ALKIMOS COASTAL NODE
LOCAL STRUCTURE PLAN

Appendix 10
Local Water Management Strategy

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Integrated Science & Design

LOCAL WATER MANAGEMENT STRATEGY

ALKIMOS COASTAL NODE LSP

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Executive Summary

LandCorp (the proponent) proposes to develop Lot 9001 and part lots 9010, 9012 and 9501 Marmion Avenue for a mixture of residential housing and commercial units. The Alkimos Coastal Node Local Structure Plan (LSP) area, referred to herein as the 'site', is located approximately 40 km north of Perth Central Business District, within the City of Wanneroo (CoW). It is located approximately 17 km north of the Joondalup Strategic Metropolitan Centre and approximately 8 km south of the Yanchep Strategic Metropolitan Centre. The site is located with Marmion Avenue to the east and the Indian Ocean to the west.

The Local Water Management Strategy (LWMS) for the Alkimos Coastal Node has been developed in accordance with *Better Urban Water Management* (WAPC 2008a), *State Planning Policy 2.9 Water Resources* (WAPC 2006) and *Planning Bulletin 92 Urban Water Management* (WAPC 2008b). Water will be managed using an integrated water cycle management approach, which has been developed using the philosophies and design approaches described in the *Stormwater Management Manual for Western Australia* (DoW 2007).

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Characteristics of both the existing and past environment within the site have been investigated. In summary, the environmental investigations conducted to date indicate that:

- The site receives 650 mm of average annual rainfall with the majority of rainfall received in June and July.
- The site is highly undulating and ranges from 4 m AHD to 43 m AHD in elevation.
- The soil types are consistent with the Quindalup dunal system comprising of sand and limestone.
- ASS risk maps classify the entire site as having no known risk of encountering ASS within 3 m of the surface.
- Vegetation across the site is thick coastal bush with occasional larger trees ranging in condition from Completely Degraded" to "Very Good–Good.
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are no wetlands within the site.
- Surface water is largely retained within the site due to the high permeability of the underlying sands.
- Surface water quality monitoring has not been possible due to there being no defined surface water bodies within the site.
- The site is partially located within a Priority 3 PDWSA.
- Groundwater underlying the site flows towards the Indian Ocean to the west.
- Given the groundwater elevations and the minimum site elevations the minimum clearance to groundwater will be 3 m, however for the majority of the site it will be >10 m.
- Groundwater quality is relatively consistent across the site.

The historical uses of the land are for stock grazing, and it is currently used by unauthorized recreational vehicles. The Alkimos Coastal Node LSP consists of approximately 89 hectares and will incorporate medium and high density residential housing, commercial and business areas.

The overall objective for integrated water cycle management for residential developments is to minimise pollution and maintain an appropriate water balance. The Alkimos Coastal Node LWMS

design objectives seek to deliver best practice outcomes using a Water Sensitive Urban Design (WSUD) approach, including detailed management approaches for:

- Potable water consumption
- Flood mitigation
- Stormwater quality management
- Groundwater management.

The criteria proposed within this LWMS are based on the characteristics of the existing environment and a contemporary best-practice approach to integrated water cycle management.

The overall approach to water conservation is to reduce the amount of scheme water required within the development at both a lot and at an estate scale. Water conservation measures proposed include fit-for-purpose water sources, including groundwater for POS and road verge irrigation, scheme water for potable uses within lots and harvested rainwater for irrigation of private lot gardens and to supplement potable water use within dwellings. Within the lot, scheme water use will be reduced by rainwater tanks, water efficient fittings and appliances, and waterwise gardens/landscaping. On an estate scale water will be reduced by use of waterwise landscaping practices including use of native vegetation. Irrigation requirements within POS areas are consistent with the provisions within the Department of Water (DoW) *North West Growth Corridor (NWGC) licensing schedule and guidelines* (DoW 2013).

Stormwater management focusses on stormwater runoff quantity and quality. The principle behind the stormwater management strategy for the Alkimos Coastal Node LSP area is to maintain the existing hydrology by retaining surface flows and to infiltrate the stormwater runoff as close to source as possible. The Alkimos Coastal Node LSP will retain all runoff up to the 100 year ARI event within the site. The 1 year 1 hour ARI event will be retained as close to source as possible using a combination of soakwells and bio-retention areas within POS. Runoff from events greater than the 1 year 1 hour ARI event will be conveyed downstream via surface flow and the road network to flood storage areas within POS where it will infiltrate to groundwater. Stormwater quality will be addressed using a treatment train approach, utilising the storage provisions discussed above.

Depth to groundwater across the site is significant and groundwater level management measures are therefore somewhat passive and the focus of groundwater management is on water quality. Groundwater quality will be managed by managing nutrient inputs within surface runoff, and will aim to ensure that groundwater leaving the site is ideally better than existing conditions. Measures to address groundwater quality are consistent with those proposed for stormwater quality.

The proposed criteria and the manner in which they are proposed to be achieved are presented in **Table E1**. This table provides a readily auditable summary of the required outcomes which can be used in the future detailed design stage to demonstrate that the agreed objectives for water management at the site have actually been achieved.

Table E 1Water management criteria and compliance summary

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
Water Conservation	WC1	Use fit for purpose water sources	Groundwater to be used for irrigation of POS in accordance with the DoW NWGC licensing schedule	Proponent	Landscape implementation
			Rainwater harvesting promoted within lots for irrigation of private gardens	Lot owner	Post-house construction
			Scheme water used within lots	Lot owner	Post-house construction
	WC2	Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water	Provision of advice to residents regarding water conservation measures	Proponent	Point of sale
			Use of rainwater tanks within lots of suitable built form	Lot owner	Post-house construction
			Promotion/use of waterwise gardening principles	Lot owner	Post-house construction
			Promotion/use of water efficient appliances	Proponent	Point of sale
			Mandated use of water efficient fittings	Lot owner	Post-house construction
	WC3	Minimise use of water at an estate scale	Promotion/use of waterwise gardening principles within lot and POS areas	Proponent	Subdivision design
			Promotion/use of water efficient appliances	Proponent	Point of sale
			Mandated use of water efficient fittings	Proponent/City of Wanneroo	Building approval
Groundwater	GW1	Maintain or improve groundwater quality onsite	Bio-retention areas to treat surface water runoff prior to infiltration to groundwater	Proponent	During detailed drainage design
			Bio-retention areas to be underlain by soils with PRI>10	Proponent	Landscape implementation

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
	GW2	Treat stormwater runoff before infiltrating to groundwater	Bio-retention areas to treat surface water runoff prior to infiltration to groundwater	Proponent	During detailed drainage design
			Bio-retention areas to be underlain by soils with PRI>10	Proponent	Landscape implementation
	GW3	Use water sensitive design approaches to recharge the superficial aquifer	Soakwells within standard residential lots sized to infiltrate up to the 1 year 1 hour ARI event	Proponent/Lot owner	Construction
			Soakwells within high density lots sized to infiltrate up to 50% of the 1 year 1 hour ARI event	Proponent/Lot owner	Construction
			Flood storage areas sized to retain and infiltrate flows up to the 100 year ARI event	Proponent	During detailed drainage design
			Bio-retention areas and verge swales sized to retain and infiltrate the 1 year 1 hour ARI event from road reserves and excess runoff from high density residential lots	Proponent	During detailed drainage design
Stormwater quantity	SW1	Accommodate all runoff from all events up to the 100 year ARI event onsite	Residential lots to retain 1 year 1 hour ARI event in soakwells and garden areas	Lot owner	Construction
			High density lots to retain 50% of 1 year 1 hour ARI event within soakwells and garden areas	Lot owner/developer	Construction
			Commercial lots to retain 100 year ARI events onsite	Lot owner/developer	Construction
			Road runoff and excess runoff from lots will be retained within bio-retention areas and flood storage areas within POS	Proponent	During detailed drainage design
	SW2	Finished floor levels of lots shall have a minimum 500 mm clearance to the 100 year ARI top water level	Lots adjacent to flood storage areas will be at least 500 mm above the top water level of the 100 year ARI event.	Proponent	During detailed drainage design
	SW3	Provide stormwater flow pathways for runoff from the 100 year ARI event	The road network will be graded towards POS areas, providing a flow path for 100 year ARI event runoff to reach flood storage areas	Proponent	During detailed drainage design

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
	SW4	Provide minimum 300 mm clearance from dynamic 100 year ARI event flood levels within road reserves	Lots will be at least 300 mm above road pavement	Proponent	During detailed civil design
	SW5	Minor roads are to be designed to remain passable in the 5 year ARI storm event	The pipe network will be designed to convey the 5 year ARI event which will ensure roads remain passable	Proponent	During detailed civil design
	SW6	Design infiltration areas to avoid creating mosquito habitat	The high infiltration rates of the underlying sands ensure that the maximum inundation time within the flood storage areas will be no more than 14.4 hours	Proponent	During detailed drainage design
Stormwater quality	SWQ1	Retain the 1 year 1 hour ARI rainfall event onsite as close to source as practicably possible	Residential lots to retain 1 year 1 hour ARI event in soakwells	Lot owner	Construction
			High density lots to retain 50% of 1 year 1 hour ARI event within soakwells and garden areas	Lot owner/developer	Construction
			Commercial lots to retain 100 year ARI events onsite	Lot owner/developer	Construction
			Bio-retention areas sized to retain 1 year 1 hour ARI event from roads and overflow from high density lots	Proponent	During detailed drainage design
	SWQ2	Size bio-retention areas to (at least) 2% of the connected impervious area	The bio-retention areas are sized to be 2.3% of the connected impervious area	Proponent	During detailed drainage design
	SWQ3	Apply appropriate structural and non-structural measures to reduce nutrient loads	Use of soakwells within residential lots	Lot owner/ developer	Construction
			Use of bio-retention areas	Proponent	During detailed drainage design
			Minimise use of fertilisers within POS and road verges	Proponent	Landscape implementation
			Maintenance of POS and drainage areas	Landscape contractor	Landscape implementation

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
			Education of residents	Proponent	Point of sale

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1 Introduction

1.1 Background

The Alkimos Coastal Node Local Structure Plan (LSP) area, referred to herein as the 'site', is located approximately 40 km north of Perth Central Business District, within the City of Wanneroo (CoW). It is located approximately 17 km north of the Joondalup Strategic Metropolitan Centre and approximately 8 km south of the Yanchep Strategic Metropolitan Centre. The site is located with Marmion Avenue to the east and the Indian Ocean to the west. LandCorp and Water Corporation (the 'proponent') proposes to develop the site for a mixture of residential housing and commercial units.

The site consists of Lot 9001 and part lots 9010, 9012 and 9501(owned by the Water Corporation – Western Australian Development Corporation (LandCorp) and Peet Alkimos Pty Ltd) Marmion Avenue, which currently consists of remnant vegetation across the sand dune system. The location of the site is shown in **Figure 1**. An aerial photograph illustrating the current condition and cadastral boundaries of the site is provided in **Figure 2**.

It is important that the manner in which stormwater runoff from urban zoned areas is to be managed to avoid flooding and protect the environment are clearly documented early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at subdivision and development stages. This Local Water Management Strategy (LWMS) details the water management approach to support the Alkimos Coastal Node LSP.

1.2 Local context

The site directly abuts foreshore reserve and the Indian Ocean to the west. Immediately to the north the land is designated as Regional Open Space pursuant to the Metropolitan Region Scheme and as reflected on the Alkimos Eglinton District Structure Plan (AEDSP). The land further to the north and south of the site is being developed for urban purposes in accordance with the AEDSP. The land to the east is reserved for Public Purposes (Water Authority of WA) as it contains the Alkimos Waste Water Treatment Plant and its associated buffer.

1.3 Town planning context

Alkimos Coastal Node is predominantly zoned 'Urban' under the Metropolitan Region Scheme (MRS) (WAPC 2010) with a small area in the east zoned 'Central City Area' and the foreshore as 'Parks and Recreation'.

The CoW District Planning Scheme No. 2 (DPS 2) (CoW 2012) zones the land as Urban Development with the foreshore area as Parks and Recreation (consistent with the MRS) and a portion at the north of the site being reserved for Public Purposes (Water Authority of WA).

1.4 District structure planning

The Alkimos Coastal Node LSP site is located within the south-west part of the AEDSP area. The Agreed AEDSP was approved by the City of Wanneroo and endorsed by the Western Australian Panning Commission (WAPC) in 2010. The Agreed AEDSP nominates a mix of 'Urban' and 'Coastal Village Activity Centre' uses over the site and reflects the 'Regional Open Space' and 'Public Purpose'

reserves in accordance with the MRS. The AEDSP also identifies a 'Secondary Public Transport System' traversing the centre of the site in a north-south direction.

1.5 Policy framework

There are a number of State Government policies of relevance to the site. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Water Plan* (Government of WA 2007)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Liveable Neighbourhoods Edition 4* (WAPC 2007)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)
- *Bush Forever* (Government of WA 2000).

- *Gnangara Sustainability Strategy* (Government of WA 2009).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urban developments should aim to achieve. These are key inputs that relate either directly or indirectly to the site and include:

- *Better Urban Water Management* (WAPC 2008)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Australian Rainfall and Runoff* (Engineers Australia 1987)
- *Decision Process for Stormwater Management in Western Australia* (DoW 2009a)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *National Water Quality Management Strategy* (ANZECC 2000).
- *North West Growth Corridor (NWGC) licensing schedule and guidelines* (DoW 2013)
- *Wanneroo Development Design Specification WD5 – Stormwater Drainage Design* (CoW 2015)
- *Local Planning Policy 4.4: Urban Water Management* (CoWa 2012).

The *Decision Process for Stormwater Management in WA* (DoW 2009a) document provides a decision framework for the planning and design of stormwater management systems. The document provides guidance as to how developments can achieve compliance with the objectives, principles and delivery approach outlined in the Stormwater *Management Manual for WA* (DoW 2007).

The guidance documents listed indicate a need for accurate water quality baseline data prior to urban development. This will ensure that any future development is able to fulfil the stormwater management requirements of DoW and engineering standards specified by the CoW, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.6 Previous studies

1.6.1 Alkimos Eglinton District Structure Plan

The Alkimos-Eglinton District Structure Plan (DSP) was prepared by the CoW in 2007 (CoW 2007). A District Water Management Strategy (DWMS) was not prepared as part of the DSP, however a Sustainability Strategy including an Integrated Water Cycle Management Strategy (IWCMS) was produced by GHD and appended to the DSP (GHD Australia 2006).

1.6.2 Alkimos Eglinton District Water Management Strategy

A Draft DWMS was prepared for Alkimos-Eglinton (GHD Australia 2011b). Objectives for the District (outlined in the *State Water Plan* (Government of WA 2007)) that were intended to be addressed in the DWMS included:

1.6.2.1 Water conservation

- Efficient use of water inside buildings and for irrigation.
- Restricted supply of potable (scheme) water for drinking and associated uses only.
- Supply of a separate fit-for-purpose water service for non-drinking water uses.

