Appendix 8

Local Water Management Strategy

(Cossill & Webley)

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URBAN QUARTER – LOT 6 TARONGA PLACE, EGLINTON – CENTRAL CELL LOCAL WATER MANAGEMENT STRATEGY

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ABBREVIATIONS

AHD	Australian Height Datum
ARI	Australian Rainfall Intensity
ASSMP	Acid Sulphate Soils Management Plan
BMP	Best Management Practices
DoW	Department of Water
EPA	Environmental Protection Authority
LOT 6 LSP1	Eglinton Lot 6 Taronga Place Local Structure Plan 1
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
PDWSA	Public Drinking Water Source Area
POS	Public Open Space
WSUD	Water Sensitive Urban Design
UWMP	Urban Water Management Plan

EXECUTIVE SUMMARY

This document, prepared for Urban Quarter WA, aims to define the strategy for water management at a district level for the Eglinton Lot 6 Taronga Place District Structure Plan Amendment (Lot 6 DSP1) area for the "Central" cell which includes the land located between the future Yanchep Rail line and Mitchell Freeway extension

The report has been prepared for the DSP Amendment, with a view that it will be further refined down to that required for a local level when a Local Structure Plan (LSP) is provided.

Background

The Lot 6 DSP1 is presented in APPENDIX A. This area is currently zoned Urban under the current Metropolitan Region Scheme (MRS).

Local Water Management Strategy

The Alkimos Eglinton District Water Management Strategy (DWMS) for the District Structure Plan area indicates that an LSP is to be supported by an LWMS which is required to address the following:

- Principles, objectives and requirements for total water cycle management
- Interim water related design objectives for an LSP area
- Existing site characteristics
- Site constraints and opportunities, and identification of the critical management issues
- Discussion of potential water sources for drinking water and other uses
- Conceptual stormwater management system
- Recommended monitoring framework
- Issues to be addressed at subdivision stage (UWMP)
- Implementation framework

These components are summarised below and discussed in further detail within the main body of this LWMS.

Water Balance and Conservation

The objective of water source planning is to identify possible water sources particularly for non-potable uses in order to reduce potable water consumption. Pre and post-development water balances at the development plan scale inform the assessment of environmental water requirements and options for use of potable and non-potable water.

The results of the preliminary water balance for the Lot 6 DSP1 indicate that an average property without water efficiency measures will meet the 100kL/person/year water consumption targets set by the Water Corporation.

A significant reduction in water use can be achieved by limiting the use of potable water outside the home. Water conservation initiatives may include:

- Xeriscaping;
- Waterwise POS designs that promote the installation of native coastal or Mediterranean species;
- Rehabilitation or revegetation areas that will remain un-irrigated post establishment;
- Areas of lawn/vegetation that require significant watering to be reduced;
- Garden and lawn care education;
- Encouraging residents to install rainwater tanks.

Stormwater Management Objectives

The water management strategy will incorporate:

Water sensitive urban design - The following structural Best Management Practices (BMPs) will be used to address water quality for the Lot 6 DSP1:

- Soakwells within lots and for use as gully pits
- Vegetated swales
- Retention/detention basins

Flood management – Surface water will be directed to POS, conveyed by a combination of overland flow paths and pipes within road reserves. Roadways will be used as flood path to each of the POS/infiltration areas located throughout the LOT 6 DSP1.

Conceptual stormwater management system - A system to maintain post-development flows consisting of the following components:

- Maximising infiltration at-source to recharge the unconfined aquifer. At source infiltration is to be achieved through the use of lot-level soak-wells, street-level drainage pits, tree pits and road-side swales,
- Use of BMPs such as bio-retention swales to manage water quality (nutrient loads),
- Retention of runoff from storm events of up to 100 year ARI within the catchment using retention/infiltration systems in line with WSUD principles,
- Conveyance of flood events to a designated infiltration basin,
- Consideration of water conservation options, such as stormwater reuse, rainwater tanks, waterwise landscaping and waterwise POS area design,
- Use of non-structural practices (e.g. ongoing maintenance programs, xeriscaping) to ensure the stormwater management system functions as designed,

Groundwater management – there is significant separation to groundwater, and hence through careful management of nutrients within the future development, it is not anticipated that development of the Lot 6 DSP1 will adversely impact groundwater quality.

Monitoring

No pre-development monitoring has been undertaken for the Lot 6 DSP1. The performance of swales and bio-filters should be monitored to confirm they are performing adequately.

1. INTRODUCTION

Cossill & Webley (CW) were commissioned by Urban Quarter WA to prepare a Local Water Management Strategy (LWMS) for the Eglinton Lot 6 Taronga Place Central Portion District Structure Plan amendment (Lot 6 DSP1) area.

This LWMS has been prepared as a supporting document to the Lot 6 DSP amendment as it relates to the Central Precinct, as identified in Figure 1.

The Lot 6 DSP1 is approximately 35 hectares in area and is situated within the City of Wanneroo, approximately 45 kilometres north of the Perth city centre. The Site is bound by future stages of the existing Shorehaven Development to the south, the future Mitchell Freeway road reserve to the north & east, and Rail Reserve and future residential development to the west. Approximately 60% of the Site is covered with vegetation, which mostly consisting of shrubs and low lying bushes. A portion of Site has been cleared previously, as presented in Figure 1 below.

