastal dunes of the Swan Coastal Plain, with calcareous deep sands and yellow sands. Review of the Rockingham Sheet of the *1:50,000 Environmental Geology Series* confirms that the Study Area consists solely of Calcareous sand (Classification S13).

3.5 Acid Sulfate Soils

There are no known areas of Acid Sulfate soils mapped within Study Area and based on the local geology they are unlikely to be encountered.

3.6 Wetlands

The City's online mapping service indicates that there is an Environmental Planning Policy (EPP) buffer area delineated along Dixon Road in the northern corner of the Study Area. However, as this area has previously been flagged for development and noting that the site is predominantly cleared, it is possible that the designated wetland could be redundant based on ground truthing. Further investigation is required prior to reclassification.

No further environment significant areas or wetlands have been identified within the Study Area.

It is noted that Lake Richmond, situated approximately 2.5km to the west of the Study Area is one of the largest freshwater lakes on the Swan Coastal Plain and of environmental significance to the region. The major stormwater conveyance drains that traverse the Study Area, owned by the Water Corporation, discharge into Lake Richmond. As such, maintaining the flow regime of these drainage elements will be a key consideration in the water management strategy for the precinct centre.

3.7 Surface Hydrology

3.7.1 Existing Surface Drainage

Review of 5m LiDAR data, plus drainage network and catchment data provided by CoR indicated that the Study Area is influenced by runoff from local sub-catchments only, with no regional surface water catchments discharging through the Study Area.

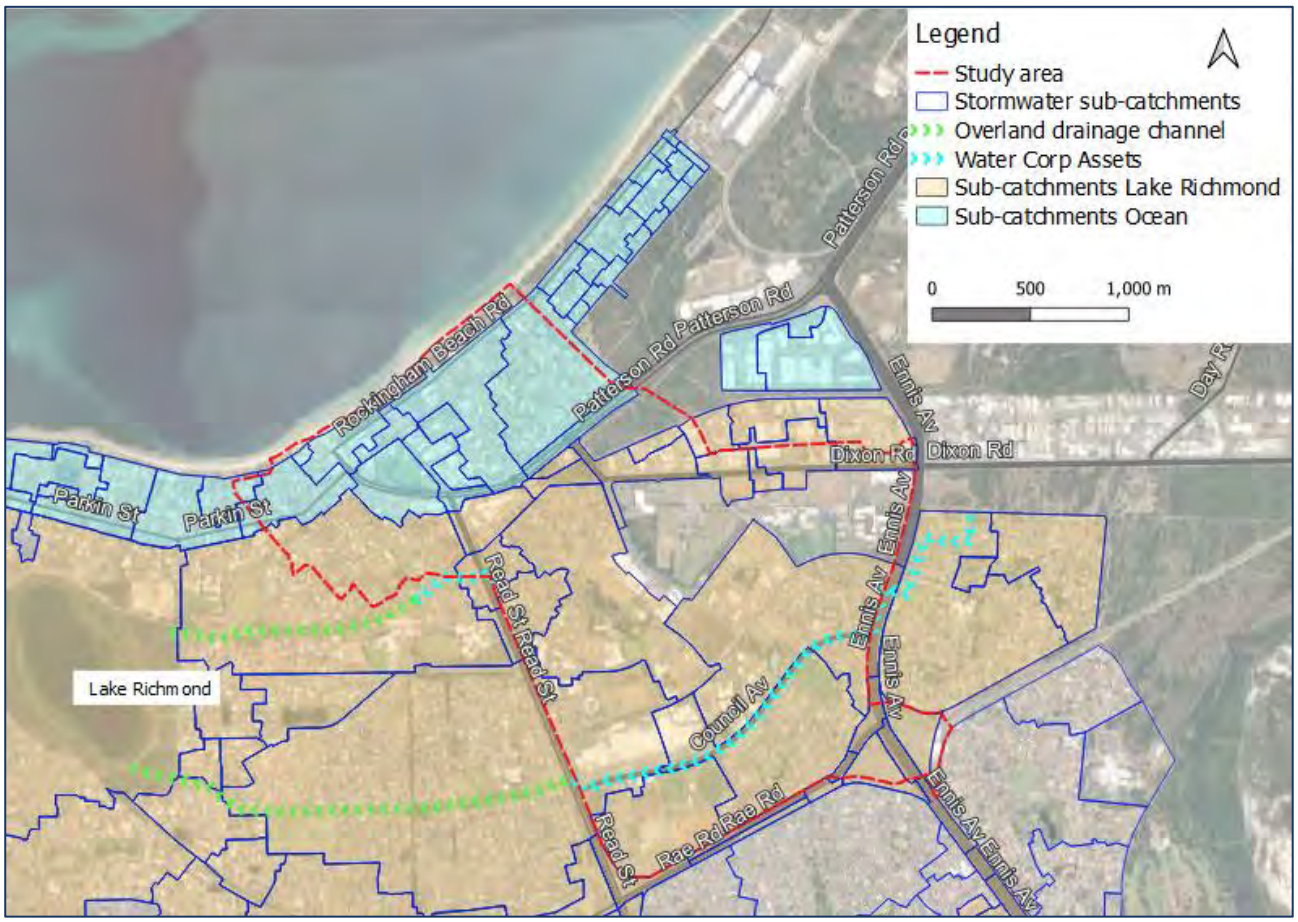
The Study Area receives runoff from one external catchment which is situated to the north east of the proposed transit centre. The external catchment drains into the Study Area under Ennis Avenue through a Water Corporation Drain which traverses the Study Area.

A majority of the Study Area is captured and conveyed by CoR underground stormwater network (shown on Figure 1, Appendix A) and Water Corporation drains. The Water Corporation drains convey flow westward into an overland flow channel that ultimately discharges into Lake Richmond.

The northern portion of the site is collected by CoR stormwater network and discharged to Rockingham Beach to the north via four ocean outfalls shown on Figure 1, Appendix A.

Refer to Figure 3-2 for the local drainage regime in and around the Study Area.

Figure 3-2 Rockingham stormwater Sub-catchment plan



3.8 Water Supply

The Water Corporation supplies potable water to Rockingham. The is sourced from various sources as part of Water Corporations integrated water supply network and includes dams, groundwater extraction and desalination plants. Treated water is stored at the Tamworth Hill reservoir from where it supplies the reticulation network.

The Study Area is situated within established systems of water and wastewater reticulation (water mains generally 100 mm or 150 mm diameter; gravity sewers generally 150 mm or 225 mm diameter).

3.9 Groundwater

Groundwater within the Rockingham region consists of unconfined, semi-confined and confined aquifers that exist as separate layered systems. The three aquifers which exist over the region, listed in order of increasing depth are;

- The Superficial and Rockingham Sand Aquifers (unconfined);
- The Leederville Aquifer (semi-confined to confined); and
- The Yarragadee Aquifer (confined).

The City of Rockingham has an abstraction licence of which 4.2 GL/annum is utilised for the irrigation of 560 ha of parks and reserves at a standard application rate of 7,500 kL/ha. Groundwater is the only form of non-potable water that is used as part of City operations

3.9.1 Superficial Aquifer

The superficial aquifer in this region is referred to as the Safety Bay Mound and consists primarily of medium grained sands as illustrated within Figure 3-3. Information obtained from the Rockingham Managed Aquifer Recharge (MAR) indicates hydraulic conductivity ranges of 5 to 50 m/day for the sands.

3.9.1.1 Groundwater Levels

The Perth Groundwater Map (DWER, 2017) indicates that the maximum groundwater contours in the Study Area range from 4 m AHD to 1 m AHD, with the minimum groundwater contours ranging from 2 m AHD to 1 m AHD. The groundwater profile for the subject site is illustrated in Figure 3-4.

3.9.1.2 Groundwater Quality

Groundwater data compiled for Hydrogeochemical Assessment of the Superficial Aquifer (DoW, 2010) was used to establish the pre-development groundwater quality. Table 3-1 below outlines water quality parameters for the Study Area as obtained from this document.

Bore 8282, located approximately 3km to the east of the Study Area, is the closest Superficial Aquifer sampling point and has been used as a benchmark in the absence of the other data. The water quality from Bore 8282 is assumed to be indicative of the water quality within our Study Area.

Table 3-1 Existing Water Quality Data – Bore 8282

Parameter	Bore 8282
Salinity	630
pH	7.97
HCO_3	236
Total Hardness ($CaCo_3$)	252.16
Iron (Fe^{2+})	0.05
Nitrate (NO_3^-)	0.44
Phosphate (PO_4^{3-})	0.28
Sulfate (SO_4^{2-})	41.0
Consumed Dissolved Oxygen (DO)	76%

3.9.2 Leederville Aquifer

The Leederville Aquifer is of Cretaceous age and consists of interbedded sandstone, siltstone and shales made up by the Mariginiup, Wanneroo and Pinjar Members and the Henley Sandstone Formation. The Leederville Aquifer is a major regional aquifer, from which large yields of fresh groundwater can be obtained.

The groundwater in the Leederville Formation is confined with the potentiometric surface in this area at approximately ground level (Davidson, 1995). In the Rockingham area the Leederville Formation ranges in thickness from approximately 150 m to 250 m and is conformably underlain by the South Perth Shale. (*Rockingham MAR Feasibility Study*, 2018)

It is noted that the Leederville Aquifer is part of the Rockingham MAR feasibility study.

3.9.3 Yarragadee Aquifer

The Yarragadee Aquifer is a confined aquifer that is too deep in the Rockingham area to provide a feasible source for groundwater abstraction.

3.9.4 Groundwater Abstraction

Within the RPSP area, there are five groundwater licence holders, all with draw points within the Perth Superficial Swan and Rockingham Sand Aquifer. Groundwater draw points are shown on Figure 2, Appendix A and summarised in Table 3-2. Note, not all of the volume is allocated to the RPSP area.