1.6.2.2 Groundwater management

- Groundwater quality is to be maintained, or improved post-development.

- Groundwater quality will be maximised through the use of the stormwater management measures described below.

1.6.2.3 Stormwater

- All lots will be required to retain stormwater on-site and infiltrate through the use of soakwells. Rainwater tanks (where used) will also be effective to attenuate runoff generated from roofs.
- All stormwater runoff will be retained for infiltration within the district structure plan area with a specific focus on infiltrating runoff from 1 year ARI events as close to source as possible.
- Stormwater runoff that is unable to be infiltrated at source will be conveyed via various methods (such as surface flow or a more traditional piped network) to landscaped infiltration areas located in parks.
- Major storm events (i.e. larger than the 5 year ARI event, up to the 100 year ARI event) will be managed via overland flow within the designated road reserves discharging to the dedicated infiltration areas.
- The landscaped infiltration areas will be designed to accommodate the estimated flows from the 100 year ARI event. Design will ensure that standing water will not persist in the basins for longer than 96 hours to reduce the risk of mosquito breeding.
- A minimum freeboard of 0.3 m is to be provided between the 100 year ARI water level and building floor levels
- Adopt a treatment train approach to runoff through the use of water sensitive urban design best management practices such as permeable pavements, buffer strips, bio-retention swales, rain gardens, bio-filtration pockets, median swales, gross pollutant traps and infiltration basins.
- A monitoring program implemented during construction and post-development to ensure that the management measures for stormwater quality are meeting the design objectives.

1.7 LWMS objectives

This LWMS has been developed in consideration of the objectives and principles detailed in the *Draft Alkimos-Eglinton DWMS* (GHD Australia 2011b) and *Better Urban Water Management* (WAPC 2008) however those proposed in the above documents have been refined to be site-specific and consistent with the contemporary expectations of CoW. It is intended to support the Alkimos Coastal Node LSP, and is further based on the following major objectives:

- Provide a broad level stormwater management framework to support future urban development.
- Incorporate appropriate best management practices (BMPs) into the drainage systems that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and CoW.
- Develop a water conservation strategy for the site that will accommodate existing groundwater allocation constraints for the area.
- Gain support from the DoW and CoW for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

Detailed objectives for water management within the site are further discussed in **Section 4**.

2 Proposed development

The Alkimos Coastal Node LSP covers an area of approximately 86.5 hectares in the south western area of the Alkimos-Eglinton DSP area. The proposed LSP includes the following land uses:

- Regional open space (ROS) (20.17 ha)
- Conservation open space (3.81 ha)
- Public open space (POS) (4.24 ha)
- Mixed use (6.87 ha)
- Commercial development (3.17 ha)
- Residential development
  - R25 – R40: 473 lots
  - R25 – R80: 45 dwellings
  - R-AC1: 1516 dwellings
- Drainage areas (2.59ha)

The overall approach to water management will be to mimic the existing hydrological environment, where runoff is infiltrated at or close to source in self-contained catchments. The infiltration will be achieved within open spaces where drainage functions are integrated into other open space requirements to maximise the useability of these areas.

The Alkimos Coastal Node LSP is included in **Appendix A**.

3 Pre-development environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context for the site:

- *National Water Quality Management Strategy* (ANZECC 2000)
- *Regional 1:50 000 Geology Map Sheet* (Gozzard 1982)
- *WA Atlas* (Landgate 2012)
- *Water Register* (DoW 2012b)
- *Perth Groundwater Atlas* (DoW 2012a)
- *Weather and Climate Statistics Data* (Bureau of Meteorology 2012).

The above information has been reviewed to determine infiltration potential within the site and existing groundwater levels. This is important, as both can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Climate

The site experiences a dry Mediterranean climate of hot dry summers and cool wet winters. Long term climatic averages indicate that the site is located in an area of moderate rainfall, receiving 650 mm on average annually (Bureau of Meteorology 2012) with the majority of rainfall received in June and July. The region experiences rainfall for 76 days annually (on average).

3.3 Geotechnical conditions

3.3.1 Topography

The topography of the site is highly variable due to the dunal nature of the landform. Levels range from 43 m Australian Height Datum (AHD) at the dune peaks to 4 m AHD in interdunal depressions. Levels along the eastern site boundary are generally lower as it joins the foreshore reserve.

Topographic contours across the site are shown in **Figure 3**.

3.3.2 Soils and geology

The site is situated within the coastal belt of the Swan Coastal Plain, within the Quindalup Dunes geomorphological unit. The complex dunal system consists of an undulating landscape varying from low hills to moderate relief dunes.

The underlying geology of the site is representative of the dunal landforms and the site is comprised of the geological units described below (Gozzard 1982):

- LS1: Limestone – light yellowish brown, fine to coarse grained, sub angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.
- LS3: Limestone – as LS1, generally with a thin (<0.5m) covering of S3 calcareous sand.
- S2: Calcareous Sand – white, fine to medium-grained, sub-rounded quartz and shell debris, of eolian origin.
- S3: Calcareous Sand – as S2, occurs as relatively thick covering over LS1.

- S7: Sand – pale and olive yellow, medium to coarse-grained, sub-angular quartz with a trace of feldspar, moderately sorted of residual origin.

The soil types on the site are highly permeable with the sands being the dominant influence at the surface. Preliminary site investigations carried out within the adjacent Alkimos South LSP, an area which has a soil profile consistent with the site and is immediately adjacent, included infiltration testing (Douglas Partners 2012b). Eight in-field infiltration tests were carried out using the falling head method with infiltration rates estimated using Hvorslev's method. Permeability rates of between 1.9 and 7.8 x 10^{-4} m/s were measured, resulting in a calculated average infiltration rate of 25 m/day (Douglas Partners 2012b). An infiltration rate of 2 m/day has been assumed within the hydraulic modelling (discussed in **Section 7.3**).

Geological mapping is shown in **Figure 4**.

3.3.3 Acid Sulfate Soils

There is no known risk of acid sulfate soils (ASS) occurring within three metres of the natural surface (DEC 2012).

3.4 Flora

There are significant areas of the site that predominantly support weeds as the result of the historical grazing land use. This is most prevalent in the relatively level inter-dunal basins. The majority of better quality vegetation on the site is located on the dune ridges that were not grazed as intensively (RPS 2014). According to ATA Environmental (2005), the condition of the vegetation that remains on the site varies from "Completely Degraded" to "Very Good–Good". There is a Bush Forever site (#397) located along the foreshore reserve and into the north-western corner of the site.

3.5 Wetlands

A review of the *Geomorphic Wetlands on the Swan Coastal Plain dataset* (DEC 1992) indicates that there are no geomorphic wetlands on site.

A small wetland, known as Karli Spring is the only surface water feature in the vicinity of the site, located approximately 1 km to the south of the Alkimos Coastal Node LSP in an inter-dunal depression within the foreshore reserve. This wetland will not be impacted by the proposed LSP (RPS 2014).

3.6 Groundwater

3.6.1 Public Drinking Water Source Areas

The site is partially located within a Priority 3 Public Drinking Water Source Area (PDWSA) (DoW 2009b), as shown in **Figure 5**, and as such is subject to restricted land uses (WC 2007; DoW 2010). There are no Well Head Protection Zones (WHPZ) located within the site.

Priority 3 (P3) classification areas are defined to '*manage the risk of pollution'* to the water source from catchment activities. Protection of P3 areas is achieved through guided or regulated environmental risk management for land use activities. Land uses considered to have significant pollution potential

are opposed or constrained (DoE 2004). All of the land uses proposed under the Alkimos Coastal Node development are classified as 'Acceptable' within P3 areas (DoE 2004).

3.6.2 Groundwater levels

Information on groundwater from the DoWs 'Online Water Register' indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan unconfined aquifer
- Perth – Leederville confined aquifer
- Perth – Yarragadee confined aquifer.

Groundwater data from the *Perth Groundwater Atlas* (DoW 2012a) show that groundwater levels across the site are less than 1 m AHD with groundwater flowing in a westerly direction. Depth to groundwater is highly variable due to the undulating topography of the site.

Groundwater monitoring has been carried out across the greater Alkimos-Eglinton DSP area (which incorporates the site) with six rounds of monitoring between July 2010 and November 2011 including groundwater levels, in situ field chemistry measurements and laboratory analysis for nutrient, metal and salt concentrations (GHD Australia 2011a).

Within the groundwater monitoring report (GHD Australia 2011a) the site is referred to as *Area 1 – South Alkimos (Lot 101).* Four working monitoring bores located within or directly adjacent to the site provided groundwater conditions for the site. Depth to groundwater across the site ranges from 11.2 m Below Top of Casing (BTOC) (WIN5742, May 2011) to 28.4 m BTOC (ALCEN4, November 2010). Depth to groundwater is largely representative of the topography, with groundwater elevation reducing with proximity to the coast. Groundwater elevation was observed to vary between approximately 0.29 m AHD and 1.04 m AHD (GHD Australia 2011a). Given the groundwater elevations and the minimum site elevations the minimum clearance to groundwater will be 3 m, however for the majority of the site it will be >10 m.

Groundwater levels and sampling locations are shown in **Figure 6**.

3.6.3 Groundwater quality

Water quality monitoring carried out across the entire DWMS area included sampling of physio-chemical parameters in-situ and laboratory analysis of nutrients, metals and salts.

The measured groundwater quality is summarised in **Table 1** and details the parameters significant to, and managed within, this LWMS (i.e. physio-chemical parameters and nutrient concentrations).

Table 1 Groundwater quality results

Bore ID	pH	EC (mS/cm)	TDS (mg/L)	TN (mg/L)	TP (mg/L)	NO_3 (mg/L)
LSPA1	7.1 (0.1)	0.7 (0.0)	414.5 (17.1)	0.02 (0.01)	3475 (330)	14.3 (1.9)
LSPA3	7.4 (0.2)	1.4 (0.7)	883.5 (413.6)	0.02 (0.01)	3350 (208)	13.8 (1.0)
ALCEN4	7.3 (0.2)	756.7 (28.9)	450 (17.3)	0.02 (0.01)	3675 (340)	15.5 (1.0)

Bore ID	pH	EC (mS/cm)	TDS (mg/L)	TN (mg/L)	TP (mg/L)	NO_3 (mg/L)
WIN5742	7.4 (0.1)	13.4 (14.9)	3020 (only reading)	0.06 (0.01)	2450 (1626)	9.7 (7.5)

Average (StDev) - taken from (GHD Australia 2011a)

The full dataset (GHD Australia 2011a) shows that since July 2010 concentrations of nutrients remained relatively stable across the site except for a decrease in Total Nitrogen (TN) and Nitrate (NO_3) and increase in Total Phosphorous (TP) within ALCEN2 over the monitoring period. Nitrogen concentrations also dropped within ALCEN3 between July and November 2011.

3.7 Surface water

3.7.1 Surface water quantity

The hydrological characteristics of the site are dominated by the high infiltration capacity of the soils onsite. This leads to little to no surface runoff except during extreme events. When combined with the steep slopes onsite and the localised low points, the result is that there will be no runoff leaving the site. The pre-development catchments are shown in **Figure 7.**

3.7.2 Modelling approach

The stormwater management strategy aims to maintain the existing runoff regime of the site. In this instance, the site is effectively self-contained and modelling of pre-development runoff will not provide significant guidance to the spatial requirements for the post-development environment. There are some minor catchments that could potentially discharge from the site, however all runoff from these areas will be retained onsite. The spatial requirements for stormwater detention are discussed in **Section 7**.

3.7.3 Surface water quality

There is no information regarding surface water quality available within the site due to surface water runoff only occurring during extreme events, and on this basis water quality analysis has not been carried out.

3.8 Current and historical land uses

There are no known historical uses of the land however it is currently used by recreational vehicles and has areas that have been used for illegal rubbish dumping and localised clearing.

3.9 Summary of existing environment

In summary, the environmental investigations conducted to date indicate that:

- The site receives 650 mm of average annual rainfall with the majority of rainfall received in June and July.
- The site is highly undulating and ranges from 4 m AHD to 43 m AHD in elevation.
- The soil types are consistent with the Quindalup dunal system comprising of sand and limestone.

- ASS risk maps classify the entire site as having no known risk of encountering ASS within 3 m of the surface.
- Vegetation across the site is thick coastal bush with occasional larger trees ranging in condition from Completely Degraded" to "Very Good–Good.
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are no wetlands within the site.
- Surface water is largely retained within the site due to the high permeability of the underlying sands.
- Surface water quality monitoring has not been possible due to there being no defined surface water bodies within the site.
- The site is partially located within a Priority 3 PDWSA.
- Groundwater underlying the site flows towards the Indian Ocean to the west.
- Given the groundwater elevations and the minimum site elevations the minimum clearance to groundwater will be 3 m, however for the majority of the site it will be >10 m.
- Groundwater quality is relatively consistent across the site.
- The historical uses of the land are for stock grazing, and it is currently used by unauthorized recreational vehicles.

4 Design criteria and objectives

This section outlines the objectives and design criteria that this LWMS and future UWMPs must achieve.

4.1 Integrated water cycle management

The *State Water Strategy* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorse the promotion of integrated water cycle management and application of WSUD principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

The key principles of integrated water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater
- Integrating water and land use planning
- Allocating and using water sustainably and equitably
- Adopting a whole of catchment integration of natural resource use and management.

Integrated water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving environments. The existing environmental context of the site has been discussed in **Section 3** of this document. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site specific studies undertaken in and around the site development. These were detailed in **Sections 1.5** and **3.1**.

The overall objective for preparing integrated water cycle management plans for proposed residential developments is to minimise pollution and maintain an appropriate water balance. This objective is central to the water management approach for the Alkimos Coastal Node LSP.

4.2 Water conservation

This LWMS proposes the following water conservation criteria:

Criteria WC 1 Use fit for purpose water sources throughout the development.

Criteria WC 2 Minimise use of water at an estate scale.

Criteria WC3 Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water.

The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.3 Groundwater management

The principle behind the groundwater management strategy is to protect the underlying groundwater. This LWMS proposes the following groundwater management criteria:

Criteria GW1 Maintain or improve groundwater quality onsite.

Criteria GW2 Treat stormwater runoff before infiltration to groundwater.

Criteria GW3 Use water sensitive design approaches to recharge the superficial aquifer.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

4.4 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3.7**. This principle and the guidance documents discussed in **Section 1.5** and **1.6** have guided the stormwater management criteria.

4.4.1 Stormwater quantity

This LWMS proposes the following stormwater quantity design criteria:

Criteria SW1 Accommodate runoff from all events up to the 100 year ARI event onsite.

Criteria SW2 Finished floor levels of lots shall have a minimum 500 mm clearance to the 100 year ARI top water level in Flood Storage Areas (FSA).

Criteria SW3 Provide stormwater flow pathways for runoff from the 100 year ARI event.