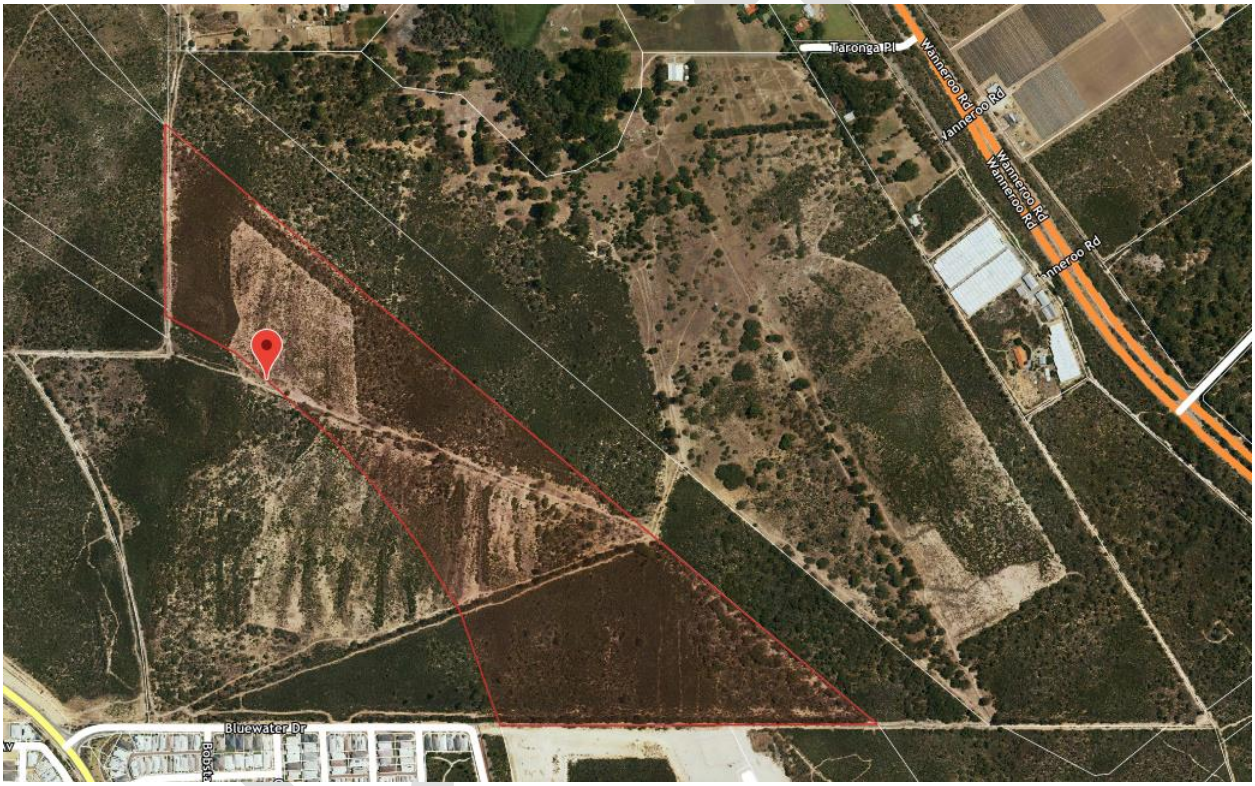


Figure 1 - Aerial Photography (MNG MAPS 2018)

A LWMS is required by WAPC's Better Urban Water Management (BUWM; WAPC 2008) to support a Local Structure Plan (LSP) prior to the development of any land zoned Urban.

Table 1 below presents the status of the Planning and Water Management strategies as required under State Planning Policy 2.9 Water Resources (WAPC 2006) and the Stormwater Management Manual for WA (DoW 2007).

Table 1 - Planning Stages and Required Management Strategies

Planning Phase	Planning Document and Status	Water Management Strategy / Plan and Status
Regional	The Alkimos Eglinton District Strategy Plan (CoW, 1995) COMPLETED	North West Metropolitan Area Integrated Water Management Study (GHD, 2005) COMPLETED
District	Alkimos Eglinton District Structure Plan (CoW, 2010) AMENDMENT PROPOSED	Alkimos Eglinton District Water Management Strategy (GHD, 2011) COMPLETED
Local	Eglinton Lot 6 Taronga Place – Central Portion - Local Structure Plan FUTURE PREPARATION	Local Water Management Strategy THIS DOCUMENT – DRAFT STATUS PROPOSED TO SUPPORT DSP AMENDMENT
Subdivision	Subdivision Application FUTURE PREPARATION	Urban Water Management Plan (UWMP) FUTURE PREPARATION

2. PROPOSED DEVELOPMENT

2.1 Previous Land Use

The Lot 6 DSP1 has previously been used for stock grazing. There is no evidence of contamination on the site itself or historical land uses which would lead to contamination.

2.2 Structure Plan

The proposed local structure plan for this site area as developed by CLE, Town Planning Consultants, is provided in APPENDIX A. The fundamental objective of the Structure Plan is the establishment of an interconnected road and pedestrian network, along with open spaces and pocket parks for both recreational use and drainage to support a residential community.

The development's land uses will primarily consist of:

- Approximately 35ha of residential land (~480 lots) and roads supporting a combination of traditional, cottage and group housing lots.
- Approximately 4ha Open Space for the provision of passive and active recreation and drainage.

2.3 Landscaping

The Lot 6 Taronga Place POS design provides for approximately 4ha of open space with a large part of this provision allocated within a centrally located area of public open space. Smaller, supporting Pocket Parks and streetscape design provide a logical distribution of POS throughout the Estate. The spacing of POS areas throughout the site ensures that all residents are located within 200 metres of a park. Preliminary landscape concepts for the Central precinct are included in Appendix E.

The following parameters also influenced the shape and location of the open space design:

- The landform and ability of the underlying topography to provide for view corridors,
- The potential for limited vegetation retention, and,
- Drainage requirements including integrating drainage within the streetscape and open spaces to complement passive recreation.

2.3.1 Landscape Theming

The parks will incorporate a multi-tiered structure of tree and shrub planting. All the parks will be designed using sound water sensitive design practice and the majority of planting will be native or native derivative shrub species with a combination of native trees and feature ornamental trees that are recognised as 'one drop' or 'two drop' species in the Water Corporation "Waterwise Guide to Gardening".

Wherever possible, areas of turf will be limited to within the parks where maximum public amenity value can be derived. Otherwise the landscape treatments will explore the use of hard or porous surfacing or alternative treatments to minimise water usage.

Areas of native planting will be positioned to augment retained areas of vegetation where possible. The species to be selected will closely align to the extant species to reinforce the local vegetative assemblage and assist in reducing the long term irrigation requirements over the development site.