Table 3-2

Licence Number	Volume	Ownership	Draw Points
65106	2746285 kL	City of Rockingham	25
166417	41250 kL	The Roman Catholic Archbishop of Perth	6
171557	56500 kL	South Metropolitan TAFE	5

Licence Number	Volume	Ownership	Draw Points
201946	7950 kL	Perpetual Nominees Limited	1
202948	110000 kL	Murdoch University	4

Figure 3-3 Superficial Aquifer groundwater flownet (Rockingham MAR feasibility study – EWP18157 2018)

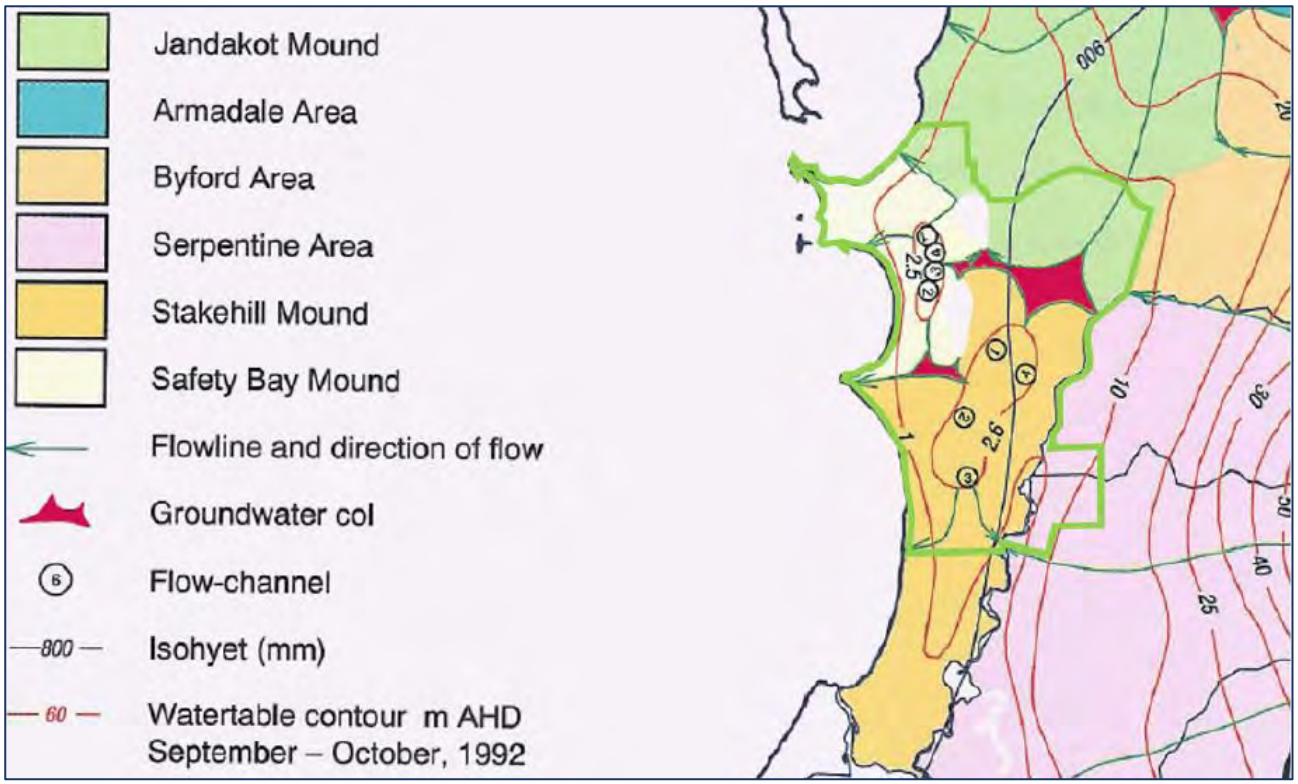
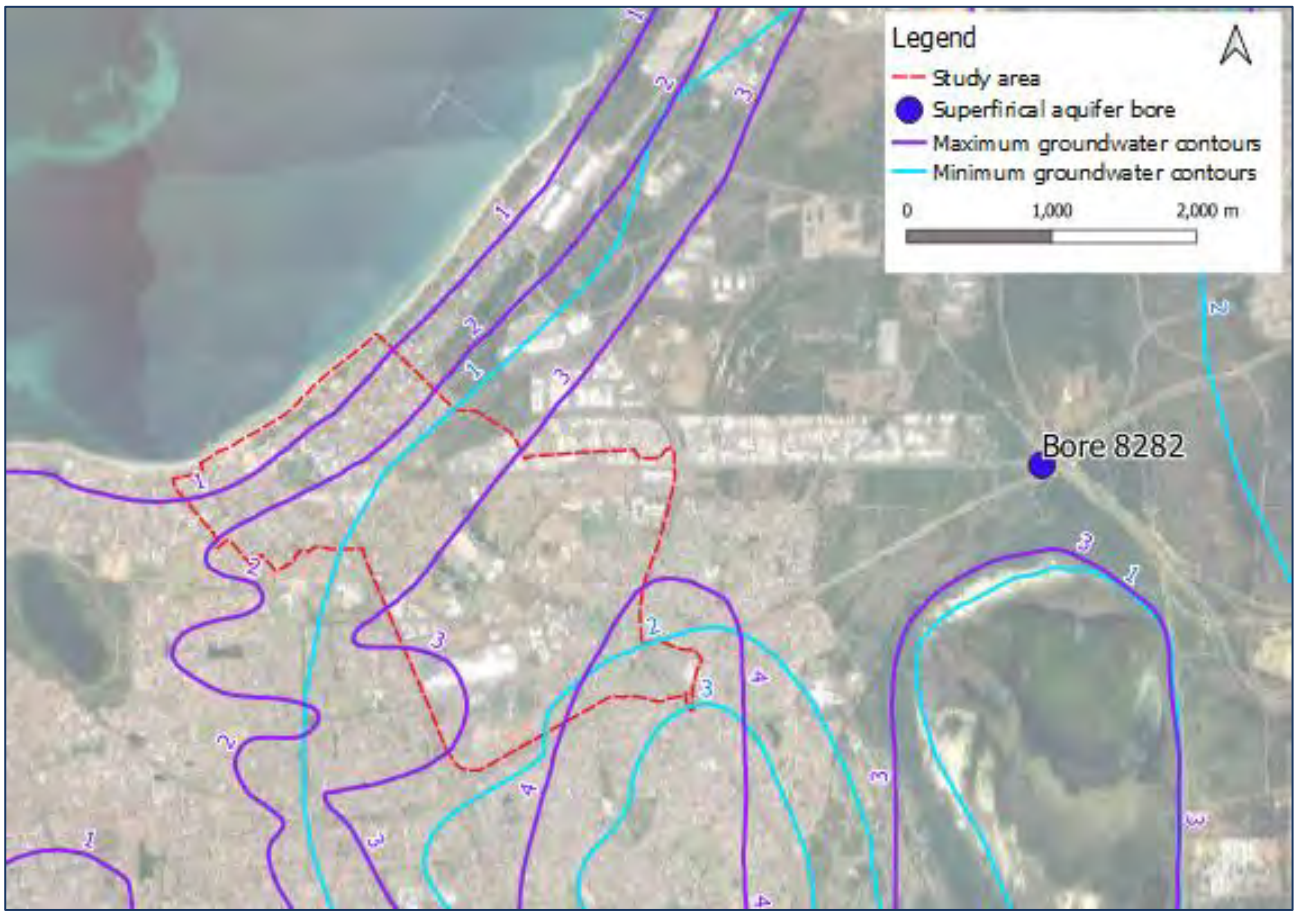


Figure 3-4 Subject site groundwater contours



4 Water Management Strategy

A holistic approach has been taken when developing this WMS to ensure that catchments in and around the Study Area are managed appropriately to maintain and improve the surface and groundwater resources for the region. The following sections will outline the strategies recommended to address all aspects of the total water cycle management applicable for the Rockingham Strategic Centre.

4.1 Water Balance

A water balance assessment is recommended to be undertaken for the RSC to understand the change in regime between aspects of the total water cycle. The water balance for the Study Area will be influenced by the frequency and intensity of rainfall and evapotranspiration and should consider precinct level scale estimates for annual rainfall, evaporation, transpiration, surface runoff and recharge.

An indicative water balance has been developed to enable assessment of the Study Area to estimate the impact of urban intensification on the RPSP.

The intensification shows only a minor increase in flows (3%) from infill and intensification, however, systems which are currently under capacity will require consideration to cope with increased flows as well.

4.1.1 Pre-development Water Balance

For the pre-development water balance assumptions are as follows;

- Average rainfall for Rockingham (based on Bureau of Metrology's Garden Island HSF site for the last ten years (2012 to 2021) of 614 mm. This period is representative of the drying climate.
- Pervious and impervious areas are assumed as follows:
    - Public open space / cleared land 0.9/0.1
    - Residential/special use 0.4/0.6
    - Commercial 0.3/0.7
- Recharge to the water table (superficial aquifer) is 9% of annual rainfall as described in Davidson and Yu (2008).

4.1.2 Post-development Water Balance

Assumptions for the post-development water balance for urban residential are as follows;

- Average rainfall for Rockingham (based on Bureau of Metrology's Garden Island HSF site for the last ten years (2012 to 2021) of 614 mm. This period is representative of the drying climate.
- Land use pervious and impervious areas are assumed as follows:
    - Public open space / cleared land 0.9/0.1
    - Residential/special use 0.4/0.6
    - Commercial 0.3/0.7
    - Residential/special use (increase density) 0.2/0.8
- Recharge to the water table (superficial aquifer) is 9% of annual rainfall as described in Davidson and Yu (2008).

Results of the water balance are presented in Table 3.