Criteria SW4 Finished floor levels of lots should have a minimum 300 mm clearance from dynamic 100 year ARI event flood levels within road reserves.

Criteria SW5 Minor roads are to be designed to remain passable in the 5 year ARI storm event.

Criteria SW6 Design infiltration areas to avoid creating mosquito habitat.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

4.4.2 Stormwater quality

This LWMS proposes the following stormwater quality design criteria:

Criteria SWQ1 Retain the 1 year 1 hour ARI rainfall event onsite as close to source as practicably possible.

Criteria SWQ2 Size bio-retention areas to (at least) 2% of the connected impervious area.

Criteria SWQ3 Apply appropriate structural and non-structural measures to reduce nutrient loads.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

5 Water source allocation, infrastructure, fit-for-purpose and water use

5.1 Fit-for-purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that scheme water is not wasted. Fit-for-purpose principles have been utilised in the water conservation strategy for the Alkimos Coastal Node LSP, and will achieve **Criteria WC1**.

5.1.1 Scheme water

The Alkimos Coastal Node LSP is located within the Water Corporation's future Eglinton ground water source area for potable water supply. Water supply to the ACNLSP area will ultimately be via a series of groundwater bores, located throughout the Alkimos– Eglinton area, linked by collector water mains to a central treatment plant and reservoir. Areas of urban development will be serviced by a network of distribution water mains, from the reservoir, connected to reticulation systems within those areas.

The Alkimos Coastal Node LSP is near the boundary of the existing Neerabup treatment and reservoir scheme and the Carabooda reservoir service areas and at ultimate development may receive water from either source at different times in the demand cycle although most water will more likely be from Carabooda reservoir (Cossill & Webley 2014).

Supply to Alkimos Coastal Node LSP will be via extension of the reticulation network from Alkimos Beach (250 mm diameter pipe) linked north through to adjacent existing development with the same size main.

5.1.2 Groundwater

The DoW 'Online Water Register' indicates that the site is located in the Perth groundwater area, within the Eglinton sub-area (DoW 2012).

Groundwater can be used for irrigation of POS areas and some road verges instead of utilising scheme water.

Groundwater licences for irrigation of POS will be issued in accordance with the licensing schedule for the North West Growth Corridor (DoW 2013), on review of detailed irrigation calculations for each structure planning area that are to be carried out following the supporting schedule guidelines. **Section 5.4** details the irrigation requirements for the Central Alkimos LSP, as determined by applying the provisions of the Schedule to the POS areas and structure plan design for Central Alkimos. A detailed irrigation analysis according to the provisions of the schedule is provided in **Appendix B**.

Full details of the groundwater allocation gained will be provided within future UWMPs.

5.1.3 Waste water reuse

Within the Alkimos Eglinton DWMS (GHD Australia 2011b) provision of a non-drinking water (NDW) supply through a dual reticulation (third pipe) network was proposed. The NDW supply was proposed for irrigation uses in the initial stages of development (up to 2015) with the intention of expanding its use to non-potable in-house water uses in the future.

Alternative water sources to supply the NDW network included groundwater, stormwater harvesting and treated wastewater from the adjacent Alkimos Wastewater Treatment Plant.

The network requires the agreement and input of a number of stakeholders across the Alkimos Eglinton DSP area, including the local government and identification of a long term service provider.

As at April 2014, a recycled effluent scheme capable of supplying a third pipe system to dwellings and commercial premises had not been agreed

5.1.4 Rainwater

Rainwater will be harvested from roof surfaces for all residential and commercial lots. The uses for rainwater will vary depending on the LSP area and the land use, however all rainwater will contribute to supplementing scheme water requirements. Rainwater harvest from roof surfaces is further discussed in **Section 5.2**.

5.2 Water conservation measures

The development will utilise groundwater for POS irrigation, active POS irrigation management, rainwater tanks (RWT), waterwise garden (WWG) principles for lot scale gardens and within estate landscaping) and water efficient fixtures and appliances (WEFA) to ensure that the development minimises the use of water. These measures are further discussed in the following Sections.

5.2.1 Rainwater tanks

Harvest of runoff from roof surfaces can be undertaken, with this water stored within RWT for later use. This water is of high quality and can be used to substitute non-potable water requirements. Stored rainwater may be used for irrigation requirements however this will need to be supplemented with scheme water towards the end of the summer period. During the higher rainfall months, the majority of the stored rainwater can be used to supplement internal building, non-potable uses.

The use of rainwater tanks as described in the following sections will not be mandated within the LSP area. An uptake rate for RWT of 15% has been assumed within the lot scale water balance (discussed in **Section 5.3**) to account for potential implementation of RWT by lot owners post-construction.

The above measure will assist in achieving **Criteria WC2** and **WC3**.

5.2.2 Water efficient fixtures and appliances

Significant reduction in in-house water uses can be achieved with the use of WEFA. **Table 2** provides an example of the water uses of typical appliances versus water efficient appliances. These water use rates have been used in the water balance analysis.

Table 2 Water efficient fixtures and appliances

Appliance	Water Use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Wash	40 Litres/Wash
Dishwashers	50 Litres/Wash	25 Litres/Wash
Shower Head	15-25 Litres/Minute	6-7 Litres/Minute
Taps	15-18 Litres/Minute	5-6 Litres/Minute

(Australian Government 2009 & Melbourne Water 2008)

The Alkimos Coastal Node LSP water conservation strategies propose that all residential dwellings and commercial buildings use water efficient fixtures and that all residential dwellings use water efficient appliances. Water efficient fittings will be mandated through the building licence, while uptake of water efficient appliances can be encouraged by state and local government rebates, as well as education from the proponent at point of sale.

The above measures will assist in achieving **Criteria WC2** and **WC3**.

5.2.3 Water wise gardens

The use of WWG measures can significantly reduce the total water usage of the lot. The following water efficiency measures will be used on lot gardens:

- Improve soil with conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Design and install the irrigation system according to best water efficient practices.
  - Control systems must be able to irrigate different zones with different irrigation rates.
  - Emitters must disperse coarse droplets or be subterranean.
  - Utilise subsoil irrigation where appropriate.
- Minimise the amount of turfed areas.
- Select turf species of a genotype endorsed by the UWA Turf Industries Research Steering Committee (e.g. Kikuyu grass).
- Mulch garden beds to 75 mm with a product certified to Australian Standard AS4454.

Water conservation can also be reduced on a development scale within POS areas. As well as using the lot scale garden measures on POS gardens, the following additional measures will be utilised:

- Retain remnant native trees within POS areas where possible. This will provide shade, reduce water requirements during POS establishment and will assist in providing buffers for waterways.
- Adopt xeriscaped POS landscaping which utilises local native species from regions with similar climates that require less water inputs than exotic species.
- Manage irrigation practices within POS areas to minimise losses to evaporation.
- Minimise water requirements for POS maintenance. This will be achieved by implementing an appropriate management and maintenance program for POS areas – to be further detailed at the UWMP stage.

The Landscape Masterplan and a concept design showing how the WWG approaches will be integrated into POS and drainage areas is contained in **Appendix C**. The above measures and the landscape plans demonstrate that **Criteria WC2** and **WC3** will be achieved.

5.3 Lot water balance

A water balance analysis has been undertaken to demonstrate the effectiveness of the water conservation strategy proposed for lot-scale measures. Assumed up-take rates have been derived from data supplied by the Australian Bureau of Statistics (ABS 2004; ABS 2010a; ABS 2010b) and development specific criteria. Note that the water balance does not include assessment of estate scale irrigation of POS; this is detailed in **Section 5.4**.

The water balance analysis has been based on the rates and calculation methodology presented in the WC Spreadsheet AltWaterSupply_Water_Use_Model.xls. This spreadsheet has been adapted to model the effects of using the water conservation measures proposed. A number of key assumptions were made to carry out the lot scale water balance including:

- Residential lots will have the following uptake rates:
  - 15% for RWT
  - 100% fittings and 35% appliances for WEFA
  - 50% for WWG
- Lot sizes and densities across the Alkimos Coastal Node LSP area have been based on the LSP plans prepared by LandCorp.
- Average residency of 2.9 people per single lot dwelling and 1.8 people per unit in group housing. (calculated from data from ABS for new housing developments in Perth (ABS 2009)).

The lot scale water consumption for the water conservation approach at Alkimos Coastal Node will be 31 kL/year/person. This achieves the state water consumption target of no more than 100 kL/year/person and the *Better Urban Water Management* aspirational goal of 40-60 kL/year/person, and satisfies **Criteria WC2** and **WC3**.

5.4 Estate scale water use

5.4.1 Estate scheme water use

In addition to the residential lot water uses, the scheme water use for other land uses within Alkimos Coastal Node has been calculated, based on the following assumptions:

- 5,662 m^2 shopping centre (retail) @ 1.08 kL/m^2/year
- 3,680 m^2 office building (commercial) 0.8 kL/m^2/year
- 1,000 m^2 hospital with 5 beds (medical centre) @ 185.82 kL/bed/year
- 1,598 m^2 sporting facility (leisure) @ 14600 kL/year
- 3,359 m^2 hotel with 300 rooms (average 40m^2 room) @ 192.01 kL/room/year
- Commercial/business lots have assumed a consumption rate of between 0.8 and 1.08 kL/m^2/year.
- All commercial uses irrigate 5% of the lot area.

Based on the above assumptions, the non-residential lots will require 68.5ML per year.

5.4.2 Estate non-potable water use

The water use at an estate scale is determined by the amount of POS provided that requires irrigation, the amount of road verge that will require irrigation and the rates at which these are irrigated. Not all of the POS areas will be irrigated at the same rates as some areas consist of native vegetation (new and retained), while others will utilise turf to provide active recreation areas. Irrigation water for POS and road verges will be supplied by groundwater.

Table 3 details the irrigation requirements for the Alkimos Coastal Node LSP, as determined by applying the provisions of the Schedule to the POS areas and structure plan design for the Alkimos Coastal Node, discussed in **Section 5.1.2**. A detailed irrigation analysis according to the provisions of the schedule has been undertaken by Aecom (2015) and is provided in **Appendix B**.

Table 3 Alkimos Coastal Node Irrigation water use

	Total Area (ha)	Maximum Temporary Allowance rate (kL/year)	Long-term usage (kL/year)
POS & drainage areas	7.34	80,000	4,102
Road verges	4.0	27,000	0
Total		*107,000*	*4,102*

The irrigation requirements specified in **Table 3** are consistent with the allocation detailed in the Schedule for Alkimos Coastal Node LSP. The irrigation water requirements discussed in **Table 3** are proposed to be supplied by groundwater. Full details of the groundwater allocation gained will be provided within future UWMPs.

The above measures will assist in meeting **Criteria WC2**

5.5 Wastewater management

The Water Corporation has commissioned the first stage of the Alkimos Wastewater Treatment Plant WWTP and the associated Quinns Main Collector Sewer for collection of flows from the south. To the north, there is a planned 1350 mm diameter gravity main to collect flow from as far north as Yanchep and deliver it by gravity to the WWTP (Cossill & Webley 2014).

The Water Corporation strategy for the Alkimos Coastal Node LSP area is to collect waste water from the individual allotments and convey the flow via local waste water gravity sewers to proposed permanent waste water pump stations, pumping the flow east to the gravity network feeding the WWTP. The waste water strategy for Alkimos Coastal Node LSP includes two permanent waste water pump stations near the foreshore reserve, to be located adjacent in or adjacent to areas of POS. (Cossill & Webley 2014).

5.6 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria, and how these are addressed within the Alkimos Coastal Node LSP, is provided in **Table 4**.

Table 4 Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Use fit for purpose water source	Groundwater to be used for irrigation of POS
		Rainwater harvesting promoted within lots for irrigation of private gardens
		Scheme water for use in lots
WC2	Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water	Provision of advice to residents regarding water conservation measures
		Use of rainwater tanks within lots of suitable built form
		Promotion/use of waterwise gardening principles
		Promotion/use of water efficient appliances
		Mandated use of water efficient fittings
WC3	Minimise use of water at an estate scale	Promotion/use of waterwise gardening principles within lot and POS areas
		Promotion/use of water efficient appliances
		Mandated use of water efficient fittings

6 Groundwater management strategy

6.1 Groundwater level management

As discussed in **Section 3.6**, depth to groundwater varies between 4 m and 42 m below natural surface. Groundwater level management measures are therefore somewhat passive and the focus of groundwater management is on water quality.

6.2 Groundwater quality management

The main objective for the management of the groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by treating surface runoff prior to infiltration via application of appropriate WSUD measures, thereby reducing the total nutrient load into the groundwater that originates from the development.

The reduction of nutrient load to the groundwater will be achieved in the development by:

- Directing stormwater to vegetated (with native wetland species) bio-retention areas (detailed further in **Section 7.2**).
- Bio-retention areas will be underlain by a 150 mm band of material with a minimum PRI of 10. It is acceptable for this to be achieved with a thicker layer of lower PRI soil.
- Fertiliser use to establish and maintain vegetation within POS areas and road verges will be minimised.
- Drought tolerant turf species that require minimal water and nutrients will be used.
- Roll-on turf will be used within the POS areas and road verges, to prevent the high nutrient input requirement during establishment of the turf.
- Garden beds will not be immediately adjacent to the flood storage areas or bio-retention areas to reduce nutrient transportation into these infiltration areas.

The above measures will improve the quality of the water prior to it infiltrating into the underlying groundwater, and will assist in achieving **Criteria GW1**, **GW2** and **GW3**.

6.3 Groundwater criteria compliance summary

A summary of the proposed groundwater quantity design criteria and how these are addressed within the Alkimos Coastal Node LSP area is provided in **Table 5**.

Table 5 Groundwater Criteria Compliance Summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Maintain or improve groundwater quality onsite	Bio-retention areas to treat surface water runoff prior to infiltration to groundwater
		Bio-retention areas to be underlain by soils with PRI>10
GW2	Treat stormwater runoff before infiltrating to groundwater	Bio-retention areas to treat surface water runoff prior to infiltration to groundwater
		Bio-retention areas to be underlain by soils with PRI>10

Criteria number	Criteria description	Manner in which compliance will be achieved
GW3	Use water sensitive design approaches to recharge the superficial aquifer	Soakwells within standard residential lots sized to infiltrate up to the 1 year 1 hour ARI event
		Soakwells within high density lots sized to infiltrate up to 50% of the 1 year 1 hour ARI event
		Flood storage areas sized to retain and infiltrate flows up to the 100 year ARI event
		Bio-retention areas and verge swales sized to retain and infiltrate the 1 year 1 hour ARI event from road reserves and excess runoff from high density residential lots

7 Stormwater management strategy

The principle behind the stormwater management strategy for the Alkimos Coastal Node LSP area is to maintain the existing hydrology by infiltrating stormwater runoff as close to source as possible. The development drainage system has been designed to satisfy the criteria stated in **Section 4.4**.