2.3.2 General Landscape Treatments

2.3.2.1 Soil Amelioration

Areas of rock will be removed and replaced with soils that promote plant growth. Imported or blended on-site moisture retentive soils will be used in appropriate areas.

2.3.2.2 Overall Irrigation Management

Irrigation systems will be designed to manage the rate of application of water to areas being irrigated.

The development is located within the City of Wanneroo's North West Urban Growth Corridor, and Public Open Space (POS) has been design in accordance with the design criteria and groundwater allocations set out in the *North West Corridor Water Supply Strategy (NWCWSS, DoW 2013),* and the associated licensing schedule. The Table included in Appendix B demonstrates compliance of the design with the NWCWSS, with an associated Landscape Concept Plan for reference.

2.4 Water Conservation Strategy

At Lot 6 Taronga Place, Eglinton the following measures will be taken to reduce water wastage and to ensure water is used in the landscape in a responsible manner:

1. Adoption of water sensitive urban design (WSUD) principles;
2. Hydro-zoning of Public Open Space Landscape and Irrigation design;
3. Incremental irrigation reduction strategy applied to Streetscapes and POS where applicable;
4. Utilising soil conditioners and mulches in garden bed areas to assist with moisture retention;
5. Utilising tree pits and roadside swales which promote return of water to the environment as close to source as practicable

2.4.1.1 Specification for Irrigation

Irrigation will be designed in accordance with the City of Wanneroo's requirements.

2.4.1.2 Maintenance

The developer intends to maintain completed POS for a period of 2 years. Thereafter, POS will be maintained by the City of Wanneroo.

3. DESIGN CRITERIA

3.1 Stormwater Management Objectives

The following objectives for stormwater management have been adopted for the development in accordance with the Stormwater Management Manual for WA (DoW 2007):

Water quality and quantity – maintain the surface and groundwater quality and quantity (total water cycle balance) within the development areas relative to predevelopment conditions.

Water Conservation – maximise the reuse of stormwater, recognising that urban water flows are a potential resource.

Protection of Public Health and Property – minimise the public risk, including risk of injury or loss of life and protect the built environment from flooding and water logging.

Social Values – ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development and Economic Viability – ensure the delivery of best practice stormwater management through planning and development of high quality developed areas consistent with sustainability and precautionary principles and ensuring the long term viability of these stormwater management systems.

3.2 Stormwater Management Principles

The principles as summarised in Table 2 below will be applied to the proposed development to address the water management objectives:

Table 2 – Stormwater Management Principles

Item	Description
Water Conservation	Consider all potential water sources in the water supply planning Minimise potable water usage where possible. If possible, target a potable water consumption target of 40-60kL/person/year. Maximise stormwater reuse

Surface Water Quality	Improve groundwater quality where possible by preventing illegal dumping through development. Introduce treatment trains through the use of tree pits, verge swales, bio-retention areas, open based pit and pits (where not under roads), permeable paving and other structural and non-structural devices outlined in the City of Wanneroo's City Water Management Strategy. Implement end-of-pipe measures to mitigate any remnant contaminants entering the groundwater prior to discharging to receiving environments.
Stormwater Management	Disposal method - On-site infiltration using swales and basins. Up to 1 year ARI events - Where grades permit target capturing "very frequent events" which are to be infiltrated in the vicinity of the stormwater runoff collection points through tree wells and verge swales, with the balance of the 1 in 1 year ARI event to be stored in POS. Greater than 1 year and up to 100 year ARI events - Storm event flow to be transferred to an infiltration swale. - Infiltration swale to be sized for the critical 1 in 5 year and 1 in 100 year ARI storm events. - 100 year ARI events are to be contained within POS depicted on the Lot 6 LSP1.
Stormwater Conveyance System and Treatment	Conveyance system - Pipe system or swales sized for the critical 5-year ARI storm event. Gross pollutants - Suitably sized gross pollutant traps to be included on the outlet of all pipe systems discharging into public area infiltration swales. - Manholes - Use of soakage manholes to enhance stormwater infiltration for low flow events. Dissolved nutrients - A combination of various structural and non-structural devices will be determined based on the City of Wanneroo's City Water Management Strategy, and may include features such as infiltration basins, permeable paving, verge swales, tree wells and bio-filtration areas. The selection and location of these features will be determined at the UWMP preparation stage.
Stormwater Collection	- Public roads to be kerbed with side-entry pits or with gaps in the kerbing to allow stormwater to flow to the piped or swale drainage system. This arrangement will allow for easier management of large spills on the road pavement.
Flood Management	Road Reserves - Storage volume is required within the road reserves and at the site of the infiltration swales to accept flows from the critical 100-year ARI storm event.

	- The flood path for water exceeding the design level of the flood storage area to be directed away from development by providing overflow flow paths and maintain a minimum of 0.3m freeboard between the 100-year flood level and finished lot levels. - A minimum of 0.3m freeboard between the 100-year water level and the finished levels for lots adjacent to POS basins.
Local Permeability	In-situ soil permeability is to be tested in drainage disposal locations to ensure the appropriate sizing of the drainage infrastructure at the UWMP stage.
Vector and Nuisance Management	Ensure, as far as practicable, the design of drainage swales, infiltration basins, road gullies etc. do not contribute to onsite mosquito breeding. Provide ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed, thereby reducing the risk of creating conditions likely to promote mosquito breeding.
Other Requirements	All other requirements as prescribed/allowed by the City of Wanneroo.

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Site Characteristics

The Site is approximately 35 hectares in area and is situated approximately 45 kilometres north of the Perth city centre, within the City of Wanneroo. An aerial view of the Site is presented in Figure 1.

4.2 Geology and Landform

The Geological Survey of Western Australia Perth Metropolitan Region Soils Maps indicates the majority of the Site is generally characterised by Limestone (LS_1) light yellowish brown, fine to coarse grained with a portion of the Site characterised by Calcareous Sand (S_1) white, fine to medium grained.