TABLE 1: SITE WATER BALANCE

Pre Development		Use	Area (ha)	Quantity mm/yr		Total kl/yr	% (Approx)
Inputs	**Rainfall**		525	614		3,223,500	100
					Input total	3,223,500	
Outputs							
	Rainfall Loss	*POS/cleared land*	129	61.4		79,206	2.5
		Residential/special use	365	245		894,250	27
		Commercial	31	184		57,040	2
	Stormwater Discharge					2,193,004	68
					Output total		100
					Balance	0	
Post Development		**Use**	**Area (ha)**	**Quantity mm/yr**		**Total kl/yr**	
Inputs	**Rainfall**		525	614		3,223,500	100
					Input total	3,223,500	100
Outputs							
	Rainfall Loss	*POS/cleared land*	85	61.4		52,190	1
		Residential/special use	256	245		627,200	19
		Commercial	31	184		57,040	2
		Pervious Area increase Residential/special use	37	123		45,510	6
		Pervious Area increase commercial	7	184		12,880	1
	Stormwater Discharge					2,293,995	71
					Output total	3,223,500	100
					Balance	0	

4.2 Water Supply and Wastewater

The additional development that may ultimately arise in the area over many years will mostly be served by connection to or extension from the existing reticulation mains that serve the area. However, in some areas developers will need to undertake some upgrades to existing infrastructure and install new infrastructure to adequately service new, higher density developments.

The Study Area is traversed by existing water and sewerage pipes, which may affect the nett development potential of some building sites, such as the need for adequate building setbacks from the rear boundary of lots because of sewer easements along the rear of the lots. If feasible, water or sewer reticulation may need to be rationalised or relocated to another suitable alignment at the developer's cost at the building stage.

4.2.1 Long term wastewater planning

The Water Corporation has developed long term wastewater planning for the Rockingham Sewer District, which includes the Study Area. This planning has made provision for wastewater flows from the relatively high development densities (R60, R80, R100) and mixed land uses contemplated in the 'Indicative Development' plan. Further adjustments to the Water Corporation's wastewater infrastructure planning will be made in future reviews, where necessary.

The nearest wastewater treatment plant is the East Rockingham wastewater treatment plant, situated approximately 3km northeast of the Study Area along Chesterfield Road in the Rockingham Industrial Estate. It is estimated that by 2070 the treatment plant will have the capacity to treat 160 million litres of waste water per day. Due to its close proximity to the Study Area, treated water from this scheme may be a viable future source of recycled wastewater.

4.2.2 Long term water planning

The city centre precinct is currently served by a large (760mm diameter) water distribution main as part of the Tamworth Gravity Scheme. Water is conveyed from the Tamworth Hill Reservoir along Rockingham Road, Dixon Road, Ennis Avenue and Council Avenue. This main provides a robust system of water supply through the city centre precinct.

Several smaller water reticulation mains (typically 100mm and 150mm diameter) branch off the distribution main and run along the road reserves through the city centre and serve existing residences and businesses in the area. It is likely that some sections of these smaller water reticulation mains will need to be upgraded by land developers with larger mains in order to meet the flow and pressure demands of high-density developments, in particular to achieve fire flow requirements for multi-storey commercial and mixed-use buildings. The need for any water reticulation mains upgrades will be determined at the future planning or building stages and undertaken at the developers' cost.

Further, in consideration of the City's CHRMAP, focus on actions that will require implementation prior to 2030 was provided and are summarised below.

4.2.2.1 Stormwater and Drainage Asset Management

R15: Update the City's Asset Management Plan to reflect adaptive measures selected by the City and develop a priority matrix to ensure assets nearer to the foreshore area are performing as expected.

Moving forward in consideration of expected Sea Level Rise (SLR), the City's drainage maintenance plan will need to be developed in accordance with the adaptation options selected by the City. It will be important that maintenance is proactive as opposed to reactive. A proactive maintenance regime could substantially prolong the useful life of the stormwater and drainage assets.

It is suggested that a priority matrix be developed that assesses maintenance of assets nearer to the foreshore areas in line with the potential impacts of erosion and inundation. This is to ensure that the assets in these vulnerable locations are performing as expected and are not hindered by blockages, or other obstructions.

Operational and maintenance activities may be targeted to mitigate critical asset failure and maintain service levels. These activities may include increased inspection frequency and higher maintenance intervention levels.

Identification of critical stormwater assets and their failure modes will be necessary to minimise risk and inform the City's asset management plan. For example, critical stormwater assets are likely to include:

- Drainage structures under main roads;

- Drainage structures under roads with no nearby alternative routes;
- Drainage structures near schools, aged care and childcare facilities;
- Drainage structures protecting emergency services sites; and
- Flood mitigation structures protecting residential land.

Drainage or flooding issues reported by residents should be reviewed and assessed to identify if the issues are related to coastal processes or hazards.

Through the implementation of a complete stormwater and drainage GIS information system, assets noted as critical can be identified and linked to a maintenance regime, based on location of the assets, to address known issues. This will help develop maintenance planning for predicted SLR and increased inundation. Maintenance regimes will need to be reviewed and a gap analysis performed to ensure that maintenance planning will address adaptation options selected by the City.

In consideration of the above, the following assets in the study Area were identified (and also shown on Figure 3, Appendix A) and will need to be incorporated into a maintenance plan to ensure longevity of operations:

- 36m of stormwater drainage will be subject to inundation now.
- 108m of stormwater drainage will be subject to inundation in 2030.
- 206m of stormwater drainage will be subject to inundation in 2070.
- 359m of stormwater drainage will be subject to inundation in 2110.

4.2.2.2 Stormwater Modelling

R16: Stormwater and drainage system be reviewed for functional capacity should issues be reported.

As the study area has four drainage outlets discharging to the ocean, understanding the capacity of the drainage network will provide an indication of what catchments will be prone to failure due to coastal processes.

Ultimately, the City should undertake direct rainfall modelling of the coastal area. This assessment will provide the City with an understanding of the areas most prone to inundation due to rainfall. This modelling should be used to determine the impact of elevated water levels on the efficiency of the drainage network.

4.3 Water Efficiency Measures

The CoR was recognised as a Gold Waterwise Council by the Water Corporation and the Department of Water and Environment Regulation (DWER) in May 2019. The CoR is required to adhere to a Water Efficiency Action Plan (WEAP) to maintain this accreditation.

To achieve water efficiency targets, the following measures are proposed for consideration to reduce scheme water usage in
the development:

- All buildings and public toilets are designed to include water efficient fixtures and fittings, such as dual flush toilets, flow control valves and spring-loaded taps;
- Use of native plants in streetscapes to reduce the demand for water;
- Turf areas to be minimised (if any);
- Use of fit-for-purpose groundwater resources for irrigation of vegetated areas;
- Stormwater harvesting or recycled wastewater for open space irrigation; and
- Use of smart rainwater tanks to obtain and release stormwater as required.

Review of the proposed precinct layout plan indicated an increase in areas zoned as public open spaces. The increase in open spaces presents an opportunity to integrate water efficiency measures into the precinct.

Consistent with the fit-for-purpose water use strategy, irrigation water needed for streetscapes will be sourced from a Superficial Aquifer groundwater supply. Alternatively, stormwater harvesting and/or recycled wastewater could be investigated for feasibility of use, depending on broader long-term plans for the region.

The irrigation system should be designed to water-wise standards with local native plants making up at least 50% of plantings. It should be noted that xeriscape planting (landscaping which reduces or eliminates the need for irrigation) considerations should be balanced against liveability gains from plants with higher evapotranspiration rates, which would reduce urban heat effects, depending on the aforementioned feasibility of recycled water for irrigation.

4.4 Stormwater Management

The stormwater drainage approach has been developed using a major/minor approach. In accordance with the CoR Urban Water Management Policy, the major drainage system is required to service storm events greater than the 10% AEP and includes the use of roads, Water Corporation drains, swales and drainage reserves to provide safe passage and disposal of stormwater runoff.

4.4.1 Major Drainage

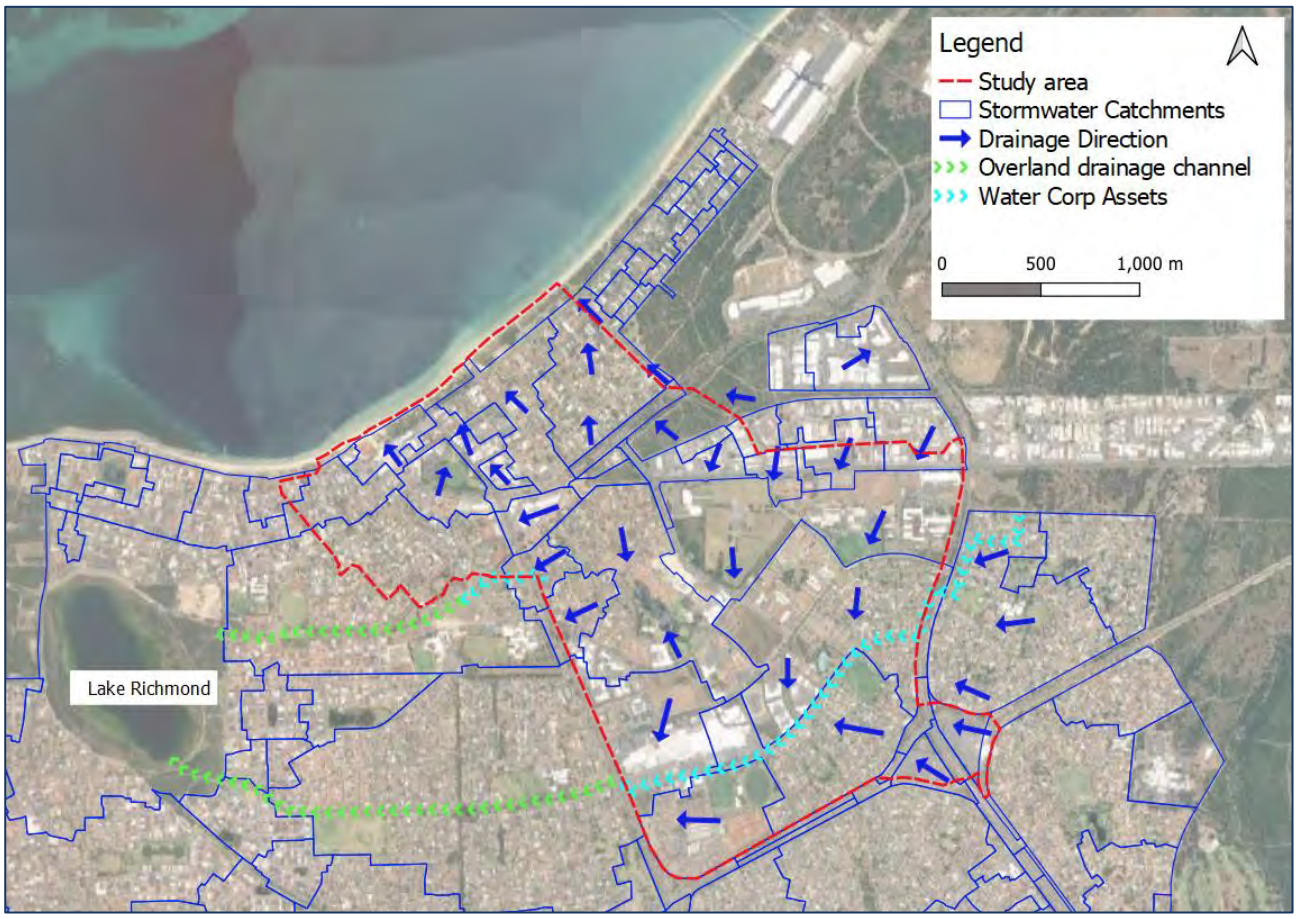
Increasing the density of development and the extent of impervious surfaces across this part of the drainage catchment will require CoR to review its local drainage strategies to ensure that stormwater runoff to the Water Corporation main drainage system is not increased. Additional flows generated by the proposed developments in the area should be detained at source or within the local catchment until the peak flows subside in the main drain.