7.1 Lot storage

7.1.1 Residential lot drainage system

Rainfall on the front and backyards of lots (garden areas) will either infiltrate directly at-source or, in large rainfall events (i.e. approximately a 5 year ARI event), a portion of the runoff may discharge to the road network. The runoff from roof areas will be directed to soakwells which will infiltrate into the sandy soil and ultimately the groundwater.

Soakwells for lots will be sized to retain all flows from the 1 year 1 hour ARI event. The exception to this are the high-density lots (those with a total lot area of less than 220 m^2) and group housing sites as these lots are generally too small to allow the required storage of the entire 1 year 1 hour ARI event,. High density lots and group housing sites will therefore be required to have soakwells with capacity for 50% of the 1 year 1 hour ARI event. The remainder will be catered for within the downstream bio-retention areas.

The implementation of soakwells will assist in achieving **Criteria SW1** and **SWQ1**.

7.1.2 Commercial lot drainage systems

Commercial lots have been assumed to retain the 100 year ARI runoff on-site. This would typically be achieved by retaining the 1 year 1 hour ARI volume beneath carpark areas within sub-surface storage/soakwells. Events greater than this (up to a 100 year ARI event) will need to be retained onsite either within additional subsurface storage or by allowing surface storage within carpark areas. This runoff would eventually infiltrate into groundwater via the soakwells.

7.2 Development drainage system

The storm water runoff from the 1 year 1 hour ARI rainfall event will be retained as close to source as practicably possible. There will be no runoff from the development during a 1 year 1 hour ARI rainfall event. This is consistent with the pre-development environment and the design criteria (see **Section 4.4**).

The retention storage will be provided via a treatment train which includes vegetated bio-retention areas and infiltration basins. The vegetation and the infiltration process within the soil column will remove a large portion of the contaminants (nutrients, gross pollutants, suspended sediments, etc.) within the stormwater runoff.

Rainfall events greater than the 1 year 1 hour ARI event will be conveyed by overland flow or a pipe network to infiltration basins. The size of the infiltration basins will be minimised due to the retention storage provided higher up in the catchment and within lots. The stormwater drainage system for Alkimos Coastal Node (including nominal locations for bio-retention areas and infiltration basins) is provided within **Figure 8**.

7.2.1 Bio-retention areas

Runoff from the 1 year 1 hour ARI event that is not captured on lot will be captured and retained within a vegetated bio-retention area. These will be located within dedicated bio-retention basins within POS. The bio-retention areas have been assumed to have a depth of 0.5 m, 1:6 side slopes and contain amended soil with a high Phosphorous Retention Index (PRI) or another media suitable for the purpose. The use of bio-retention areas will assist in achieving **Criteria SW1, SWQ1** and **SWQ2**.

7.2.2 Flood storage areas

Flood storage areas will be utilised to infiltrate major event flows in order to maintain the pre-development hydrological regime. The flood storage areas are not designed to be permanently wet. To achieve this, the inverts of the basins will have a significant clearance above groundwater (>10m). There will be no offsite discharge from the flood storage areas. Flood storage areas will be a maximum of 1.2 m deep and will have 1:8 side slopes. The sizes and spatial requirements for flood storage areas are further discussed in **Section 7.3**.

The design of flood storage areas will be such that maximum top water levels within basins will remain at least 500 mm below finished floor levels of adjacent lots to ensure protection from flooding during extreme rainfall events.

The use of flood storage areas will achieve **Criteria SW1**, while the design of the basins will ensure that **Criteria SW2** and **SW7** are achieved.

7.3 Drainage design assessment

As described in **Sections 7.1** and **7.2**, this LWMS proposes to utilise soakwells, bio-retention areas and flood storage areas to retain runoff from all events up to the 100 year ARI event onsite. The sizing of these retention areas is best achieved via a computational model. The post-development modelling methodology and parameters detailed in the hydrological and hydraulic Modelling Report provided in **Appendix D**. Post-development catchments for the Alkimos Coastal Node are shown in **Figure 8**.

7.3.1 Minor rainfall event modelling results

The 1 year 1 hour ARI rainfall event will be retained onsite to satisfy **Criteria SWQ1**. The location and size of the proposed retention storage in Alkimos Coastal Node required to achieve the design criteria is presented in **Figure 8** and the design depth, volume and inundated areas of the bio-retention areas are shown in **Table 6**. The bio-retention areas have been assumed to have a maximum depth of 500 mm and 1:8 side slopes.

Table 6 1 year 1 hour ARI bio-retention storage

Bio-retention area	Top water level surface area (m^2)	Volume (m^3)
Ct1	479	180
Ct1a	251	84
Ct2	744	296
Ct3	463	173

Bio-retention area	Top water level surface area (m^2)	Volume (m^3)
Ct4	1,141	475
Ct5	502	190
Ct6	537	205
Ct7	617	240
Ct8	440	163
Ct9	737	293
Ct10	578	223
Total	***6,489***	***2,522***

The total size of the bio-retention system, achieved through at-source retention storage provided by swales and bio-retention areas, is equal to 2.3% of the connected impervious area, which achieves **Criteria SWQ2**. Native vegetation known for nutrient uptake potential will be used for areas equal to at least 2% connected impervious area to ensure nutrient uptake is undertaken.

The inundated area within the Alkimos Coastal Node LSP for the 1 year 1 hour ARI event is shown in **Figure 9**. Note that the number of bio-retention areas can be modified at detailed design stage, provided the assumed storages detailed in **Table 6** are maintained. The Alkimos Coastal Node LSP Landscape Masterplan, provided in **Appendix C**, shows how the development and stormwater management components within the development are intended to be landscaped.

Based on the assumed infiltration rate of 2 m/day, the bio-retention areas should fully infiltrate within 6 hours following cessation of rainfall.

7.3.2 Major rainfall event modelling results

The Alkimos Coastal Node LSP area aims to retain runoff from events up to the 100 year ARI event, as required under **Criteria SW1**. This is achieved by the use of at-source retention and infiltration storage within bio-retention areas and flood storage areas. The proposed locations of the infiltration areas are shown in **Figure 8**. The design depth, volume and inundated areas in the 5 year and 100 year ARI events are provided within **Table 7**.

Table 7 Infiltration basin volumes, depths surface areas in a 5 year and 100 year ARI events

Catchment/ FSA number	5 year ARI event			100 year ARI event		
	Top water level surface area (m^2)	Volume (m^3)	Depth (m)	Top water level surface area (m^2)	Volume (m^3)	Depth (m)
Ct1	662	283	0.66	1,178	770	1.2
Ct1a	447	178	0.72	830	480	1.2
Ct2	923	408	0.63	1,566	1,115	1.2
Ct3	1,095	463	0.56	1,875	1400	1.2
Ct4	2,027	893	0.54	3,095	2,580	1.2

Catchment/ FSA number	5 year ARI event			100 year ARI event		
	Top water level surface area (m^2)	Volume (m^3)	Depth (m)	Top water level surface area (m^2)	Volume (m^3)	Depth (m)
Ct5	862	426	0.77	1,309	885	1.2
Ct6	1,207	511	0.55	2,035	1,550	1.2
Ct7	928	404	0.61	1,594	1,140	1.2
Ct8	741	311	0.62	1,338	910	1.2
Ct9	1,638	707	0.54	2,608	2,100	1.2
Ct10	1,241	544	0.58	2,045	1,560	1.2
Total	11,772	5,128		19,473	14,490	

The 5 year and 100 year ARI event stormwater inundation areas and flow paths are shown in **Figure 10** and **Figure 11** respectively.

Based on the assumed infiltration rate of 2 m/day, the flood storage areas should fully infiltrate within 14.4 hours following cessation of rainfall.

The above measures will help to achieve **Criteria SW1** and **SWQ1**.

7.4 Non-structural water quality measures

The structural measures proposed within the Alkimos Coastal Node LSP provide both a storage and treatment function to stormwater runoff, as detailed in **Sections 7.1** and **7.2**. A number of non-structural measures will also be implemented across the site to help reduce nutrient loads within stormwater runoff. These measures include:

- Minimising fertiliser use to establish and maintain vegetation within POS areas and road verges.
- Drought tolerant turf species that require minimal water and nutrients will be used.
- Garden beds will not be located immediately adjacent to the flood storage areas or bio-retention areas to reduce nutrient transportation into these areas.
- Education of residents regarding fertiliser use and nutrient absorbing vegetation species within lots.
- Street sweeping will be regularly implemented to remove sediment-bound particulates and nutrients.

The above measures will assist in achieving **Criteria SWQ3**.

7.5 Stormwater criteria compliance summary

A summary of the proposed stormwater design criteria and how these are addressed is provided within **Table 8**.

Table 8 Stormwater management criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Accommodate all runoff from all events up to the 100 year ARI event onsite	Residential lots to retain 1 year 1 hr ARI event in soakwells and garden areas
		High density lots to retain 50% of 1 year 1 hr ARI event within soakwells and garden areas
		Commercial lots to retain 100 year ARI events onsite
		Road runoff and excess runoff from lots will be retained within bio-retention areas and flood storage areas within POS
SW2	Finished floor levels of lots shall have a minimum 500 mm clearance to the 100 year ARI top water level	Lots adjacent to flood storage areas will be at least 500 mm above the top water level of the 100 year ARI event.
SW3	Provide stormwater flow pathways for runoff from the 100 year ARI event	The road network will be graded towards POS areas, providing a flow path for 100 year ARI event runoff to reach flood storage areas
SW4	Provide minimum 300 mm clearance from dynamic 100 year ARI event flood levels within road reserves	Lots will be at least 300 mm above road pavement
SW5	Minor roads are to be designed to remain passable in the 5 year ARI storm event	The pipe network will be designed to convey the 5 year ARI event which will ensure roads remain passable
SW6	Design infiltration areas to avoid creating mosquito habitat	The high infiltration rates of the underlying sands ensure that the maximum inundation time within the flood storage areas will be no more than 14.4 hours
SWQ1	Retain the 1 year 1 hour ARI rainfall event onsite as close to source as practicably possible	Residential lots to retain 1 year 1 hour ARI event in soakwells
		High density lots to retain 50% of 1 year 1 hour ARI event within soakwells and garden areas
		Commercial lots to retain 100 year ARI events onsite
		Bio-retention areas sized to retain 1 year 1 hour ARI event from roads and overflow from high density lots
SWQ2	Size bio-retention areas to (at least) 2% of the connected impervious area	The bio-retention areas are sized to be 2.3% of the connected impervious area
SWQ3	Apply appropriate structural and non-structural measures to reduce nutrient loads	Soakwells within lots and bio-retention areas in POS
		Minimise use of fertilisers within POS and road verges
		Maintenance of POS and drainage areas
		Education of residents

8 Subdivision and Urban Water Management Plans

The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW, 2008b). The main areas that will require further clarification within future UWMPs include:

- Modelling of local road drainage network
- Stormwater storage within non-residential lots
- Flood storage area configurations
- Imported fill specifications and requirements
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Compliance with Irrigation Schedule
- Status of groundwater abstraction license.

These are further detailed in the following sections. Ongoing monitoring will be detailed in the UWMP, however in this LWMS is outlined broadly in **Section 9**.

8.1 Modelling of local road drainage network

It is acknowledged that the drainage strategies documented in this LWMS, are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for development of the proposed infiltration basin sizes and are of an appropriate level of detail; however verification of proposed subdivision drainage designs within the LSP area will be undertaken by modelling the catchments serviced by the piped drainage network. Such modelling will allow verification that the development undertaken within the LSP area is consistent with this LWMS. The design of the drainage system to date has been undertaken at an appropriate level for local structure planning and runoff-routing computer modelling of the stormwater drainage system will be reviewed once detailed drainage design has commenced for the area. It is anticipated that this will occur during the subdivision design process and detailed within the future UWMPs.

The exception to the requirement to revise the surface runoff modelling is if the catchment details and basin designs are consistent with the assumptions made in this LWMS. If this were the case it would be acceptable to provide design calculations for the concrete pipe and detention/retention areas to demonstrate compliance with the LWMS.

8.2 Stormwater storage within non-residential lots

The Alkimos Coastal Node LSP stormwater management strategy assumes that all commercial/ business lots will retain all runoff from the 100 year ARI event. Future UWMPs will be required to confirm the manner in which this will be achieved.

8.3 Flood storage area configurations

The Alkimos Coastal Node LSP area drainage catchments have been defined based on a preliminary earthworks model, and it is therefore possible that these could undergo some change to

accommodate stakeholder feedback prior to final subdivision design. The exact location and shape of the flood storage areas will still need to be specified and presented within the future UWMP.

In order to review the final flood storage area configurations, the hydrological model that has been developed to support this LWMS may need to be refined in light of stakeholder feedback. It is expected that the civil drainage designs will be progressed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. The ultimate aim of revising the hydrological model will be to confirm that the post-development runoff volumes and peak flows are able to meet the performance criteria proposed in **Section 4** of this LWMS.

8.4 Imported fill specifications

As discussed previously soils beneath bio-retention areas will require a high PRI to ensure at-source nutrient retention leading to the protection of downstream water bodies. The specification for this would typically be that a 150 mm band of soil with a PRI >10 will be imported beneath any bio-retention or treatment areas. This specification will be confirmed at UWMP stage and within the detailed landscaping designs.

8.5 Implementation of water conservation strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation strategies will be incorporated into the design and the ongoing maintenance of all POS areas. Landscape design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMPs produced for the development. The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners will also be discussed within the future UWMP.

8.6 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the POS areas. It is expected that the future UWMP will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

8.7 Management and maintenance requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within bio-retention areas, swales and flood storage areas will require ongoing maintenance. It is therefore expected that the future UWMP will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the CoW and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.8 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed either in the future UWMP or a separate Construction Management Plan (CMP).

8.9 Compliance with Irrigation Schedule

The future landscape designs will need to demonstrate compliance with the DoW North West Coastal Development Corridor Irrigation Schedule. A preliminary assessment has been provided in **Section 5.4** of this LWMS. This will need to be refined at UWMP stage and presented with more detailed landscape designs to demonstrate that the schedule can (and will) be complied with.

8.10 Groundwater license status

A groundwater abstraction licence is yet to be applied for to supply water for irrigation of POS within the Alkimos Coastal Node LSP area (as discussed in **Section 5.4**). Future UWMPs will demonstrate that adequate allocation of water has been obtained to irrigate POS and road verges within the Alkimos Coastal Node LSP consistent with the requirements of the North West Coastal Development Corridor Irrigation Schedule, or that an appropriate contingency plan has been established.

9 Monitoring

It is proposed that the overall condition of the development will be monitored on a bi-annual basis. This monitoring will be implemented after the completion of the civil and landscaping works and will continue for a period of two years.

A visual assessment will be undertaken to monitor the overall condition of the development, with the aim to ascertain that the maintenance activities are achieving the overall management objectives for the development. The parameters that will be monitored include:

- Gross Pollutants
- Terrestrial Weeds
- Irrigation
- Vegetation density
- Paths, benches, walkways and other infrastructure.