This soil type is well suited to urbanisation, and is generally very permeable, allowing for the on-site disposal of runoff from newly created roads and lots. *Figure 2* below presents the geology across the Lot 6 DSP1.

Although a detailed geotechnical investigation has not been completed across the whole Site, it is anticipated that some surface rock will be present, predominately as cemented limestone along ridge lines within the existing dunes.

Based on our experience on similar projects within the area, the Site is well suited for future urban development and the on-site disposal of runoff generated from newly created roads and lots.

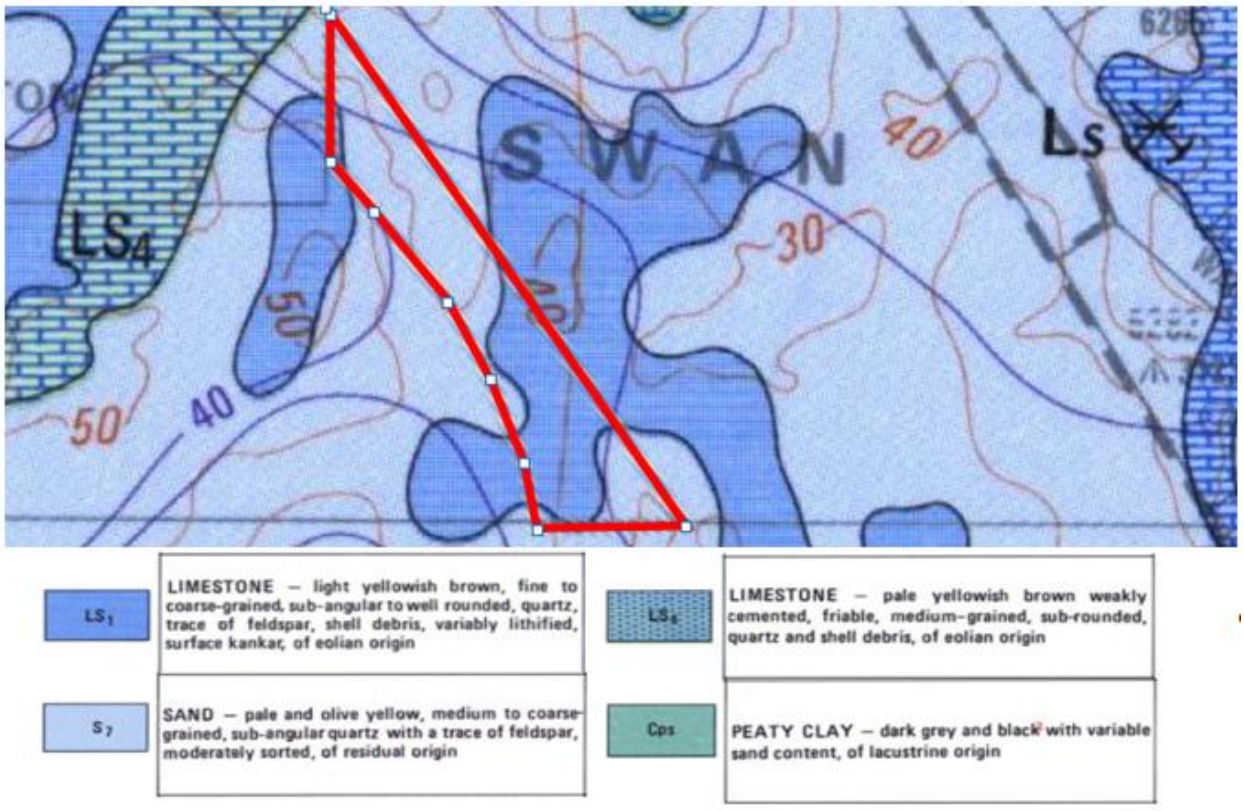


Figure 2 - Geotechnical Information (Geological Survey of WA)

4.3 Existing Topography

The Site comprises undulating dunes ranging in elevation from a peak of 45m AHD at the southern end of the western boundary where it abuts the Yanchep Rail Reserve, to a low of approximately 22m AHD on the north-eastern boundary with the Future Mitchell Freeway reserve as presented in Figure 3 below. Other significant topographical features include a ridge running in a north-south direction at the mid point of the Site at approximately 40m AHD, and a low point of 26.0m AHD in the south-eastern corner of the site.