The Rockingham city centre and adjoining land to the east and south fall within the catchment of the Rockingham North Main Drain and the Rockingham Central Main Drain (refer to Figure 4-1.). These drains are operated and maintained by the Water Corporation under licence conditions stipulated by the Economic Regulation Authority. Water Corporation has been consulted as part of this water management strategy to provide preliminary advice in regard to the management and future planning of their assets. The aim for managing major stormwater runoff through the Study Area is to ensure that no adverse impacts are experienced within the Water Corporation assets or downstream receiving waterways.

The urban drainage system through the city centre area was originally designed and constructed to serve development of much lower density compared to what is proposed. The Water Corporation drains have piped and open sections that have finite hydraulic capacity. The Water Corporation's 2008 review of its drainage system concluded that the system was currently operating within the required levels of service stipulated in its operating licence. However, higher density, mixed use development across the city centre catchment could have a major impact on the operation of the drainage system in the future. The Corporation is not able to accept increased rates of flow into the main drains.

The Water Corporation drains flow to the west and discharge into Lake Richmond and ultimately into the ocean. Water Corporation is required to operate the system under conditions that maintain existing surface levels at Lake Richmond and to manage water quality at the site.

Figure 4-1 Major Drainage Paths for Study Area



In order to satisfy conditions for the receiving waterway of Lake Richmond, Water Corporation assets, the following stormwater management outcomes will need to be achieved within the Study Area:

> Maintain peak flow rates and regimes within Water Corporation drains to current conditions. This is proposed to be achieved through the implementation in lot-scale, street scale and sub-catchment scale detention measures upstream of the Water Corporation drains to ensure that peak flow volumes and rates mimic present day conditions;

4.4.2 Minor Rainfall Events

In the RPSP area, high density development is typically categorised by lots zoned R80 and above (including RAC-0). Building typologies expected to be delivered within this density band are primarily mid-rise (4-8 storeys) and high-rise apartments (8 storeys and above). Medium density is categorised by lots zoned R40 and R60. The primary building typologies proposed in this density range are terraces and low-rise apartments (2-3 storeys). For minor events up to and including 20% AEP (residential) and 10% AEP (high density residential , commercial and industrial), stormwater management systems must be designed to provide appropriate levels of serviceability, amenity and road safety

If necessary, CoR may need to identify and set aside additional areas within public open space across the catchment for local drainage infrastructure to detain stormwater runoff in the catchment. CoR should also ensure that commercial and residential developments in the catchment make adequate provision for on-site soakage as a condition of any planning and building approvals.

Key points for the design of the minor drainage system are as follows:

> Extensive use of roadside swales and central median swales to limit the use of piped drains as far as practical;

> Kerb breaks and flush kerbing to be utilised to encourage overland flow;

> Where required, piped drains sized to convey runoff from the 10% AEP storm event;

4.4.3 Small Rainfall Events

Any upgrades to the minor drainage system are to include a treatment train of Best Management Practice (BMP) water quality structural controls such as vegetated swales that provide water quality treatment in the Study Area.

Key points for the design/management of small rainfall events are as follows:

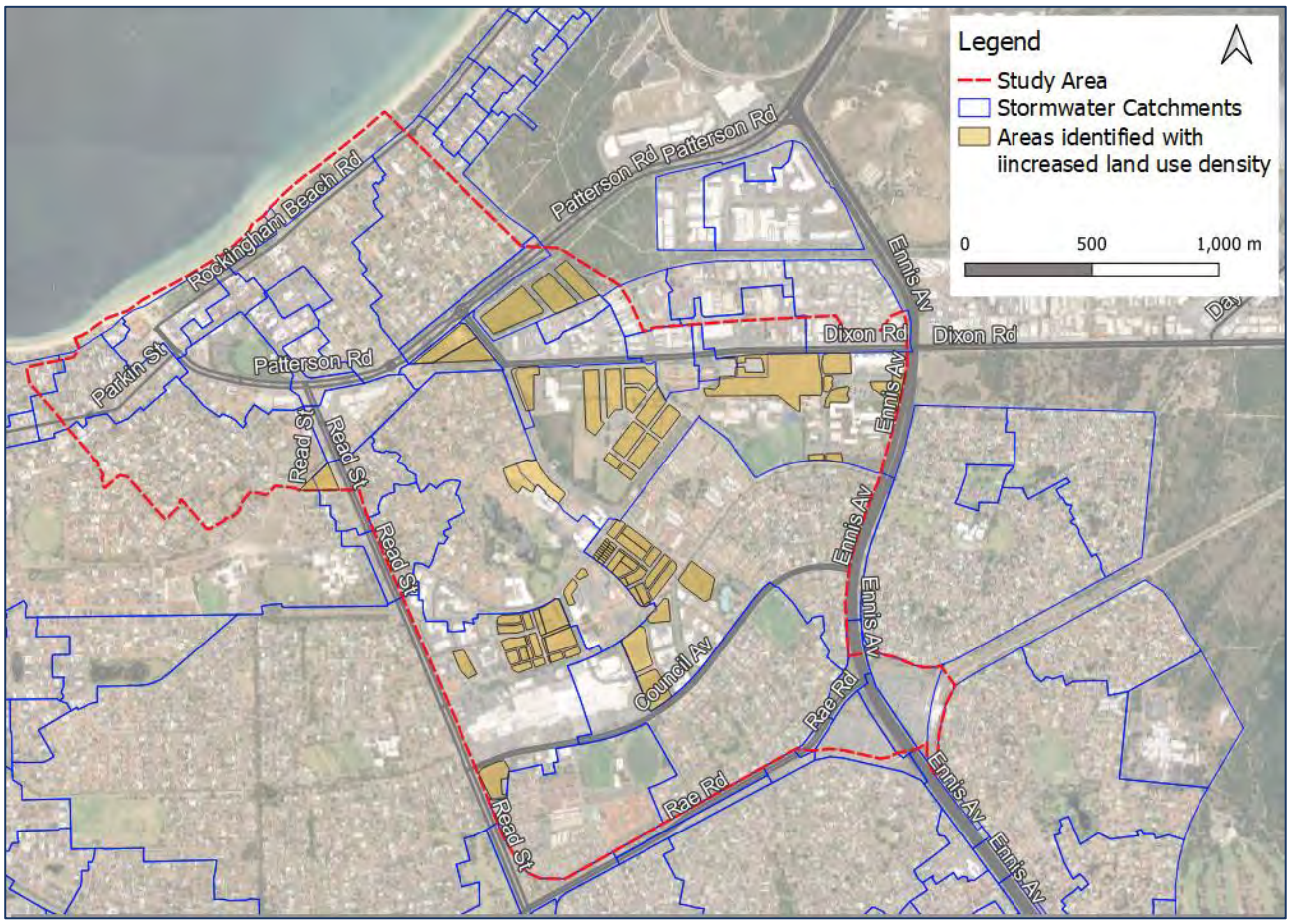
- Runoff from residential, mixed use and commercial lots for the first 15 mm of rainfall to be infiltrated in soak wells, as a minimum;
- Where runoff is from roadways or other potentially dirty sources the runoff should be directed to bioretention areas to assist filtering of the storm water. Drainage treatment train of roadside swales, central median swales and raingardens for all roads with capacity to treat 15 mm of rainfall; and
- The first 15 mm of rainfall from road runoff should be treated within a bio-retention zone in proposed detention basins (if it is not possible to achieve this in upstream structures such as a raingarden). Bio-retention should be co-located with stormwater detention basins with appropriate landscape features and landscaping to ensure amenity can be derived from the area.
- In order to satisfy conditions for the receiving waterway of Lake Richmond, Water Corporation assets, the following stormwater management outcomes will need to be achieved within the Study Area:
  - In accordance with local guidelines, the first 15mm of rainfall is to be captured at the upstream source and allowed to infiltrate into the groundwater table. Soak well systems have demonstrated success in delivering this objective. Where runoff is from roadways or other potentially dirty sources the runoff should be directed to bioretention areas to assist filtering of the storm water.
  - Ensure water quality objectives for Lake Richmond are achieved through the implementation of water quality treatment devices upstream of the Water Corporation discharge points.
  - Using UNDO, demonstrate that development will maintain predevelopment exported nitrogen and phosphorous loads in Lake Richmond.