The management and maintenance objectives will be detailed within future UWMPs along with details of the corresponding monitoring program.

9.1 Groundwater monitoring

Given that there will be no surface water discharge from the site during a 1 year 1 hour ARI event it will be very difficult to collect a water quality sample for treated surface runoff. Further, given the significant depth to groundwater and the upstream landuses (residential development and a wastewater treatment plant) it is unlikely that monitoring data from groundwater will provide any useful or meaningful data. On this basis, post-development groundwater quality monitoring is not proposed.

9.2 Reporting

A post-development monitoring report will be prepared on conclusion of the two year monitoring period, and will be provided to the CoW and the DoW. Interim results can be provided to either CoW or DoW on request during the monitoring program.

10 Implementation

The LWMS is a key supportive document for the LSP. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a total water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMP.

10.1 Roles and responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the CoW. The responsibility for working within the framework established within the LWMS rests with the subdivider, although it is anticipated that the future UWMP will be developed in consultation with the CoW and DoW and in consideration of other relevant policies and documents.

Roles, responsibilities and anticipated timing is summarised in **Table E1**.

10.2 Funding

The site is comprised of more than one landowner, and the costs to implement the development will be borne by the proponent (which will likely be a joint venture between LandCorp and Water Corporation). While there is no regional drainage system for the development to connect to, the proponent will need to work with the CoW and Water Corporation to ensure provision of services is staged appropriately throughout the construction process.

10.3 Review

It is not anticipated that this LWMS will be reviewed, unless additional land parcels/lots are added to the LSP area prior to subdivision, or the LSP undergoes significant change post-lodgement of the LWMS. If additional areas are required to be covered by the LWMS it is most likely that an addendum to cover these areas could be prepared. If the LSP is substantially modified, surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals will be supported by a UWMP. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS, and will demonstrate compliance with the Criteria proposed in **Section 4**.

In addition to the issues detailed in **Section 8**, the UWMP will address:

- Compliance with design objectives within the LWMS
- Detailed stormwater management design
- Specific structural and non-structural methods to be implemented and their manner of implementation
- Details of proposed roles and responsibilities for the above measures.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the CoW through policy (or modification of these where necessary), building license or awareness programs (such as the Water Corporation's Waterwise program).

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FIGURES

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Figure 1:	**Locality Diagram**	**Plan Number: EP12-026(01)--F02a**	
Project:	Alkimos Coastal Node LWMS	Drawn: KNM	Date: 22/02/2016
		Approved: DPC	Date: 22/02/2016
Client:	LandCorp	Checked: DPC	Scale: 1:15,000@A4

0 200 400 600 Metres

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Figure 2: Site Boundary

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F03a

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0 200 400 Metres

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Figure 3: Topographical Contours

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F04a

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Approved:	DPC	Date:	22/02/2016
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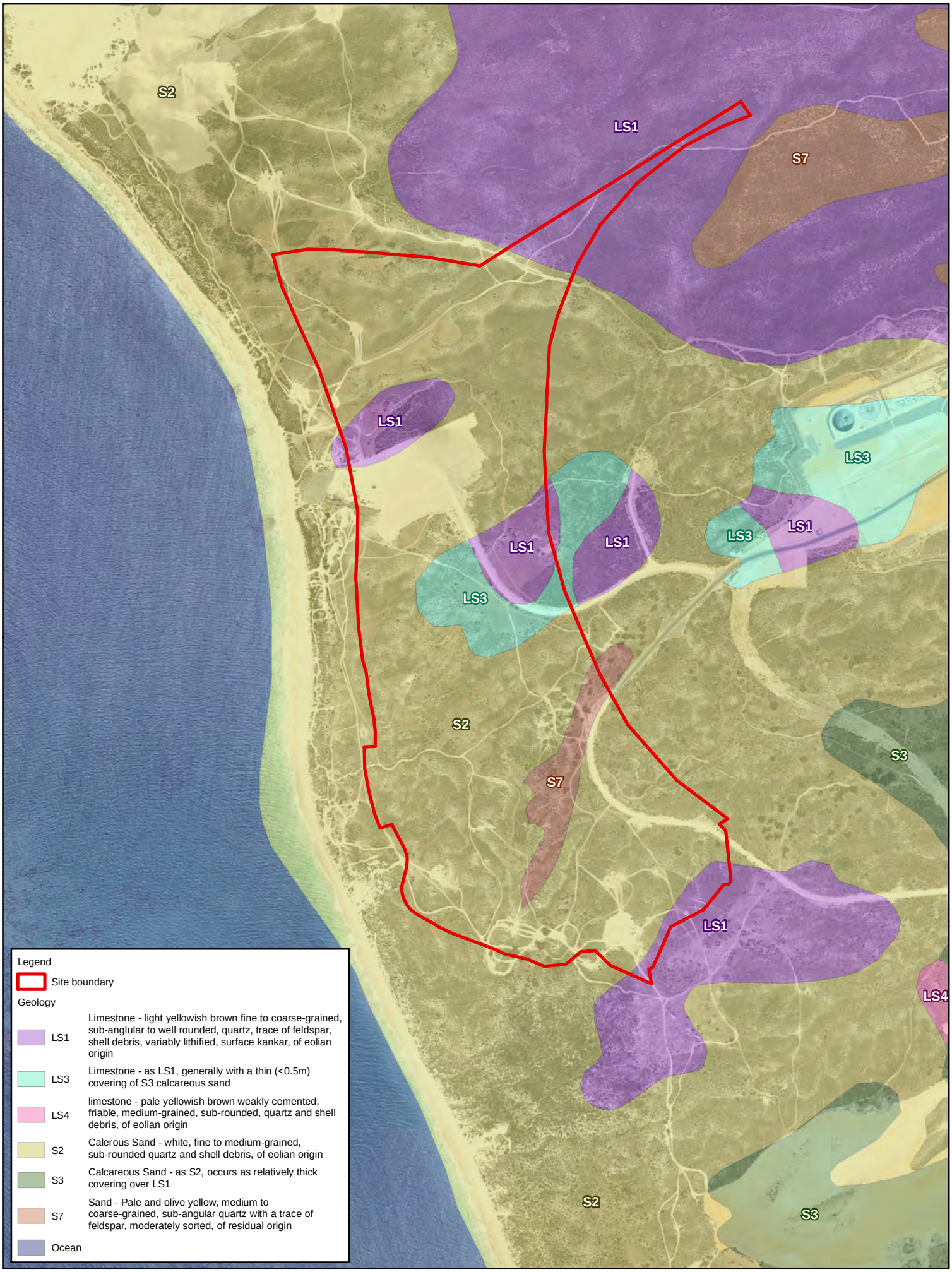

Figure 4: Geological Units

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F06a

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Sources: The following datasets were used in the production of this map: Geology - Perth Geological Survey (1986)

Figure 5: Hydrological Features

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F07a

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Sources: The following datasets were used in the production of this map: Public Drinking Water Source Areas - DoW (2011)

Figure 6: **Groundwater Levels and Bore Locations**

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F09a

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Figure 7: Pre-development Catchments

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F08a

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Bio-retention 10		
1 year 1 hour ARI		
Area (m^2)	=	578
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	223
Flood Storage Area 10		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	1241
Depth (m)	=	0.58
Volume (m^3)	=	544
100 year ARI		
Area (m^2)	=	2045
Depth (m)	=	1.2
Volume (m^3)	=	1560

Bio-retention 9		
1 year 1 hour ARI		
Area (m^2)	=	737
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	293
Flood Storage Area 9		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	1638
Depth (m)	=	0.54
Volume (m^3)	=	707
10 year ARI		
Area (m^2)	=	2608
Depth (m)	=	1.2
Volume (m^3)	=	2100

Bio-retention 6		
1 year 1 hour ARI		
Area (m^2)	=	537
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	205
Flood Storage Area 6		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	1207
Depth (m)	=	0.55
Volume (m^3)	=	511
100 year ARI		
Area (m^2)	=	2035
Depth (m)	=	1.2
Volume (m^3)	=	1550

Bio-retention 8		
1 year 1 hour ARI		
Area (m^2)	=	440
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	163
Flood Storage Area 8		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	741
Depth (m)	=	0.62
Volume (m^3)	=	311
100 year ARI		
Area (m^2)	=	1338
Depth (m)	=	1.2
Volume (m^3)	=	910

Bio-retention 3		
1 year 1 hour ARI		
Area (m^2)	=	463
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	173
Flood Storage Area 3		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	1095
Depth (m)	=	0.56
Volume (m^3)	=	463
100 year ARI		
Area (m^2)	=	1875
Depth (m)	=	1.2
Volume (m^3)	=	1400

Bio-retention 7		
1 year 1 hour ARI		
Area (m^2)	=	617
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	240
Flood Storage Area 7		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	928
Depth (m)	=	0.61
Volume (m^3)	=	404
100 year ARI		
Area (m^2)	=	1594
Depth (m)	=	1.2
Volume (m^3)	=	1140

Bio-retention 2		
1 year 1 hour ARI		
Area (m^2)	=	744
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	296
Flood Storage Area 2		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	923
Depth (m)	=	0.63
Volume (m^3)	=	408
100 year ARI		
Area (m^2)	=	1566
Depth (m)	=	1.2
Volume (m^3)	=	1115

Bio-retention 5		
1 year 1 hour ARI		
Area (m^2)	=	502
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	190
Flood Storage Area 5		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	862
Depth (m)	=	0.77
Volume (m^3)	=	426
100 year ARI		
Area (m^2)	=	1309
Depth (m)	=	1.2
Volume (m^3)	=	885

Bio-retention 1a		
1 year 1 hour ARI		
Area (m^2)	=	251
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	84
Flood Storage Area 1a		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	447
Depth (m)	=	0.72
Volume (m^3)	=	178
100 year ARI		
Area (m^2)	=	830
Depth (m)	=	1.2
Volume (m^3)	=	480

Bio-retention 4		
1 year 1 hour ARI		
Area (m^2)	=	1141
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	475
Flood Storage Area 4		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	2027
Depth (m)	=	0.54
Volume (m^3)	=	893
100 year ARI		
Area (m^2)	=	3095
Depth (m)	=	1.2
Volume (m^3)	=	2580

Bio-retention 1		
1 year 1 hour ARI		
Area (m^2)	=	479
Side slope	=	1 in 6
Depth (m)	=	0.5
Volume (m^3)	=	180
Flood Storage Area 1		
Side slopes	=	1 in 8
5 year ARI		
Area (m^2)	=	662
Depth (m)	=	0.66
Volume (m^3)	=	283
100 year ARI		
Area (m^2)	=	1178
Depth (m)	=	1.2
Volume (m^3)	=	770