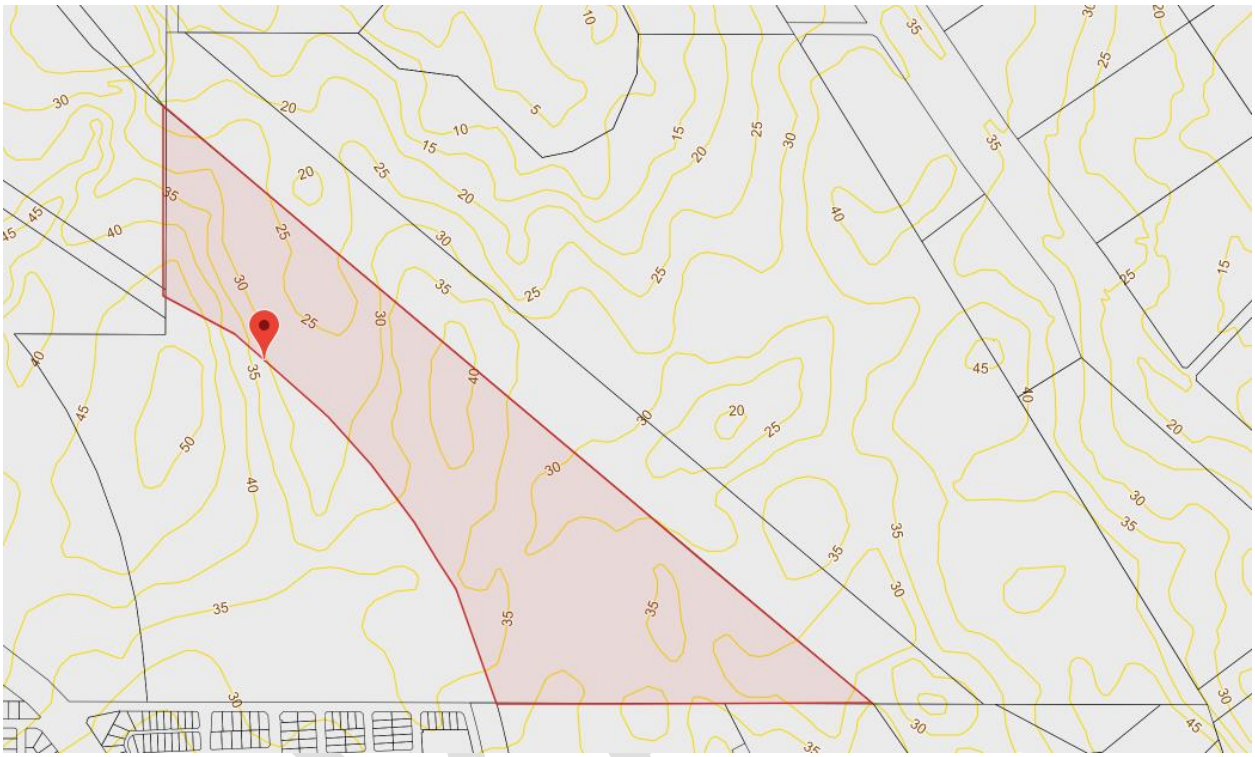


Figure 3 - Site contours (MNG Maps 2018)

4.4 Karstic Formations

Karstic ground formations are known to occur in the limestone rock in a north-south band along the eastern side of Wanneroo Road.

A visual inspection of the site was undertaken by the Western Australian Speleological Group (WASG) in 2007 identifying surface karst, confirming the likely presence of subterranean voids.

CMW Geosciences were engaged to review the likely impact of karst formations within the Site, and their report is presented in Appendix C for information. The eastern portion of the Site is considered to be within a recognised zone of potential karst features as presented below in Figure 4.

CMW's preliminary assessment recommends mitigating the risk where development is proposed within the karst risk zone. The majority of the karst risk area of the site coincides with areas of deep fill (more than 3m).

Figure 4: Inferred Potential Karst Risk Zone (CMW)

4.5 Unexploded Ordnance

The Department of Fire and Emergency Services (DFES) Unexploded Ordinance (UXO) has confirmed the Site lies within the north eastern portion of the former WWII Eglinton Training area where there may still be a slight risk from UXO contamination.

There are no known previous UXO assessments or survey over the Site, so whilst the risk from UXO is minimal, it is recommended that a limited UXO assessment survey (Field Validation Search @ 10% Coverage) be completed to confirm or discount whether explosive filled munitions have impacted the Site. If no evidence is found, then the area can be regarded as at very low risk and no further assessment or survey will be required by DFES at or during any future planned subdivision works. The awarded Site Contractor will be required to consider UXO in their Safety Management Plans.

4.6 Acid Sulphate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the North Metropolitan Region for potential for acid sulphates soils (ASS) indicates the Site is classified as having no known risk of ASS potential. Given the low risk is not proposed to undertake any ASS testing or prepare an ASSMP as part of the development.

4.7 Groundwater Hydrology

The Annual Average Maximum Groundwater Level (AAMGL) varies from approximately RL 3.0m AHD on the western boundary to just over RL 4.0m AHD at the eastern boundary according to the Department of Water's Perth Groundwater Map. Given the natural ground levels across the Site, ground water will not control earthworks designs, nor impact adversely on any development.

4.8 Wetlands and Water Dependant Ecosystems

There are no wetlands or water dependant ecosystems within the extent of Lot 6 LSP1.Wetland UFI 8016 is located about 400m east-north-east of the Site.