4.5 Stormwater Detention Measures

Review of the proposed developed layout has indicated that the Study Area has a reduction in designated pervious surface areas from 92ha (9%) in the pre-development scenario, to 60ha (6%) in the proposed development scenario. The reduction in pervious areas generally correlates to an increase in stormwater runoff volume, frequency and peak flow rates in the absence of stormwater detention measures. Given the sensitive nature of the downstream environment, and capacity constraints within the Water Corporation drains, it is a requirement that there is no increase in peak flow rates within the Study Area.

Figure 4-2 illustrates the regions within the Study Area that are subject to the largest increase in land-use density, which generally correlates to the change from pervious lots to developed lots.

Figure 4-2 Opportunities for stormwater detention infrastructure



A coordinated approach to stormwater quantity management should be applied in future planning stages. Where substantial redevelopment occurs that includes reduction in pervious areas and general civil works there the opportunity to provide a coordinated basin which allows for increased runoff from private lots. This may be advantageous compared to lot scale management of the excess runoff as the lot scale management is likely to be via small underground structures.

4.6 Water Quality Management

As mentioned previously, the downstream receiving waterways are subject to stringent environmental conditions and water quality objectives. The *Lake Richmond Management Plan* (CoR, 2021) states that the Water Corporation drains have increased the fresh water and nutrient discharge into the lake which has resulted in the increase in detrimental algae species. As such, it is paramount that water quality management controls are incorporated into the structure plan to ensure no further degradation of water quality discharging to the downstream water bodies.

Recommendations to manage water quality for the site have been categorised into structural and non-structural controls. The effective implementation of the structural and non-structural controls as part of the water management strategy aims to enhance the quality of water discharged from the Study Area as a result of the land use change.

Non-structural source controls aim to reduce nutrient export from the site by focusing on reducing the need for nutrient inputs into the landscape. The following strategies are proposed:

- Local endemic species are to be used in vegetated and drainage areas;
- Controls to be put in place around the use of fertilisers and irrigation to minimise nutrient export; and
- Street sweeping and waste management/collection to be co-ordinated with the CoR.

Structural source controls are proposed to complement the non-structural source controls and provide a complete stormwater treatment train. The following structural controls are considered appropriate for the Study Area:

- The use of bioretention zones within swales, rain gardens and basins;
- Open bottom maintenance holes; and
- Gross Pollutant Traps to capture larger pollutants.

The minimum specifications for all bioretention systems (swales and storages) are presented in Table 4-1.

Table 4-1 Minimum Specification for bio-retention systems

Item	Specification
Amended soil media (DoW, 2011)	1. Minimum 500 mm thick. 2. Hydraulic Conductivity, ksat = 3 m/day. 3. PRI ≥ 10. 4. Light compaction only. 5. Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per an appropriate monitoring program.
Plant selection, planting density and distribution	6. Species and densities to be in accordance with the Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia (Oversby et al., 2014).

Biofiltration systems should be considered as part of an overall strategy for managing stormwater in a development where the depth to Maximum Groundwater Level (MGL) is less than 5 m.

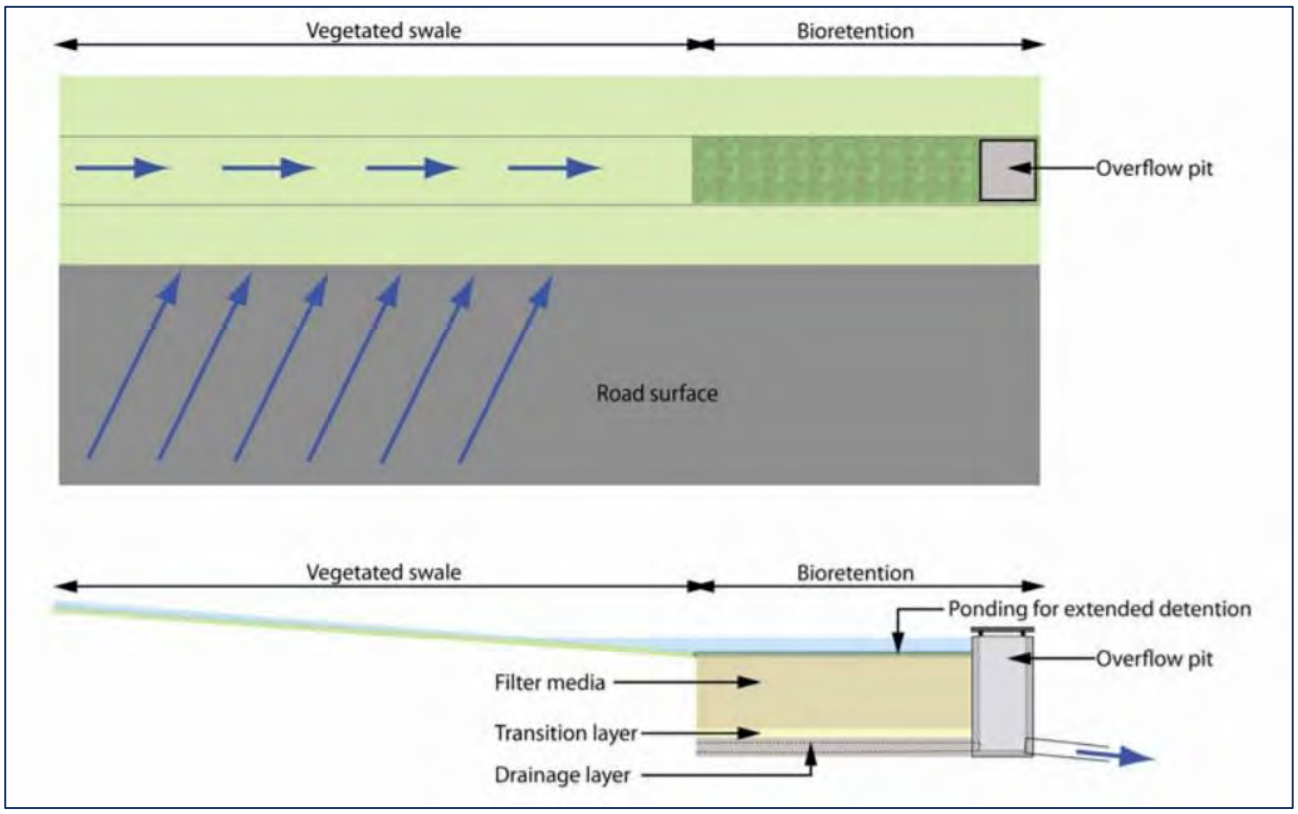
The bioretention systems should be sized to function correctly with a saturated hydraulic conductivity (k_{sat}) of 3 m/day. Recent research conducted by the Facility for Advancing Water Biofiltration (FAWB, 2008) indicates that the desirable range for k_{sat} is 2.5 to 7 m/day to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

It should be recognised that data currently guiding the design of bioretention systems is only recent and largely based on laboratory testing. The specifications provided in this document should be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

4.6.2 Typical Bioretention swales

Bioretention swales are swales that have a bioretention system installed in the base such that they provide both treatment and conveyance functions. The vegetated swale component provides conveyance (and retardation of flow) and pre-treatment of the stormwater through the removal of coarse to medium sediments as the flow passes through the vegetation. The bioretention system, often placed at the end of the swale, removes finer particulates and associated contaminants through fine filtration, extended detention treatment and some biological uptake. Bioretention swales are limited to flows that are not excessive as this will result in scouring of the filter media. A typical layout of a bioretention swale is shown in Figure 4-3.

Figure 4-3 Typical Bioretention Swale Layout



Key Water Quality Options for this Study:

- Gross pollutant traps at end-of-line pits prior to discharge into trunk infrastructure or basins;
- Bioretention-swales along street frontages to treat stormwater prior to entering underground network (where this does not conflict with the orderly placement of crossovers); and
- Regional bio-retention / detention basins for larger scale development or redevelopment (such as development extending over multiple lots).

4.6.3 Water Quality Management Strategy

The proposed water quality management strategy is provided in Table

Table 4-2 Water Quality Management

System design element	water quality management strategy
Groundwater management system	> **Conveyance through vegetated swales at discharge points.** > **Upgrade to treatment in biofiltration areas where legacy contamination has been identified in the** sub catchment**.**
At source water management (public open space)	> **Playing fields to incorporate a layer of amended soils.** > **Facilities to be connected to deep sewerage.** > **Limit use of fertilizers and pesticides.**
At-source water management (residential lots)	> **Management of runoff from first 15mm of rainfall in soakwells, raingardens, rainwater tanks, buffer strips etc.**

At-source water management (commercial and industrial lots)	> **Management of chemicals, materials and equipment to prevent pollution (including bunding of washdown and storage areas).** > **Treatment of all wastewater prior to discharge (including any runoff from washdown and storage areas).** > **Management of runoff from first 15mm of rainfall in soakwells, raingardens, rainwater tanks, buffer strips etc.**
At source water management (road reserves)	> **Management of runoff from first 15mm of rainfall in soakwells, raingardens, rainwater tanks, buffer strips etc.**
Additional measures to manage legacy issues	> **Avoid locating infiltration systems in areas with known legacy contamination (including elevated nutrients).** > **Provide additional treatment via biofiltration systems at outlets of subsurface drainage systems.**

4.7 Groundwater Management

In accordance with the CoR Urban Water Management Planning Policy, if the maximum groundwater level (MGL)(based on DWER 1997 groundwater levels) is at or within 1.2 m of the surface a subsoil drainage system or additional imported fill is required (please also refer to section 4.7.1 to consider SLR). It is not expected that this condition will apply to Study Area. However, should MGL (and with considerations of SLR) be found to be within 1.2, of the surface, the following criteria shall apply (as adopted from IPEWA's Specification for separation distances for groundwater-controlled urban development):

- Underground infiltration systems – 0mm from the 50% AEP phreatic surface.
- Surface infiltration systems – 300mm from the 50% AEP phreatic surface.