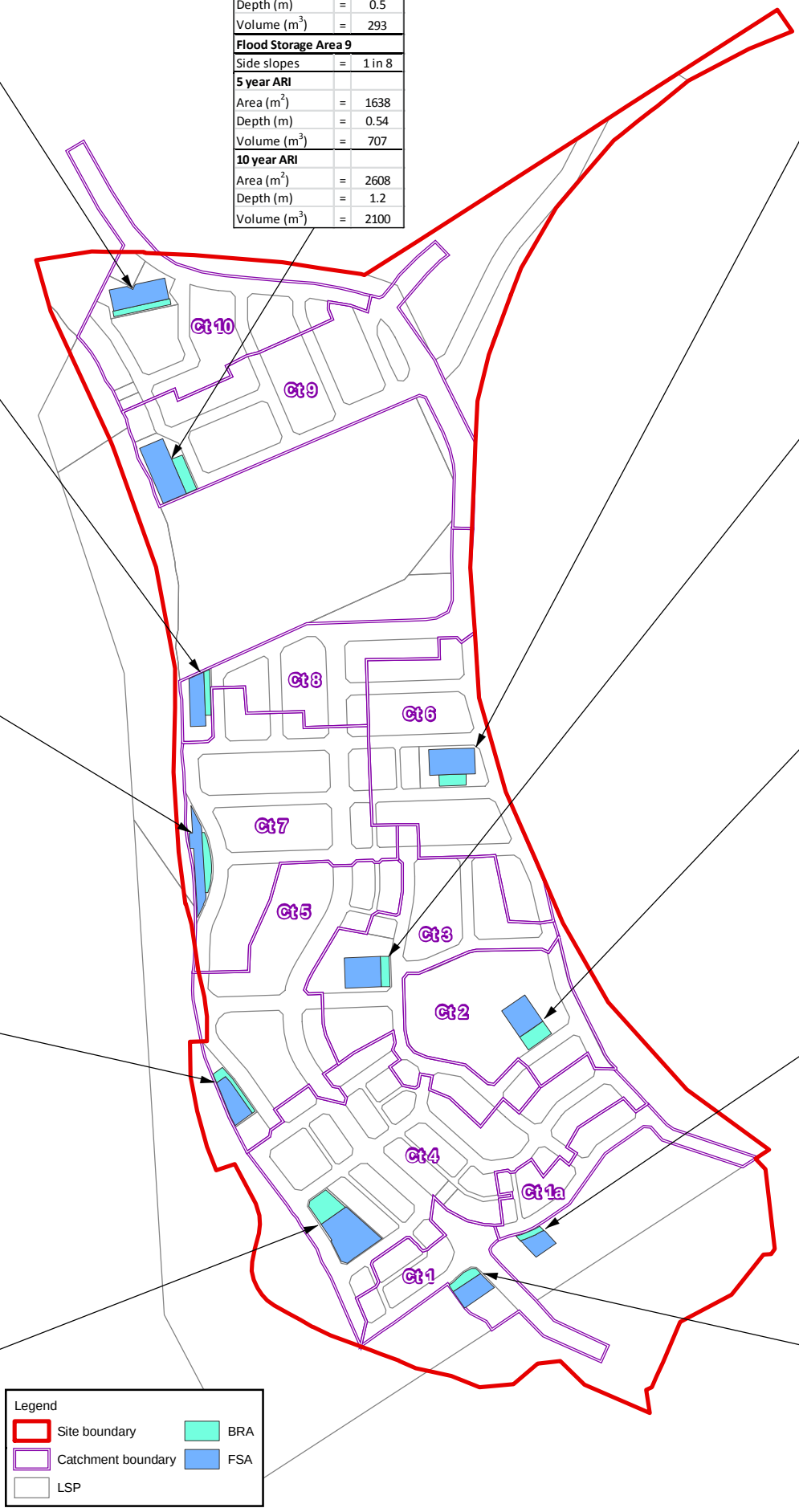

Figure 8: Stormwater Management Features

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F10b

Drawn:	KNM	Date:	22/02/2016
Approved:	DPC	Date:	24/02/2016
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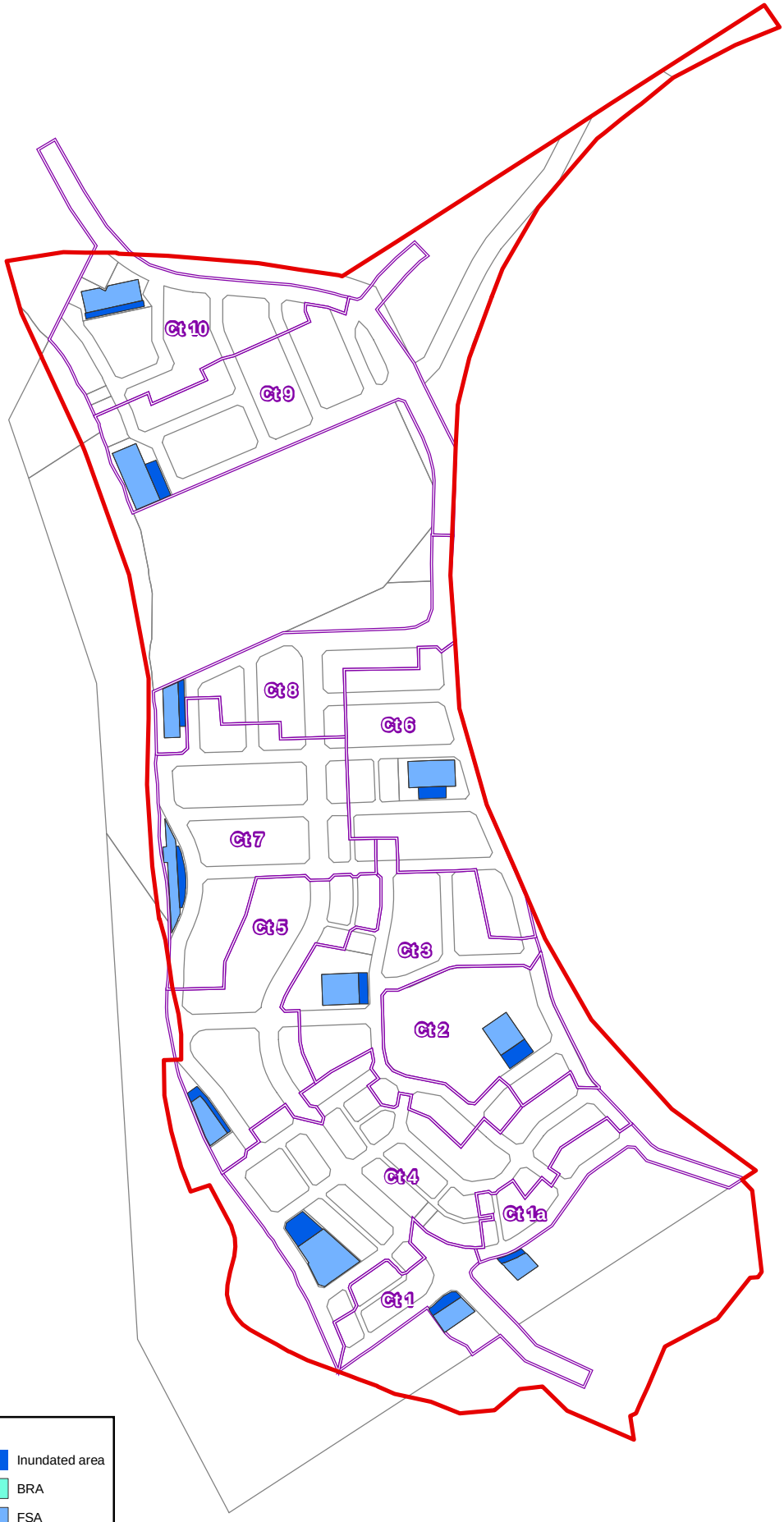

Legend

- Site boundary
- Catchment boundary
- LSP
- Inundated area
- BRA
- FSA

Figure 9: **1 Year ARI Inundation Areas**

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F11b

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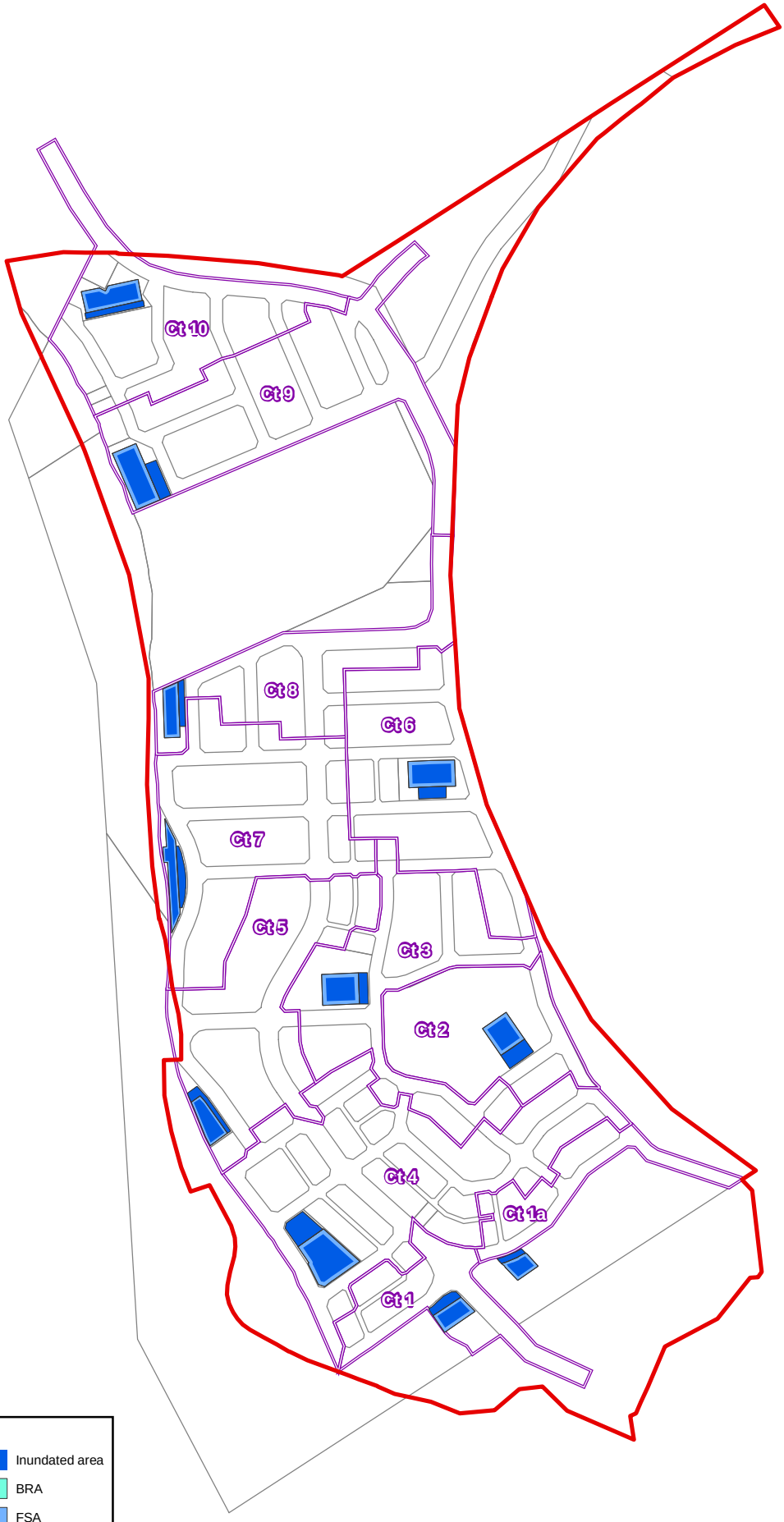

Figure 10: 5 Year ARI Inundation Areas

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F12b

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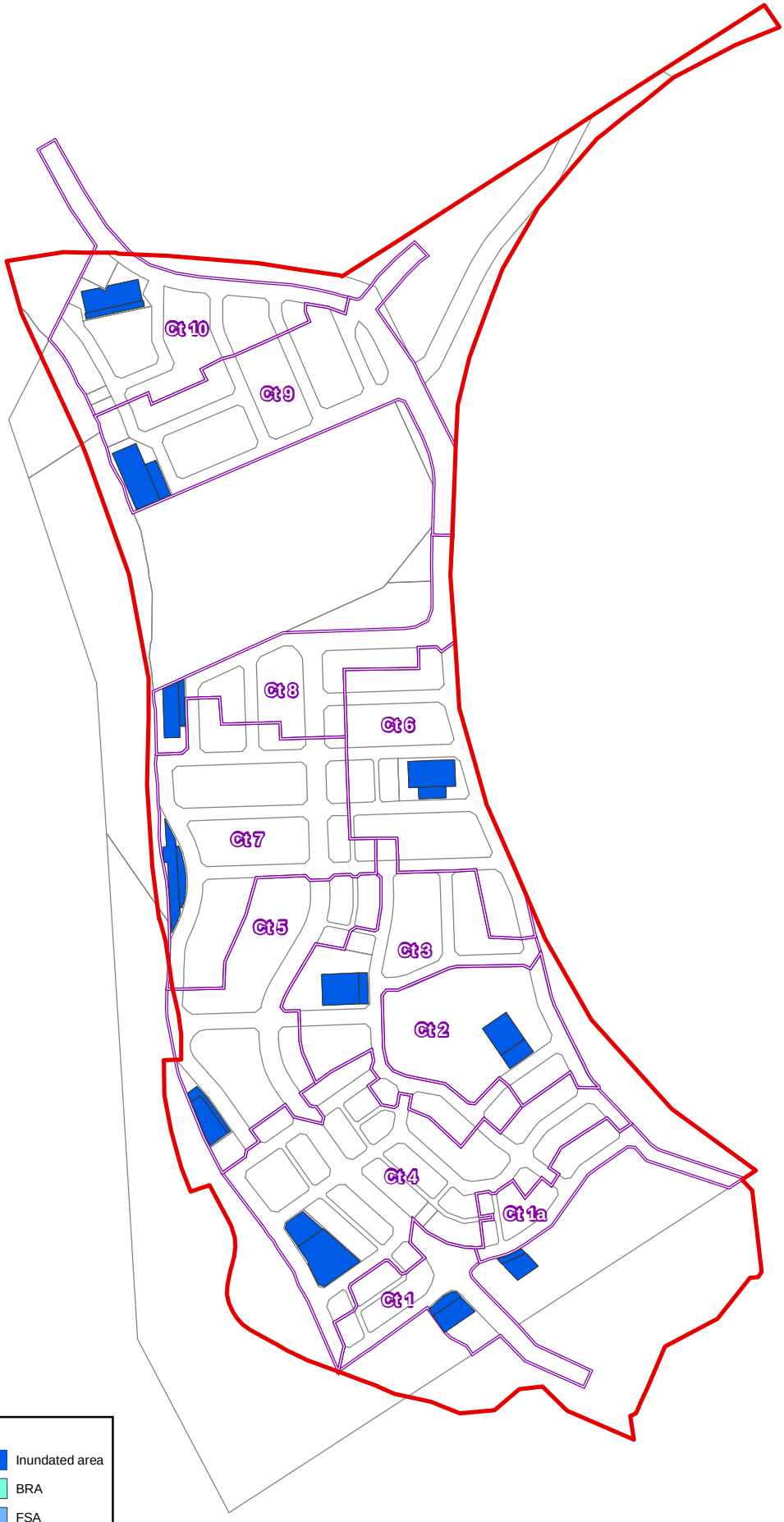

Legend

- Site boundary
- Catchment boundary
- LSP
- Inundated area
- BRA
- FSA

Figure 11: 100 Year ARI Inundation Areas

Project: Alkimos Coastal Node LWMS

Client: LandCorp

Plan Number: EP12-026(01)--F13b

Drawn:	KNM	Date:	22/02/2016
Approved:	DPC	Date:	24/02/2016
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0 100 200 300 Metres

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APPENDIX A

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ALKIMOS COASTAL NODE LSP

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LEGEND

Structure Plan Boundary

ZONES

- Commercial
- Residential
- Mixed Use

RESERVES

- Parks and Recreation
- Public Purpose (Subject to Further Planning)

MOVEMENT

- Integrator Arterial (B)
- Neighbourhood Connector
- Coastal Road
- Secondary Transit System (STS Route)
- Pedestrian and Cyclist Route
- Regional Foreshore Shared Path
- Public Open Space (Conservation)
- Strategic Open Space (Indicative Location)

OTHER

- RMD 25 — R-Codes Residential Density
- Areas Subject to Future MRS Amendment
- Indicative Surf Lifesaving Club
- 100 Year Coastal Process Line (as per digital data from MP Rogers)
- Indicative Waste Water Pumping Station location
- 30m Waste Water Pumping Station Buffer
- Indicative Future Marina Layout

(1) To rezone from MRS 'Urban' Zone to 'Public Purpose' Reserve.

(2) To rezone from MRS 'Parks and Recreation' Reserve to 'Urban' Zone.

(3) To rezone from MRS 'Urban' Zone to 'Parks and Recreation' Reserve.