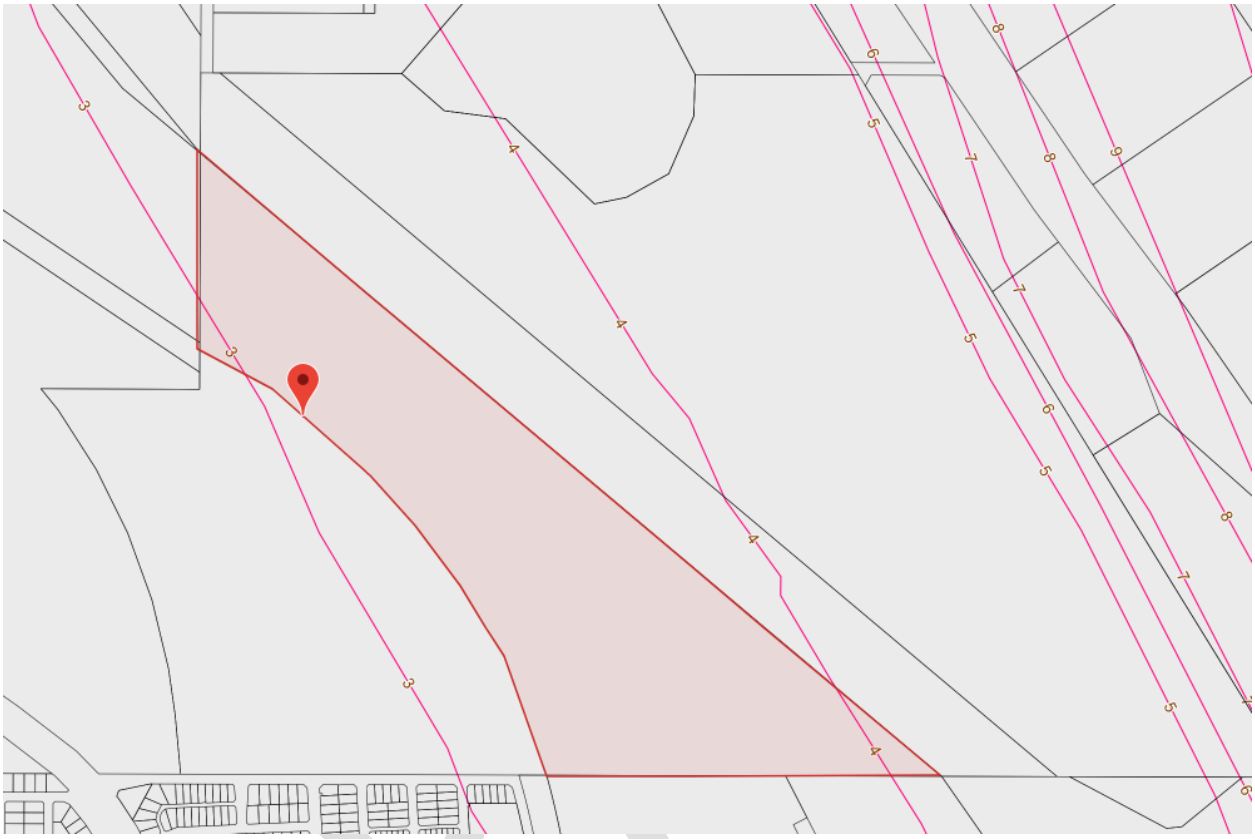


Figure 4 – Ground Water Contours – Historical Maximum (Dept. of Water 2015)

4.9 Environmental Assessment Summary

The following summarises the site from an environmental perspective -

- The majority of the site has been used for grazing purposes. Whist portions of the site support native vegetation, the majority of this vegetation is regrowth, having been previously cleared within the previous 20 years. Firebreaks and previously grazed paddocks are also present,
- Vegetation across the site encompasses approximately 33ha, comprised of low woodlands and shrublands with occasional larger eucalypt trees which have been planted, possibly as wind breaks. The condition of the vegetation ranges from Completely Degraded to Excellent.
- Approximately 20 ha of the vegetation provides foraging habitat for Carnaby's Black Cockatoo species.
- There are no surface water bodies within the LSP area. The nearest wetland is a Sump-land Resource Enhancement Wetland (UFI 8016) adjacent to the northern boundary of Lot 6 Taronga Place, approximately 400m from the LSP area. Surface water is largely retained within the site due to the high permeability of the underlying soils and the wetland is up-gradient of the site.
- The EPA has formally assessed Metropolitan Region Scheme Amendment 1029/33 for the broader Alkimos Eglinton area which identified specific areas of regional environmental significance which included scattered Tuart trees and Carnaby's Black-Cockatoo habitat. In response, 500 hectares of the identified environmental significant area (20% of the Alkimos-Eglinton region) was reserved for conservation purposes as Parks and Recreation or Public Purposes (Conservation) zonings.

- The EPA during its assessment of MRS Amendment 1029/33 did not identify any areas of regional conservation significance within the urban zoned portion of the Lot 6 DSP1.
- The Commonwealth Government is concluding its assessment and approval is expected to be granted in early September

4.10 Pre-Development Groundwater Quality

The Alkimos Eglinton DWMS prepared for the Alkimos Eglinton Land Owners (AELO) by GHD, contains groundwater quality monitoring results. The bore in closest proximity to the Site is EGSOU2, which is located north-west of the Site. Groundwater quality result parameters significant to the LWMS are summarised in the Table below.

Bore ID	pH	EC (mS/cm)	TDS (mg/L)	TN (mg/L)	TP (mg/L)	NO_3 (mg/L)
EGSOU2	7.5	<0.1	608	130-180	<0.01	<0.05

4.11 Public Drinking Water Source Area

The Lot 6 DSP1 is situated within a Priority 3 (P3) Public Drinking Water Source Area (PDWSA). P3 PDWSAs are declared over land where drinking water supply sources need to coexist with other land.

5. WATER SUSTAINABILITY INITIATIVES

5.1 The Water Cycle

Figure 5 below demonstrates the difference between the pre-development and post-development non-potable water supply.

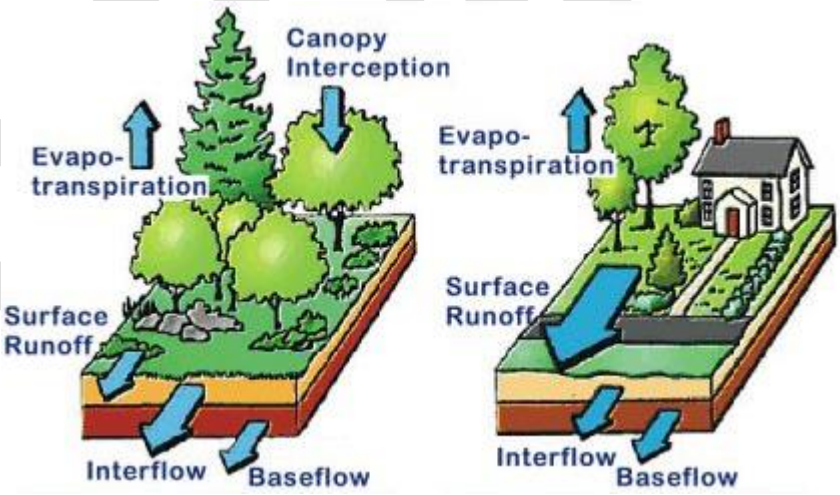


Figure 5 -Water Cycle (Pre and Post Development)

5.2 Water Demand

Water conservation is part the development's objectives with regards to managing a sustainable integrated water cycle. At the broad scale, the approach includes incorporation of water sensitive urban design at the local and lot scales, facilitating reduction in scheme water use, maximising the use of water efficient devices in houses and buildings and water efficient gardens and landscaping and substituting scheme water with non-drinking water for some uses.

In terms of water conservation, the developer recognises water as a valuable natural resource, and is well aware of water conservation initiatives and the need to reduce water use across the estate.

The hierarchy of the five water conservation principles will be followed: avoiding water use, reducing use, recycling, disposing appropriately, and ensuring feedback and adaptive management. The emphasis will be on the most preferred principle of avoiding water use.