It is understood that the wetlands within the greater Rockingham region are largely groundwater dependent. As such it is not recommended that there is an increase in groundwater abstraction as it may adversely impact the health of these systems. In order to preserve and replenish the groundwater system the following objectives for groundwater management are recommended for the Study Area;

- Incorporate soakage well systems on a lot basis to maximise the infiltration into the groundwater table;
- Manage and monitor groundwater levels to protect infrastructure and assets;
- Maintain groundwater regimes for the protection of groundwater dependent ecosystems;
- Protect the value of groundwater resources; and
- Adopt nutrient load reduction design objectives for discharges to groundwater.

Key Groundwater Options for this Study include:

- Incorporate soakage systems on a lot basis to maximise the infiltration into the groundwater table; and
- Aquifer reinjection in accordance with a managed Aquifer Recharge Scheme

4.7.1 Groundwater Rise Assessment

As noted in the CHRMAP, it is generally accepted that SLR will cause groundwater levels adjacent to the coast to increase the same i.e. 0.9m increase in Mean Sea Level will result in a 0.9m increase in coastal groundwater levels. Inundation can also affect groundwater levels creating groundwater 'mounding' dependent on the aquifer properties.

Adapted from Timms, Anderson & Carly (2008), SLR can potentially affect groundwater resources by:

- Seawater intrusion – migration inland of the freshwater/saline water interface;
- Seawater inundation of unconfined aquifers;
- Contamination of production bores; and
- Impact on infrastructure.

Within the RPSP, the depth to groundwater will become shallower by varying amounts dependent on distance to the coast, geology and proximity to lakes and drains. The impact of this increase will vary dependent on the current depth to groundwater. Where groundwater is currently shallow, any increase would have more significant impacts than areas where the water table is deeper.

As stated in the CHRMAP, Cardno utilised DWERs 1997 MGL contours for the groundwater rise assessment. 2110 SLR was then added to the groundwater levels to provide groundwater elevations in 2110. Following this, the groundwater levels calculated were subtracted from the DEM to determine surface assets that would be impacted by sea level rise. Survey of drainage infrastructure inverts was compared to the predicted groundwater level to determine drainage assets that may be impacted by groundwater rise.

It should be noted that this is a simplistic approach to reviewing the impacts of coastal hazard risk but appropriate for a macro scale assessment. Groundwater levels near the coast can be greater during higher tides and during storm events as the sloping beach face fills (vertical infiltration) at a greater rate than it can drain (horizontal seepage) (Turner, Coates & Acworth, 1996).

The groundwater assessment took into account impacts on drainage infrastructure, open water bodies and groundwater production bores only. In consideration of the RPSP, the following infrastructure is considered potentially impacted by groundwater level rise (Figure 3, Appendix A):

- Eight pits impacted by groundwater rise; and;

> Four groundwater bores which may be prone to saline intrusion.

To future prove new development, when undertaken detailed design, SLR needs to be considered to meet the criteria noted in Section 2.2:

> Achieve free drainage for sub-surface drainage outlets under an SLR scenario; and

> 0.3m of separation to MGL under a SLR scenario for the invert of drainage infrastructure (or to the satisfaction of the City).

4.8 Summary of Recommended Actions

Based on the review of the proposed Rockingham Strategic Centre the following options have been deemed the most relevant to the study area and will be reviewed within the Multi Criteria Analysis;

1. Soakage well systems on lot level;
2. Regional bioretention/ detention basins;
3. Bio-swales along road frontage;
4. Rainwater tanks;
5. Treated stormwater & wastewater for irrigation; and
6. Aquifer re-injection.

5 Multi Criteria Analysis

Throughout this study a range of options have been presented to address components of the total water cycle in the fields of stormwater quantity, stormwater quality, water efficient measures, and groundwater management.

In order to determine which recommendations are best suited to the proposed Rockingham Strategic Centre, a Multi-Criteria-Analysis (MCA) has been developed and implemented. The MCA focuses on scoring the project objectives as outlined within Table 2-3 and details whether the proposed water management options address the criteria.

It is noted that most options only address some components (i.e. water quality and groundwater) of the total water cycle, and it will likely be a combination of different options that will provide a holistic, practical approach for managing water within the study area.

The criteria for the MCA have been summarised in Table 5-1, with the results of each option presented in Table 5-2.

Based on the highest scores, Option 2, regional bioretention/ detention basins, and Option 3, bio-swales along road frontage, are the preferred option for water quality treatment and management in the RPSP.

Table 5-1 Criteria and Weighting for MCA

No.	Criteria	Score and Description				
		0		5		10
1	**Stormwater Quantity Management** Protect infrastructure, property and downstream environment from major storm and flooding events.	Does not mitigate peak flow rates in any events	↔	Mitigates peak flow rates in some events	↔	Mitigates peaks flow rates in all events and manages catchment runoff for the Study Area including projected increases due to climate change
2	**Water Quality Management** Protect the downstream receiving environment through the application of WSUD principles and nutrient load reduction design objectives for stormwater runoff.	Does not manage or improve stormwater quality	↔	Maintains or partially improves stormwater quality discharging from site	↔	Achieves pollutant reduction targets from the BUWM
3	**Groundwater Management** Managing and minimising changes in groundwater levels and groundwater quality following development.	Does not manage impacts to groundwater	↔	Addresses some components of groundwater management	↔	Satisfies all groundwater management objectives
4	**Water Conservation** Preserve natural resources through the development of a water conservation strategy and considers factors such as recycling, re-use, reduction	Does not consider any water conservation measures	↔	Address some factors of water conservation	↔	Satisfies objectives of a holistic water management strategy
5	**Cost** Cost of implementing option	$1,000,000 high cost to implement	↔	$100,000 moderate cost to implement	↔	$10,000 low cost to implement
6	**Maintenance** Cost of maintaining option	+$25,000 high cost to maintain	↔	$15,000 moderate cost to maintain	↔	$5,000 low cost to maintain

Table 5-2 Outcome of MCA for each option

Options	Criteria 1: stormwater quantity	Criteria 2: water quality	Criteria 3: groundwater management	Criteria 4: water conservation	Criteria 5: cost	Criteria 6: maintenance	Overall Score
Option 1 soakage well systems on lot level	5	0	5	0	10	10	30
Option 2 regional bioretention/ detention basins	10	10	5	0	5	5	35
Option 3 bio-swales along road frontage	5	10	5	0	10	5	35
Option 4 rainwater tanks[1]	5	0	0	5	5	10	25
Option 5 treated stormwater and wastewater for irrigation	5	0	5	10	0	0	20
Option 6 aquifer re-injection	0	5	10	5	0	0	20

Note 1: Option 4 could be enhanced to manage stormwater quantity through smart tanks which pre-release stored water in advance of expected rainfall.

6 Conclusion

A Water Management Strategy has been prepared for the proposed Rockingham Strategic Centre to support the Rockingham Strategic Centre Precinct Structure Plan. The key objectives for the WMS were to review the existing conditions of the site and make recommendations for the best WSUD and total water cycle management options that could be incorporated into the RPSP to address the criteria of water quality, water quantity, water conservation and groundwater management within the study area.

The options that were deemed the most suitable for the RSC and assessed within the MCA were;

1. Soak well systems at the lot level
2. Regional bioretention/ detention basins
3. Bioretention swales along road frontage
4. Rainwater tanks
5. Treated stormwater and wastewater for irrigation
6. Aquifer re-injection

It is noted that the recommendations and options presented within this WMS are concept level only and provide high level planning guidance only. Further investigation must be undertaken to develop options to enable the options to progress to detailed design and construction.

6.1 Implementation

The water management strategy noted in Section 4 and criteria provided in Section 2.2 should guide development of Water Management Strategies for individual precincts in the RPSP.

The water management strategy is to be prepared by the developer and should demonstrate to the satisfaction of the WAPC and the City (and if required, on the advice of DWER) in accordance with this Precinct Structure Plan:

- How the key principles and criteria of this plan have been met;
- How the urban structure will address water use and management; and
- Existing and required water management infrastructure.

The water management strategy must demonstrate proof of concept including how the water management strategy addresses the issues and criteira identified in this strategy and will achieve the criteria in Section 2.2.

Detailed surface water modelling will be required to support future water management strategies. This modelling will need to include consideration of the risks associated with surface and groundwater interaction both now and in the future taking into consideration SLR. The establishment of appropriate antecedent conditions in drainage infiltration basins and at outfalls will need to consider changing groundwater levels and SLR.

Further, as detailed in the CHRMAP (CoR, 2019) the following should be implemented:

- Recommendation 15 (Stormwater and Drainage Asset Management): Update the City's Asset Management Plan to reflect adaptive measures selected by the city and develop a priority matrix to ensure assets nearer to the foreshore area are performing as expected.
- Recommendation 16 (stormwater modelling): Stormwater and drainage system be reviewed for functional capacity should issues be reported.