9016

9501

RMD 25-40

RMD 25-40

RMD 25-40

1012

Alkimos Waste Water Treatment Plant

R-AC1

9001

RMD 25-40

R-AC1

R-AC1

RMD 60-80

RMD 25-40

9019

RMD 40

9019

15450

Indian Ocean

ALKIMOS COASTAL NODE LOCAL STRUCTURE PLAN

NORTH

Scale 1:3750 @ A1 | 1:7500 @ A3

0 40 80 120 160 200m

DATE:	22/01/2016	DRAFTEE:	JP
REVISED:	17/02/2016	PLANNER:	KB
PROJECTION:	PCG 94	CHECK:	KB
DATUM:	AHD	PLAN NUMBER:	LCPAC-2-007A

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APPENDIX B

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GROUNDWATER IRRIGATION SCHEDULE

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POS ID	POS name (indicative only)	Type	Total Area (ha)	Area required for drainage	Design Area of Turf / Permanently Irrigated Zone (Ha)	% area to be irrigated	Irrigation rate (kL/Ha)	Establishment Phase (2 years) Irrigated Area (ha)	Establishment Phase (2 years) Irrigation Demand (kL/year)	Permanent Passive Irrigated Area (ha)	Permanent Passive Irrigation Demand (kL/year)	Commencement Date
A	Eco-Drainage Park	Passive, Conservation + Drainage	0.4480	0.2623	0.0224	5%	6750.000	0.090	604.8	0.022	151.2	Feb-17
B	PAW-1	Passive	0.0450	0.0000	0.0000	0%	6750.000	0.009	60.8	0.000	0.0	Feb-17
C	Village Park	Passive + Drainage	0.4739	0.2393	0.0711	15%	6750.000	0.095	639.8	0.071	479.8	Jun-17
D	Hillside Pocket Park	Passive	0.1566	0.0000	0.0235	15%	6750.000	0.031	211.4	0.023	158.6	Oct-17
E	Lookout Park	Passive	0.3623	0.1073	0.0362	10%	6750.000	0.072	489.1	0.036	244.6	Oct-17
F	Local Kick-About	Passive	0.4651	0.1755	0.0930	20%	6750.000	0.093	627.9	0.093	627.9	Oct-15
G	Coastal Drainage Park	Passive (Nature Play) + Drainage	0.3121	0.1380	0.0624	20%	6750.000	0.062	421.3	0.062	421.3	Jul-17
H	Community Kick-About Park	Passive (Play) + Drainage	0.7531	0.1573	0.1506	20%	6750.000	0.151	1016.7	0.151	1016.7	Aug-16
I	Surf Lifesaving Park	Passive + Drainage	0.2658	0.1075	0.0532	20%	6750.000	0.053	358.8	0.053	358.8	Aug-16
J	Local Oceanside Park	Passive + Drainage	0.4656	0.3055	0.0698	15%	6750.000	0.093	628.6	0.070	471.4	Jun-17
K	PAW-2	Passive	0.0487	0.0000	0.0000	0%	6750.000	0.010	65.7	0.000	0.0	Jun-19
L	Eco Drainage Park	Passive + Drainage	0.3825	0.0950	0.0268	7%	6750.000	0.077	516.4	0.027	180.7	Jun-19
M	Bushland Park	Conservation	0.9459	0.0000	0.0000	0%	6750.000	0.189	1277.0	0.000	0.0	Aug-18
N	Bushland Park	Conservation	2.8683	0.0564	0.0000	0%	6750.000	0.574	3872.2	0.000	0.0	Mar-17
										Long Term Demand Total	4,111	kL/Yr
Total			7.9929	1.6441	0.6090							
	DoW Target Long Term Allocation	Flow Cells K & J Water Corporation of WA		J	1004.0000	K	3110.000	sum =	4114		4114	
											2.980	
	Permanent POS Irrigation demand	kL/year									4111.020	

These calculations do not include irrigation for the Public Purpose zoned land. Should temporary sporting ovals be required on the Public Purposeland, an alternative water source from the Waste Water Treatment Plant will be required.

Establishment Stage Irrigation Demand 0% Verges and medians will not be irrigated once established

Definitions - CoW LPP 43	
Active	Active open space means land for which the primary function is organised, high intensity sporting use
Passive	Passive open space means land for which the primary function is unstructured recreational pursuits (picnics, children's play, dog walking) or low intensity active recreation (jogging, walking, casual kick-about).
Conservation	Conservation open space means land for which the primary function is the retention and ongoing management of indigenous flora and fauna. These sites may be modified from their original condition in line with best practice environmental management and to facilitate public access for passive recreational purposes.

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APPENDIX C

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LANDSCAPE MASTERPLAN

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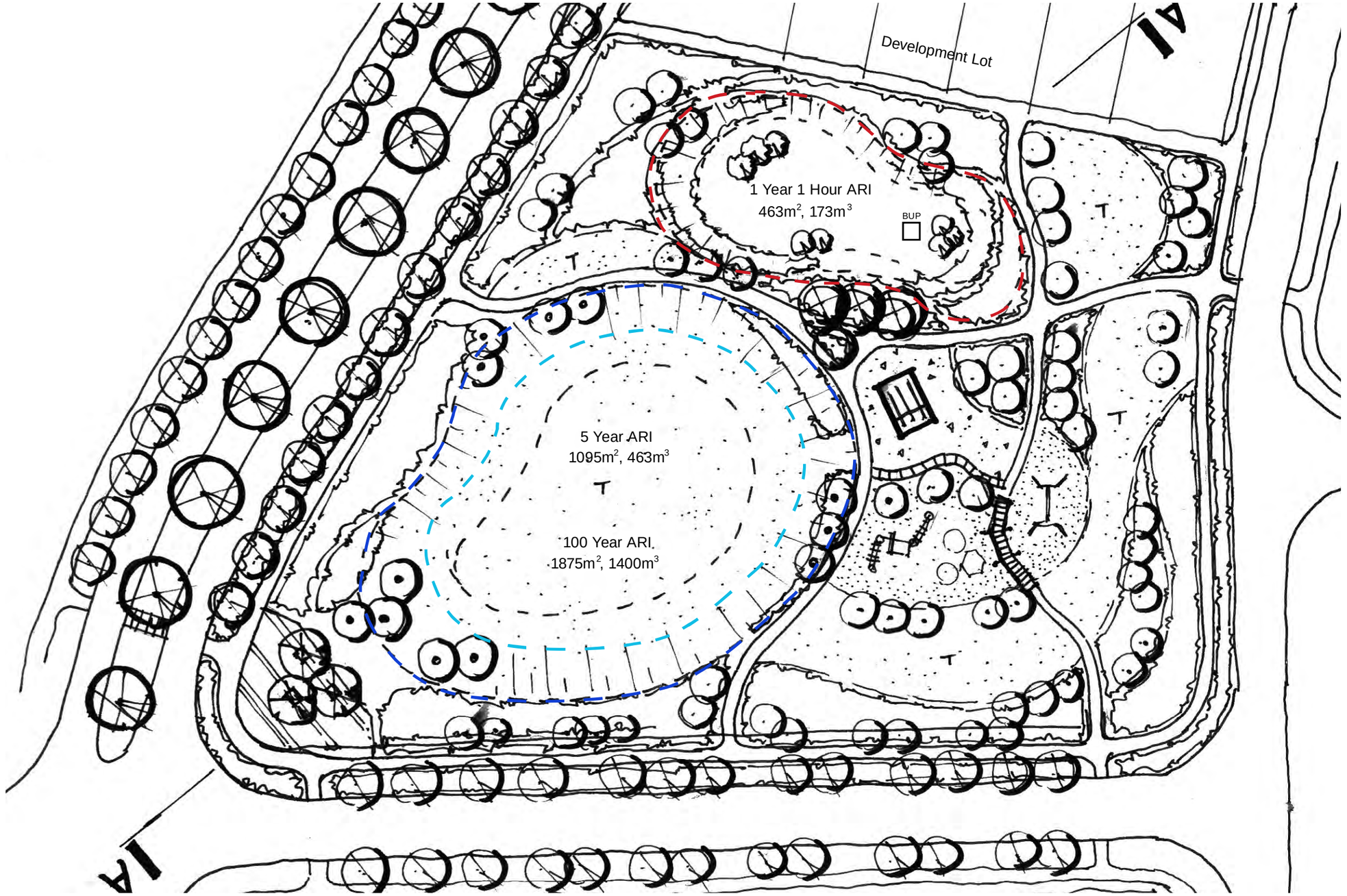
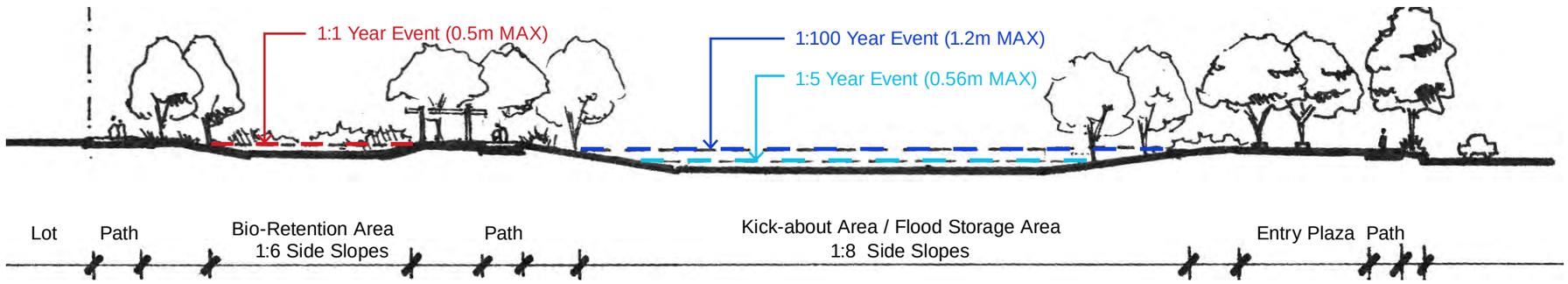
KEY PLAN

LEGEND

- ENTRY PLAZA
- PAVED NODE
- SAND (PLAY AREA)
- TURF
- PLANTING AREA
- SHELTER
- PATH
- SEAT WALL
- BOARD WALK





N

0 5 10 15 20 25 m

Landscape Concept Plan

Section A-A

AECOM

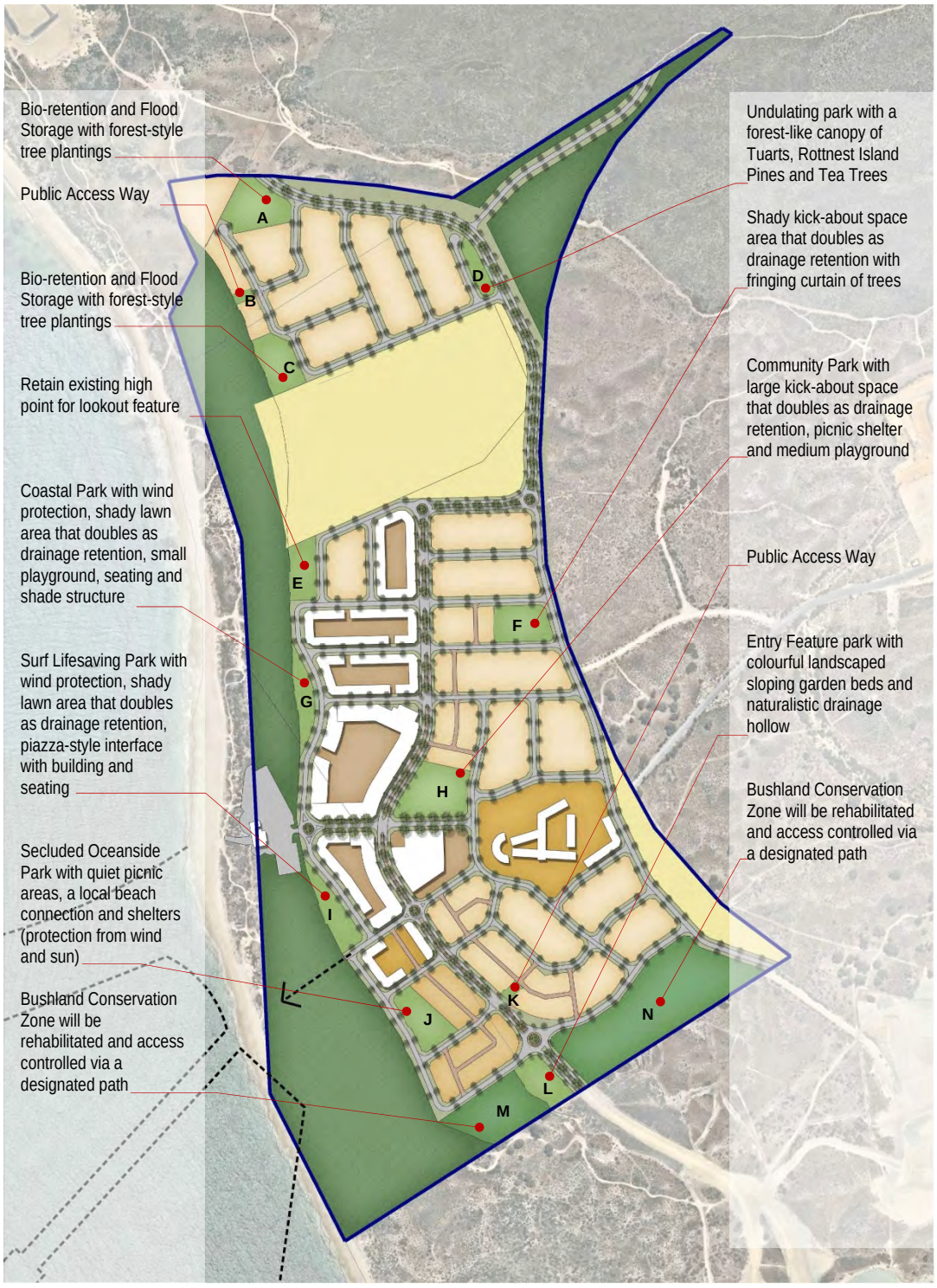
GPO BUILDING, LEVEL 4, 3 FORREST PLACE, PERTH WA 6000 T 08 6430 2900 F 08 6430 2994

60270402

DRAWING NUMBER SK01

23 FEBRUARY 2016

Alkimos Coastal Node LSP Concept Design - Local Park H


Bio-retention and Flood Storage with forest-style tree plantings
Public Access Way
Bio-retention and Flood Storage with forest-style tree plantings
Retain existing high point for lookout feature
Coastal Park with wind protection, shady lawn area that doubles as drainage retention, small playground, seating and shade structure
Surf Lifesaving Park with wind protection, shady lawn area that doubles as drainage retention, piazza-style interface with building and seating
Secluded Oceanside Park with quiet picnic areas, a local beach connection and shelters (protection from wind and sun)
Bushland Conservation Zone will be rehabilitated and access controlled via a designated path
Undulating park with a forest-like canopy of Tuarts, Rottnest Island Pines and Tea Trees
Shady kick-about space area that doubles as drainage retention with fringing curtain of trees
Community Park with large kick-about space that doubles as drainage retention, picnic shelter and medium playground
Public Access Way
Entry Feature park with colourful landscaped sloping garden beds and naturalistic drainage hollow
Bushland Conservation Zone will be rehabilitated and access controlled via a designated path
A
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APPENDIX D

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MODELLING SUMMARY REPORT

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MODELLING ASSUMPTIONS SUMMARY REPORT

ALKIMOS COASTAL NODE LWMS

Project Number EP12-26

Prepared for LandCorp
February 2016

Document Control

DOC NAME	MODELLING ASSUMPTIONS SUMMARY REPORT				
DOC NO.	EP12-026(01)--003B AP				
REVISION	DATE	AUTHOR		REVIEWER	
1	April 2014	Amila Prasad	AP	Dave Coremans	DPC
A	February 2015	Amila Prasad	AP	Dave Coremans	DPC
B	February 2016	Amila Prasad	AP	Dave Coremans	DPC
C					
D					

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Table of Contents

Figures

1 Modelling Assumptions

In order to calculate the surface water runoff volumes within the Alkimos Coastal Node Local Structure Plan (LSP) area, referred to herein as 'the site', XPSWMM hydrologic and hydraulic modelling software was used (XPSWMM 2013).

The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrologic model include:

- Runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment.
- Sub-catchment areas and slopes are determined from surveyed topographical data and earthworks plans.
- Infiltration rates and percentage imperviousness is based on experience with model preparation for similar soil conditions.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSWMM. Assumptions associated with the hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow paths onsite) between nodes within a sub-catchment are given the length of 10 m and slope of 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a 'storage' node, a 'dummy intermediate' node or a conduit/link.
- Links between sub catchment storages act as conveyance channels (e.g. sheet flow within roads in 100 year ARI event). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- Channels represent the roads are designed with a width of 4 m, roughness of 0.014 (Manning's n) and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Soakwells are modelled as nodal-reservoirs with infiltration depth-rating curves.