The development of the Lot 6 DSP1 will focus on encouraging the community to use water saving devices and appliances through providing incentives; promoting the use of plants native to the locality as well as water wise plants in other areas, providing information and community education programs about water conservation issues.

5.3 Water Balance Modelling

5.3.1 Water Demands

Development of a greenfield site will impose changes to the water cycle within the developable and surrounding area, therefore it is necessary to predict the effects that urban development will have on the land and plan for the water demand of future development. The projected water balance for the Lot 6 DSP1 has been calculated in accordance with the Alkimos Eglinton DWMS.

A lot scale water balance has been undertaken for the Lot 6 DSP1 area to assess the impact of the lot scale water conservation measures on water consumption. The approach is based on three scenarios:

- Scenario 1: Conventional Scenario with a combination of traditional and cottage lots with a median size (500 m^2 lot), 10% of the lot irrigated with no water conservation measures and 2.7 persons/dwelling.
- Scenario 2: Lot 6 DSP1 best outcome: median 500 m^2 lots with all houses having waterwise gardens, 2000L rainwater tanks and water efficient fittings on all lots and 2.7 persons/dwelling
- Scenario 3: Lot 6 DSP1 likely outcome: median 500 m^2 lots with use of waterwise gardens on 30% of lots, 2000L rainwater tanks on 15% of lots and water efficient fittings on 50% of lots and 2.7 persons/dwelling.

Assessments were undertaken on the basis of the Water Corporation spreadsheet water_balance_tool.xls.

Numbers of persons per dwelling are based on the assumptions used in this spreadsheet. In all cases, allowance is made for irrigation of the verge.

The results of the modelling are presented in Table 3 below. The results indicate a total water use of 63 kL/person/year, with 46.8 kL/person/year of scheme water is anticipated. Results of the water balance indicate that an average property without water efficiency measures will meet the current Water Corporation target of 100 kL/person/year water consumption.

Scenario	Total Water Use (kL/person/year)	Potable Water Use (kL/person/year)
Scenario 1	69	47
Scenario 2	61	46
Scenario 3	63	46.8

Table 3 – Lot Water Balance

5.4 Ground Water Allocation

Lot 6 previously held a groundwater licence under the name of G. Spiers (Licence No. 153683),who was the previous owner. The total licensed volume is 54 850 kL/yr and the licence is valid until 19 November 2019.

The purchaser of Lot 6 (the proponent of this LSP has transferred the previous licence to their name.

The calculations included in Appendix B confirm that the portion of Lot 6 included in the LSP and LWMS can be irrigated in accordance with the NWCWSS and not exceed the licenced volume.

5.5 Water Conservation and Efficiency

Water conservation is highly dependent on WSUD principles, which promote maximising infiltration through source control Best Management Practices (BMPs), and minimising the effective impervious area of the development plan. Consequently, the adoption of appropriate surface and groundwater management strategies is vital to the viability of total water cycle management and its requirements to maximise water conservation and reuse.

In order to quantify water conservation for the Lot 6 DSP1, a detailed water balance will need to be undertaken at the UWMP phase. Various measures for water reuse (such as rainwater tanks for non-potable use) will also be further investigated at UWMP phase.

The Water Corporation's Domestic Water Study in 2003 revealed that the total average use per household is 460 kL per annum. Assuming 2.7 people per household (Australian Bureau of Statistics 2001 Census Figures), this equates to 164 kL/person/year. The State Water Strategy target was to reduce water usage to 155 kL/person/year, however as this target has been met in recent years, the State Water Plan has set a target of 100 kL/person/year.

The use of potable water should be minimised where drinking water quality is not essential, particularly for irrigation and external uses.

An estimation of POS irrigation requirements for the site, including a breakdown of total POS area, irrigated areas (permanent and establishment), non-irrigated areas, irrigation rates, etc, has been included in Appendix B of the LWMS.

5.5.1 Water conservation initiatives

The Water Corporation estimates that garden watering accounts for up to 60% of Perth's domestic scheme water usage. This is a particularly low value use for what is, in essence, a high quality resource (drinking water). Consequently, a significant reduction in potable water use can be achieved by minimising water use outside of homes. Based on this, the following initiatives will be considered in the LWMS and UWMP phases to reduce water usage for the Lot 6 LSP1:

- Xeriscaping,
- Reduced areas of lawn/gardens that require significant amounts of watering,
- Waterwise POS designs that promote the installation of native coastal or Mediterranean species,
- Promoting infiltration at source,
- Garden and lawn care education,
- Encourage residents to use rainwater tanks.

5.5.2 Waterwise landscaping

Provision of Waterwise landscaping packages will be considered by the proponents to land owners to achieve the following principles (as recommended on the Water Corporation's Waterwise website):

- Minimise the extent of high water consumption planting and lawn areas,
- Maximise the use of water conserving elements and techniques,

- Apply the basic principle of hydrozoning to planting design (grouping plants on the basis of having similar water requirements).

These design principles can be achieved through the following initiatives:

- Maximise the use of non-planting treatments such assoil conditioners and mulches,
- Keep planted areas dense and consolidated since sparse, scattered plants are more difficult to water efficiently than ones that are in defined areas,
- Keep lawn to the minimum consistent with functional and aesthetic requirements and avoid planting lawn on slopes or in narrow necks or paths which are difficult to water efficiently and maintain,
- Plant waterwise lawn and garden areas, which reduce the amount of grassed areas and employ water efficient sprinklers ,
- Controlled water application rates to suit the water requirement of plant, climate and rainfall patterns,
- Maximise at-source infiltration through WSUD principles using soakwells and infiltration BMPs such as bio-retention swales and detention storage zones within the POS areas.

5.5.3 Waterwise POS Design

Groundwater will be utilised for POS irrigation at Lot 6 DSP1.

To further reduce this water use, POS areas will be landscaped with the following to reduce irrigated areas:

- Mulches and groundcovers,
- Use of native coastal or Mediterranean species,
- Swale littoral planting and rehabilitation planting,
- Reduced turf areas,
- Incrementally reduce irrigation cycles as plants become established.