7 References

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APPENDIX A

FIGURES

FIGURE 1

1:14,000 Scale at A3

Meters

0 175 350 525 700

Rockingham Drainage Network

ROCKINGHAM STRATEGIC METROPOLITAN CENTRE
HAMES SHARLEY

N

Cardno

Map Produced by Cardno WA
Date: 2022-04-05 | Project: CW1181500
Coordinate System: GCS GDA 1994
Map: CW1181500-EN-001_Hydro 01.mxd 01
Aerial Imagery provided by Aerometrex

FIGURE 2

1:14,000 Scale at A3

Meters
0 180 360 540 720

Production Bores and Abstraction Licences

ROCKINGHAM STRATEGIC METROPOLITAN CENTRE
HAMES SHARLEY

Cardno

Map Produced by Cardno WA
Date: 2022-04-05 | Project: CW1181500
Coordinate System: GCS GDA 1994
Map: CW1181500-EN-001_Hydro 02.mxd 01
Aerial Imagery provided by Aerometrex

FIGURE 3

1:18,000 Scale at A3

Meters

0 230 460 690 920

Sea Level Rise and Drainage Infrastructure Hazard Map

ROCKINGHAM STRATEGIC METROPOLITAN CENTRE
HAMES SHARLEY

N

Cardno

Map Produced by Cardno WA
Date: 2022-04-05 | Project: CW1181500
Coordinate System: GCS GDA 1994
Map: CW1181500-EN-001_Hydro 03.mxd 01
Aerial Imagery provided by Aerometrex

Appendix B Water Corporation and Department of Water Environment Regulations Commentary (WC & DWER, 2024)

<table>
<tr><th>Name</th><th>Address</th><th>Comment</th></tr>
<tr>
<td>1. Mr Mark Hingston
Planning Advice – Kwinana Peel Region
Department of Water and Environmental Regulation</td>
<td>PO Box 332
MANDURAH WA 6210

mark.hingston@dwer.wa.gov.au</td>
<td>Thank you for providing the opportunity to comment on the draft Rockingham Strategic Centre Precinct - Structure Plan Amendment 191 received with correspondence dated 3 May 2023.
The Department of Water and Environmental Regulation (the Department) has reviewed the amended Local Structure Plan (LSP) and associated documents and provides the following comments.
The structure plan amendments propose an increase in development densities within a number of the structure plan's sub-precincts. A Water Management Strategy produced by Cardno in December 2021 has been provided in the document package received by the Department which intends to provide the framework for the application of total water cycle management. With an identified reduction in pervious areas and an increase in density within sub-precinct areas the Department recommends further information be provided in the Water Management Strategy (WMS). The Department provides the attached comments for your consideration. Accordingly, the proposed structure plan amendment should not be finalised prior to the endorsement of a satisfactory WMS by the Department.

In the event there are modifications to the proposal that may have implications on aspects of environment and/or water management, the Department should be notified to enable the implications to be assessed.

Should you require any further information on the comments, please contact Mark Hingston at the Mandurah office on 9550 4209.

Attachment 1 - Department of Water and Environmental Regulation - comments on the Rockingham City Centre, Precinct Structure Plan, Water Management Strategy (Cardno, 2021)
Contact for further information: Mark Hingston – 9550 4209
<table>
<tr><th>No.</th><th>Page</th><th>Section</th><th>Rev 1 -DWER Comments</th></tr>
<tr><td>1</td><td></td><td>General Comments</td><td>Please ensure that references to DoW are changed to DWER (Department of Water and Environmental Regulation)</td></tr>
<tr><td>2</td><td>8</td><td>Section 2.2 - WMS Objectives</td><td>Reference to sub-surface drainage (subsoils) should state that they are to be set at or above maximum groundwater level (MGL).</td></tr>
<tr><td>4</td><td>15</td><td>Section 4.4 - Stormwater Management</td><td>The Water Management Strategy (WMS) identifies that the amendment will create additional stormwater runoff and that this runoff must be infiltrated on-site. The WMS should,
• Quantify the volume of additional runoff from proposed density changes,
• Quantify the amount of additional land required, if any, for drainage/infiltration purposes,
• If required, identify likely areas available for future stormwater drainage infrastructure, and
• Discuss the potential for increased groundwater recharge and possible effects on groundwater dependent ecosystems and current and future development.</td></tr>
<tr><td>5</td><td>18</td><td>Section 4.6 - Water Quality Management</td><td>The WMS notes that biofiltration systems should be considered as part of an overall strategy for managing stormwater in a development where the depth to Maximum Groundwater Level (MGL) is less than 5 m.
Please note, the use of biofiltration systems are also dependant on other factors including, location of groundwater dependent ecosystems, soil types and direction of groundwater flow.</td></tr>
</table>
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<tr>
<td>5. Brett Coombes
Senior Urban Planner
Development Services
Water Corporation</td>
<td>PO Box 100
LEEDERVILLE WA 6007

land.planning@watercorporation.com.au</td>
<td>Thank you for your letter of 3 May 2023 inviting comments on Amendment 191 and the accompanying Rockingham Strategic Centre Structure Plan.

The Water Corporation has no objections to the various rezonings and associated text provisions pertaining to planning and development control within the Rockingham Centre.
The water and wastewater planning summary at Section 4.2 of the Cardno Precinct Structure Plan report was provided by the Water Corporation. Long term infrastructure planning for the centre will need to be reviewed to reflect the land uses and development yields envisaged in the structure plan.

The commentary under Sections 4.4 through 4.7 regarding stormwater management and detention measures and recommended options to be explored further for on-site detention need further clarification. A Local Water Management Strategy should be prepared for the area and referred to DWER and the Water Corporation for assessment.

As previously advised, the Corporation's urban drainage network through Rockingham has finite hydraulic and environmental limits, and the system is not able to accept increased rates of flow. The advice (section 4.4.1) regarding retention of runoff to predevelopment levels and the downstream environmental controls/limits imposed by the need to protect levels in Lake Richmond are critical matters that need to be more fully addressed and detailed in the LWMS.
If you have any queries or require further clarification on any of the above issues, please contact me on Tel. 9420-3165.</td>
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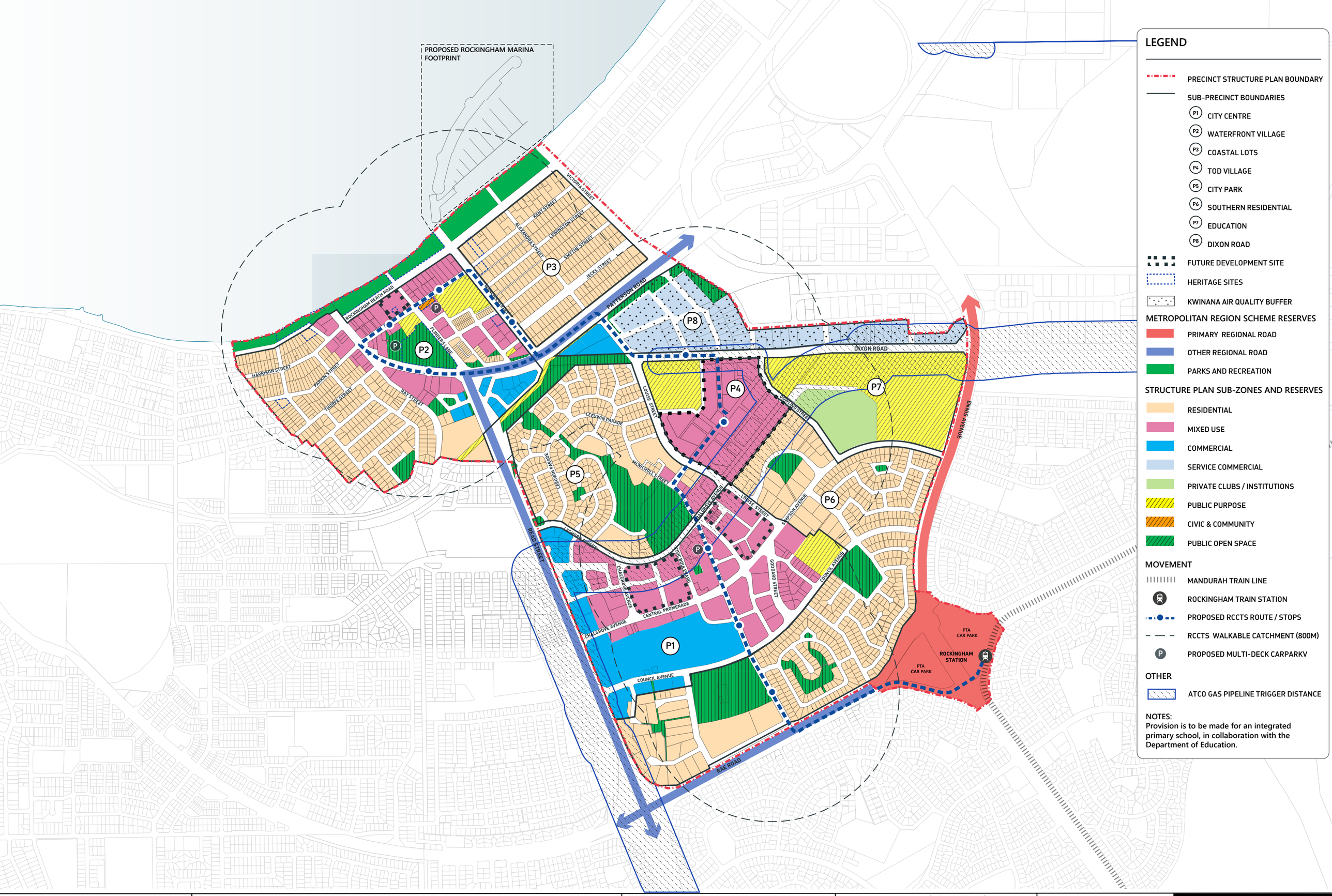
</table>

Appendix C Rockingham City Precinct Structure Plan (Hames Sharley, 2025)



LEGEND

- PRECINCT STRUCTURE PLAN BOUNDARY
- SUB-PRECINCT BOUNDARIES
  - P1 CITY CENTRE
  - P2 WATERFRONT VILLAGE
  - P3 COASTAL LOTS
  - P4 TOD VILLAGE
  - P5 CITY PARK
  - P6 SOUTHERN RESIDENTIAL
  - P7 EDUCATION
  - P8 DIXON ROAD
- FUTURE DEVELOPMENT SITE
- HERITAGE SITES
- KWINANA AIR QUALITY BUFFER

METROPOLITAN REGION SCHEME RESERVES

- PRIMARY REGIONAL ROAD
- OTHER REGIONAL ROAD
- PARKS AND RECREATION

STRUCTURE PLAN SUB-ZONES AND RESERVES

- RESIDENTIAL
- MIXED USE
- COMMERCIAL
- SERVICE COMMERCIAL
- PRIVATE CLUBS / INSTITUTIONS
- PUBLIC PURPOSE
- CIVIC & COMMUNITY
- PUBLIC OPEN SPACE

MOVEMENT

- MANDURAH TRAIN LINE
- ROCKINGHAM TRAIN STATION
- PROPOSED RCCTS ROUTE / STOPS
- RCCTS WALKABLE CATCHMENT (800M)
- PROPOSED MULTI-DECK CARPARKV

OTHER

- ATCO GAS PIPELINE TRIGGER DISTANCE

NOTES:
Provision is to be made for an integrated primary school, in collaboration with the Department of Education.