Ponding conditions of not more than 5% of total volume of a storage node have been allowed within 1 year 1 hour ARI storage nodes for events greater than the 1 year 1 hour ARI event.

2 Pre-development Model

Pre-development model was developed to analyse the existing hydrology of the site and to find the critical durations for major rainfall events.

2.1 Pre-development catchment hydrology

Pre-development catchments were identified using publically available topographical data (Landgate 2013, DOW 2013).

Pre-development catchment properties and their land-use characteristics are provided in **Table 1** and **Table 2** respectively.

Table 1 Pre-development catchment properties

Catchment	Area (ha)	Slope
CtFS01	2.174	0.059
CtFS02	3.402	0.045
CtFS03	2.735	0.055
CtFS04	1.387	0.045
CtFS05	0.951	0.120
CtFS06	2.671	0.110
CtFS07	4.043	0.050
CtFS08	2.687	0.090
CtFS10	2.176	0.050
CtFS11	0.543	0.230
CtFS12	9.019	0.062
CtFS13	1.819	0.124
CtFS14	0.555	0.161
CtFS15	3.337	0.074
CtFS16	6.19	0.075
CtFS17	5.882	0.046
CtFS18	3.99	0.052
Total	53.561	

Infiltration losses and surface roughness values are assumed from the experience project team had with the similar projects involved same land-use types in the area.

Table 2 Pre-development land-use characteristics

Land Type	Initial Loss (mm)	Continual Loss (mm/hr)	Manning's Number (n)
Sandy Sparse Vegetation	25	3.5	0.1

Assumptions associated with defining the pre-development infiltration losses are;

- Land-use types are similar to the latest publicly available aerial photos.
- Both the land-use type and soil properties govern the catchment infiltration and surface roughness
- Pre-development conditions of the catchment similar to its conditions prior to build existing infrastructure and buildings.

There are no storages within the catchments that will affect the overall infiltration and catchment storage parameters.

3 Critical Duration Event Analysis

Several durations varies from 10 minutes to 3 days were analysed to find the 5 year and 100 year ARI event critical duration that gives the maximum runoff volume for majority of sub-catchments.

The critical duration for both the 5 year and 100 year ARI events is 6 hours.

A sample of critical duration analysis hydrographs for catchment Ct FS18 for a range of 100 year ARI event are given in **Chart 1**.

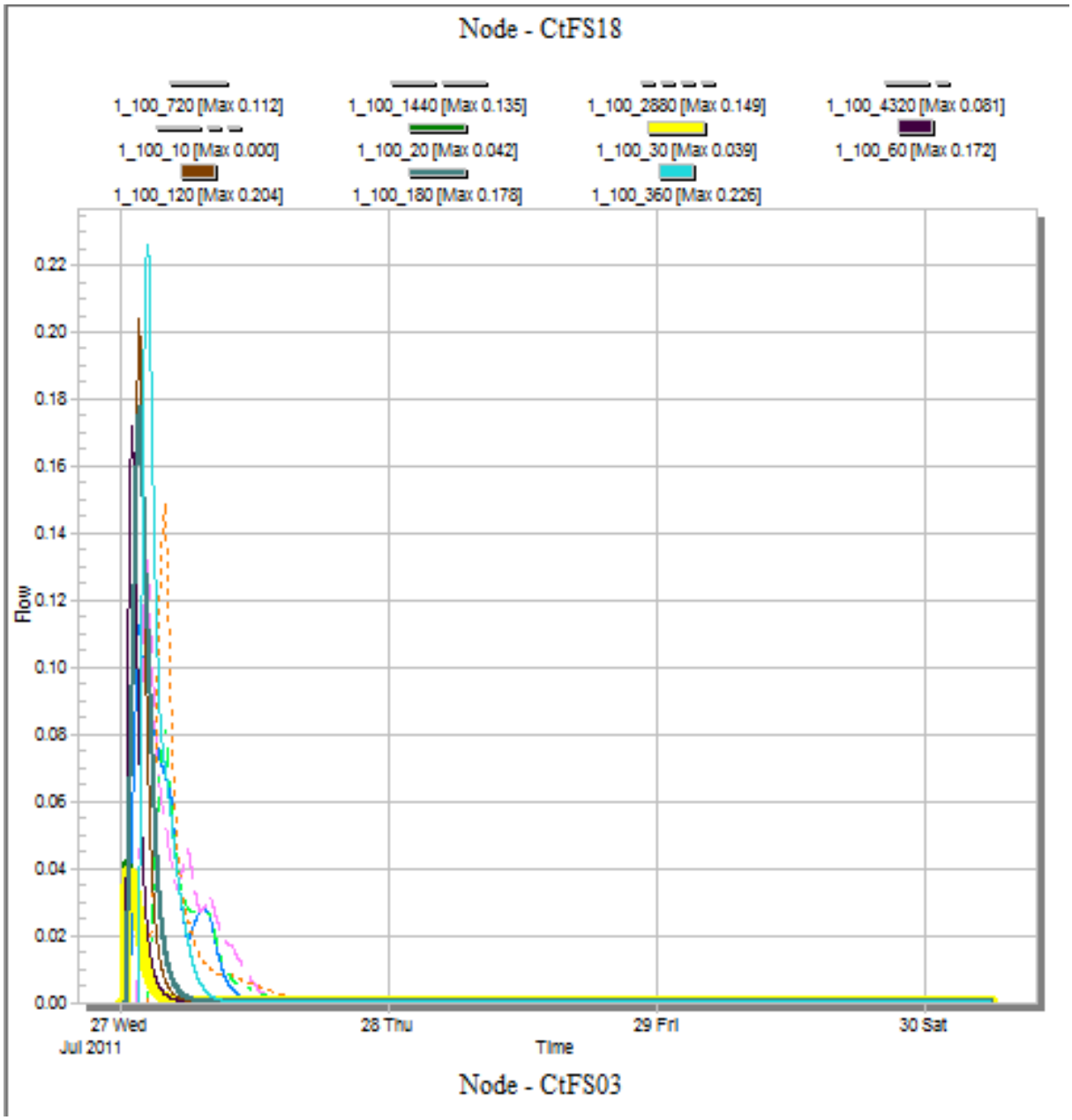


Chart 1: 5 year ARI critical duration analysis

4 Post-development Model

In order to determine the post-development hydrology of the site to assist the required retention storage, post-development model has been developed using XPSWMM.

4.1 Post-development catchment hydrology

Post-development catchments within the site were derived using the local structure plan supplied by the project team. Post-development catchment areas are shown in **Table 3** and land use characteristics are shown in **Table 4**, while Figure 9 in the LWMS shows the catchment boundaries.

Table 3 Post-development catchment parameters

Sub-catchment	Total area	Slope	Area (ha)					
			Road	Residential lots	High density lots	Group housing	Commercial lots	POS
Ct1	2.276	0.040	1.245	0.000	0.649	0.000	0.000	0.383
Ct1a	1.563	0.040	0.776	0.787	0.000	0.000	0.000	0.000
Ct2	3.479	0.024	0.523	0.235	0.000	2.721	0.000	0.000
Ct3	4.820	0.017	1.564	2.035	0.000	0.000	0.469	0.753
Ct4	7.875	0.044	3.118	2.569	0.709	0.579	0.384	0.516
Ct5	5.048	0.040	1.808	0.488	0.000	0.000	2.487	0.266
Ct6	4.804	0.020	1.670	2.668	0.000	0.000	0.000	0.465
Ct7	6.116	0.020	2.264	0.735	0.000	0.000	2.795	0.322
Ct8	3.352	0.020	1.580	0.796	0.000	0.000	0.613	0.362
Ct9	6.182	0.030	2.822	2.729	0.000	0.000	0.000	0.630
Ct10	4.674	0.029	2.276	1.903	0.000	0.000	0.000	0.495
Total	*50.188*		*19.645*	*14.945*	*1.358*	*3.299*	*6.748*	*4.191*

An “initial loss - continual loss” infiltration model was adopted to represent the post-development environment, with loss values chosen based on project team experience with similar development areas in Perth. Post-development land-use characteristics are provided in **Table 4**.

Table 4 Post-development land-use characteristics

Land Type	Initial Loss (mm)	Continual Loss (mm/h)	Manning's Number (n)
Road Surface	1	0.1	0.014
Road Verge	2	0.1	0.04
Roof	1	0.1	0.014
Lot IMP	1	0.1	0.02
Gardens	20	2.5	0.05
POS	17.5	2.0	0.05

The infiltration rates used in the post-development model were predominantly based upon the following assumptions:

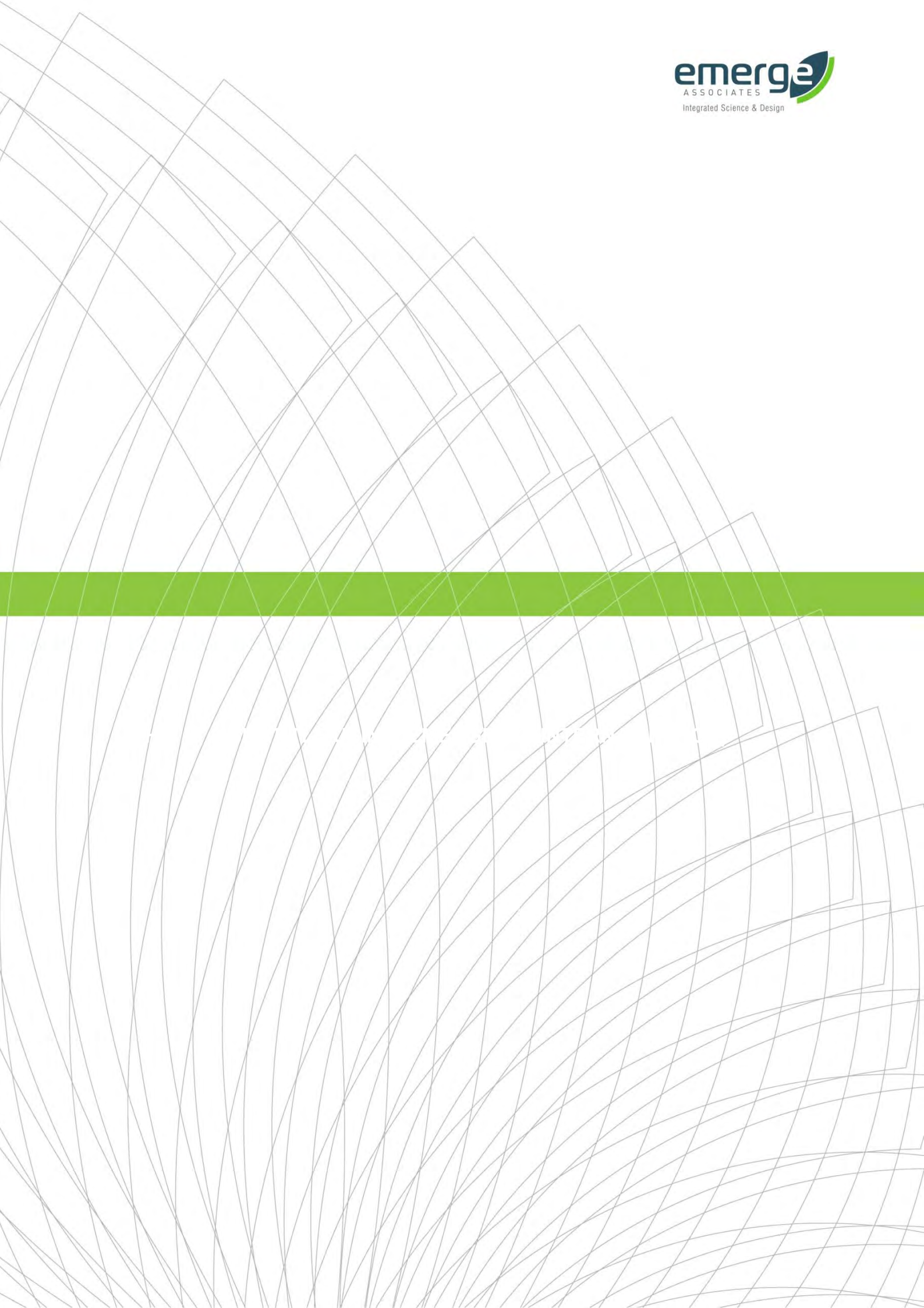
- Lots on average will be consistent with other new developments in the area and have 50% roof areas with the remainder of the lots paved (25%) and pervious garden (25%).
- High density group house lots consists with 50% roof areas with the remainder of the lots paved (45%) and pervious garden (5%). Parking areas represent within the paved area.
- Normal road reserve contains 48% pervious verge and 52% impervious bitumen.
- Roads surrounded by commercial buildings and high density group housing lots contain 25% pervious verge and 75% impervious area (i.e. Bitumen, parking areas, foot paths and other pavements).
- There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss, this is accounted for in the initial and continuing loss values.
- Garden areas will have high infiltration rates as it is likely that sand or mulch will be used.
- Open space areas or drainage reserves will likely contain dense vegetation or turf over a sand-based landscape mix. This turfed area will become compacted over time and reduce initial infiltration rates. It is anticipated that the infiltration losses allowed for in the initial loss and continual loss will be higher than the rate of runoff accumulation from the 1 year 1 hour ARI event.
- The road verge area is similar in characteristics to open space areas except that it will also have an impervious footpath and some driveway crossovers. It is anticipated that the averaged initial loss will be lower than open space initial loss rates.
- The 1 year 1 hour roof runoff from residential lots is retained on-site within lot soakwells.
- Group houses retain 50% of their roof runoff within on-site soak wells.
- Commercial lots retained 100 year runoff on-site within sub-surface storage under car parks.
- The 1 year 1 hour runoff from road reserves and rest of the 1 year 1 hour runoff from lots is retained within 0.5m deep bio-retention areas which has 1:6 side slopes.
- 100 year critical duration runoff retained on-site fully in 1.2m deep square flood storage areas with 1:8 side slopes.
- Conservation open spaces are self-retained for 100 year critical duration ARI event.
- Soakwells will have 4m/day infiltration from their bottoms and side walls and all the other storages will have 2m/day infiltration including 50% clogging factor.

- Volumes leaving the system through evapotranspiration were assumed to be negligible when compared to the total runoff volume, and since the duration of model run was comparatively short. XPSWMM default evapotranspiration assumptions are therefore used.

5 References

Landgate 2013, WA Atlas, Retrieved 24 January, 2013, from https://www2.landgate.wa.gov.au/bmvf/app/waatlas/.

Department of Water (DoW) 2013a, Perth Groundwater Atlas 2004 Edition 2, Department of Water, Perth.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