Structure Plan Map

Rockingham Strategic Centre Precinct Structure Plan

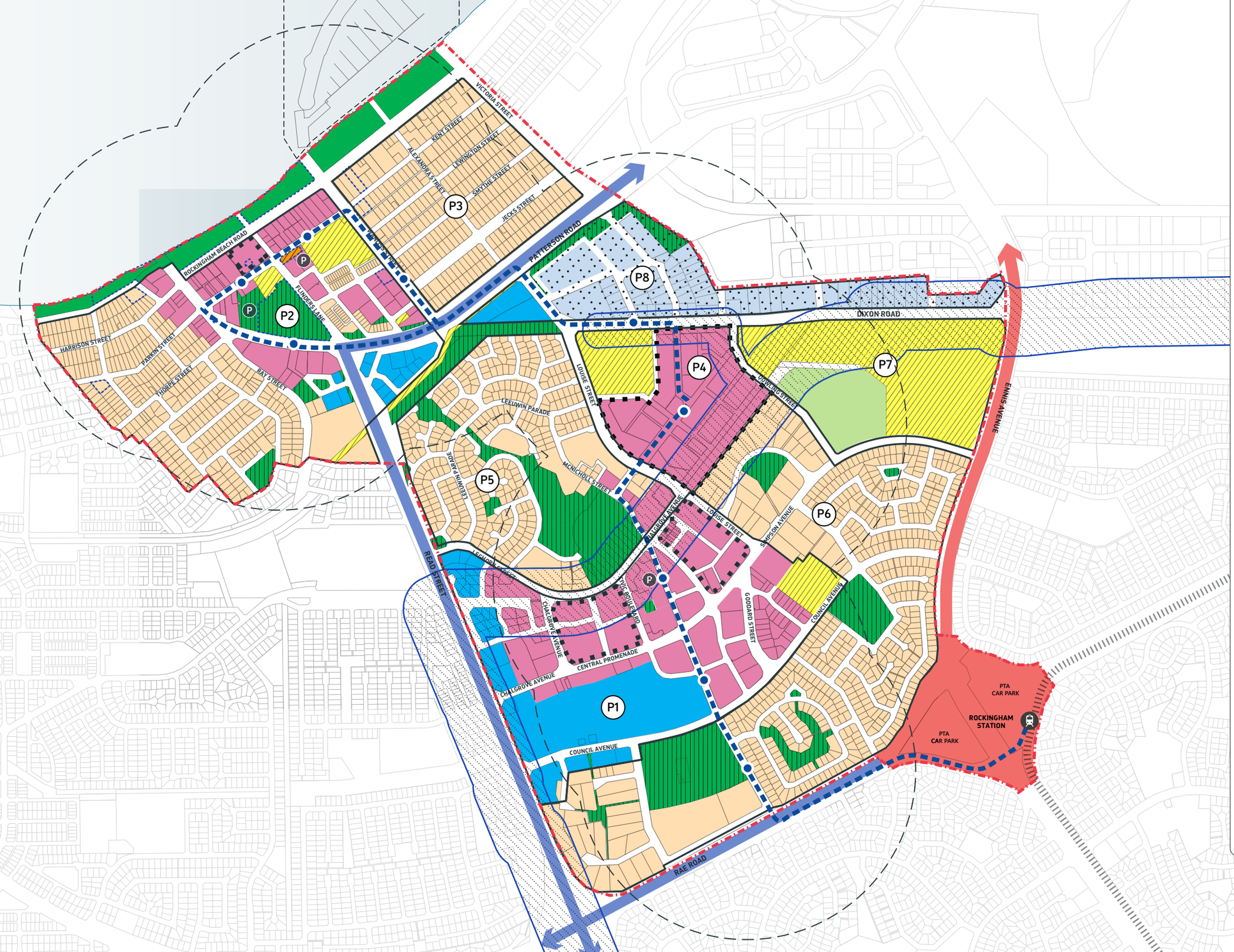
Status : Draft for Public Advertising

Scale: 1:15,000 @ A3

0 300 600

North:

Project Number: 44322
Revision: E
Date: 28/03/25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P8
VICTORIA STREET
KENT STREET
ALEXANDRA STREET
LEWINGTON STREET
SMYTHE STREET
JECKS STREET
ROCKINGHAM BEACH ROAD
FLINDERS LANE
PATTERSON ROAD
HARRISON STREET
PARKIN STREET
THORPE STREET
RAY STREET
LEEUWIN PARADE
LEEUWIN PARADE
LOUISE STREET
MCNICHOLL STREET
DIXON ROAD
LAWRENCE STREET
ENNIS AVENUE
BALGROVE AVENUE
LOUISE STREET
SIMPSON AVENUE
READ STREET
CHALGROVE AVENUE
CHALGROVE AVENUE
CENTRAL PROMENADE
CENTRAL BOULEVARD
GODDARD STREET
COUNCIL AVENUE
CHALGROVE AVENUE
COUNCIL AVENUE
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Department of Educati

Appendix D Department of Water Environment Regulations Commentary (DWER, 2025)

Government of Western Australia
Department of Water and Environmental Regulation

Your ref: Project 300204265
Our ref: REQ-0001308
Enquiries: Jane Sturgess, Ph 9550 4228

City of Rockingham
PO Box 2142
Rockingham WA 6967

Attention: Tristan Fernandes

Dear Tristan

ROCKINGHAM CITY CENTRE PRECINCT STRUCTURE PLAN LOCAL WATER MANGEMENT PLAN ADDENDUM

Thank you for providing the opportunity to comment on the draft Rockingham City Centre Precinct Structure Plan Local Water Management Plan Addendum (LWMP Addendum) received 27 August 2025.

The Department of Water and Environmental Regulation (Department) has reviewed the LWMP Addendum and attachment 1 contains the Department's comments for your consideration.

Should you require any further information on the comments, please contact the undersigned at the Mandurah office on 9550 4228.

Yours sincerely

Jane Sturgess
A/Program Manager – Planning Advice
Kwinana Peel Region

03 / 10 / 2025

Kwinana Peel Region
107 Breakwater Parade Mandurah Ocean Marina Mandurah Western Australia 6210
PO Box 332 Mandurah Western Australia 6210
Telephone: 08 9550 4222 Facsimile: 08 9581 4560
www.dwer.wa.gov.au

Attachment 1 - Department of Water and Environmental Regulation comments on the draft Rockingham City Centre Precinct Structure Plan Local Water Management Plan Addendum (Stantec, August 2025)

Contact for further information: Jane Sturgess

Page/Section	Topic	Comments
Pg 2 Table 2-1	WMS Section 1.2 Location	This section states that additional POS at the beach and roadside has been included and represented in Figure 2-1. However, this figure does not illustrate the additional POS.
Pg 2 Table 2-1	WMS Section 2 Proposed Development	This amendment states that previous POS land use areas have been changed to Service Commercial, Mixed Use and Public Purpose". Does this impact on drainage infiltration locations? If so, please provide a figure that illustrates and annotates where changes to infiltration areas have occurred and new or expanded infiltration areas.
Pg 11 Section 4.1 Surface Water Management	Criteria SW4	It is recognised that additional infiltration will be provided in POS areas to ensure post-development flows do not exceed pre-development flows into drains that discharge into Lake Richmond. However, designs are to ensure that pot-development flows are not reduced into Lake Richmond to ensure its water levels are maintained.
Pg 16 Table 5-1	Groundwater	Criteria – subsoils are to discharge into biofiltration areas for water quality improvement prior to infiltration.
General comments	It is disjointed moving between the Addendum and the LWMS. It would read better if an amended LWMS was presented in its entirety.	

Stantec Action

Page/Section	Topic	Comments	Action
Pg 2 Table 2-1	WMS Section 1.2 Location	This section states that additional POS at the beach and roadside has been included and represented in Figure 2-1. However, this figure does not illustrate the additional POS.	No action required. Stantec has clarified that this refers to the updated PSP boundary and associated drainage implications resulting from the update.
Pg 2 Table 2-1	WMS Section 2 Proposed Development	This amendment states that previous POS land use areas have been changed to Service Commercial, Mixed Use and Public Purpose". Does this impact on drainage infiltration locations? If so, please provide a figure that illustrates and annotates where changes to infiltration areas have occurred and new or expanded infiltration areas.	**Action:** Stantec to update the report to confirm that the drainage strategy has been developed based on the revised land uses. The report identifies that there is no increase in post-development flows. Stantec up to update text to the City of Rockingham has committed to undertaking a 2D drainage study to investigate drainage capacity at the next stage of assessment.
Pg 11 Section 4.1 Surface Water Management	Criteria SW4	It is recognised that additional infiltration will be provided in POS areas to ensure post development flows do not exceed pre-development flows into drains that discharge into Lake Richmond. However, designs are to ensure that pot-development flows are not reduced into Lake Richmond to ensure its water levels are maintained.	**Action:** Stantec to include in the modelling statement that *"In the 1% AEP event, there is no significant decrease in post-development flows. In more frequent events, a minor reduction occurs; however, the water balance indicates increased groundwater recharge. This may contribute to Lake Richmond, though the proportion and effects are outside the current scope.*
Pg 16 Table 5-1	Groundwater	Criteria – subsoils are to discharge into biofiltration areas for water quality improvement prior to infiltration.	**Action:** Stantec to include in the report that *"The City of Rockingham will include incorporating water quality improvements as part of the detailed design for stormwater management within POS areas."*

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