5.5.4 Waterwise Streetscaping design

To further reduce this water use, road reserve designs in UWMP stage should consider the following initiatives to reduce water usage:

- Street trees, shrub or groundcover planting should be waterwise, with predominantly native coastal or Mediterranean species,
- The promotion of infiltration at source in verge swales in the 1:1 year or (if appropriate) the 1:5 year ARI storm event.

5.5.5 Infiltration

Infiltration of stormwater is common practice in West Australian land development projects and is considered an appropriate source control measure that can significantly reduce the magnitude and volume of stormwater runoff generated from the site.

Infiltration of rainwater generated from roof areas into the groundwater can be adopted without the need for pre-treatment on the basis that roof areas generate significantly lower nutrient loads. The infiltration of roof runoff can be through the use of soakwells installed at the building stage.

5.5.6 Rainwater tanks

Rainwater tanks capable of collecting stormwater directly from a roof or other above ground surfaces promote the reuse of the collected water as a substitute for potable water for use as a source of irrigation water and in some cases toilet flushing, laundry use or for hot water.

The use of rainwater tanks will be encouraged; but not mandated for this development.

5.6 Non-Potable (Third Pipe) Water Supply

The third pipe system for non-potable water supply is a technique where POS and household irrigation water is extracted from a production bore located within close proximity to the irrigation area. The third pipe system generally caters for a broader irrigation area supplying water to many consumers (rather than individual bores for each consumer). Based on the relatively small scale and commercial nature of this project, it is not proposed to install a third-pipe water supply at this development, as the irrigation areas at an allotment scale will be relatively minor.

6. STORMWATER MANAGEMENT STRATEGY

6.1 General

Best Management Practices (BMPs) in accordance with the Department of Water's Stormwater Management Manual and the City of Wanneroo's City Water Management Strategy will be implemented where drainage is required on site. At the detailed design and UWMP preparation stage, the planning layout and site characteristics will guide the selection of BMPs appropriate for the development. BMPs are the best practical approach for achieving water resource management objectives within an urban framework.

Best Management practices include the following elements which will be implemented for this project:

- Integration of active and passive POS areas into local urban water management.
- Design of road layout and streetscape to deal with water as a resource and an amenity. This will generally involve the use of roadside swales planted with natural, coastal vegetation.
- Structural and non-structural control measures such as; bio-retention areas, verge swales, tree wells, open based pit (where permitted by the City) and pipe structures (where not under roads), community education and street sweeping.

6.2 Flood Management Design

The overall stormwater catchment plan for the site is presented in Drawing 5826-00- SK42 provided in Appendix D. The design is based on the following design parameters:

- All runoff from lots greater than 300m^2 will be retained on-site within soakwells and garden areas. Lots less than 300m^2 will retain the 1yr 1hr ARI event in on-site soakwells.
- Runoff from the road network for "very frequent events" will be detained as much as practical at source through the use of tree pits and roadside swales. To this end for this project the "very frequent event" adopted is the 15 minute 4 EY event (equivalent to 6.28mm of rainfall as per the BOM website). Any additional runoff not contained upstream in the catchment will be directed to POS areas. Flows which overtop the 1yr 1hr detention areas will flow into the POS storage/infiltration basins,
- Road runoff from events up to 5 year ARI will be conveyed via the piped drainage network to infiltration swales situated within POS areas. This will ensure that roads and walkways remain serviceable during these flood events. Side entry/gully pits will be located to suit appropriate spread rates and pit spacing for the required ARI storm event and road hierarchy,
- The 100 year flow paths are to be conveyed by overland flow paths within the road reserve to POS areas,
- The POS areas will be able to accommodate runoff from events from 1 in 5 year to 1 in 100 year ARI without unreasonably impacting on the amenity of proposed parks,
- Building pad levels will be at least 300 mm above the 100 year ARI flood level within each sub-catchment to the dynamic part of the drainage system, with 500mm freeboard being provided to end-of-line basins,

- An infiltration rate of 2m/day for tree wells, roadside swales and 1 in 1 year basins and an infiltration rate of 5m/day for POS which is not regularly inundated. Infiltration rates are to be validated following the completion of bulk earthworks. In some cases, more than 5m of earthworks is required to expose design levels making it impractical to determine infiltration rates now.
- A coefficient of runoff of 0.6 has been assumed for the 1 in 1 year ARI event. A coefficient of 0.8 from road reserves has been assumed for all events exceeding the 1 in 1 year ARI event, which is consistent with CoW policy. For lots less than 300m2, a runoff co-efficient of 0.65 has been assumed for all events exceeding the 1 in 1 year ARI event, which takes into account the 1 in 1 year ARI event detained within the individual lots.
- Due to the significant depth to the groundwater table, it is considered appropriate to allow the 1 in 1 year basins to be inundated in larger events. This approach has been assumed and will facilitate more flexibility with respect to POS design and lead to POS which has good amenity.

6.3 Drainage Area Requirements

The strategy adopted for stormwater quantity management for the development plan is to provide storage on a sub-catchment level to detain flows for storm event greater than 1 year 1 hour ARI, and up to the critical 100 year ARI events. Flood storage will take the form of swales and basins within the POS areas.

6.4 Preliminary Drainage Basin Sizes

Drawing 5826-00-SK 42 presented in Appendix D depicts sub-catchment areas as determined by Cossill & Webley and includes a table summarising drainage calculations undertaken as part of preparation of this LWMS.

The following methodology was used to determine preliminary drainage basin areas and volumes -

- Catchments were identified and runoff volumes calculated for the in 1 year, 1 in 5 year and 1 in 100 year ARI events,
- Drainage for the 1 in 5 year and 1 in 100 year ARI has been assumed to be disposed by way of rectangular basins within POS each having side slopes of 1 in 6, except where in the locations of 1 in 1 year basins where a 300mm step in ground levels is proposed,
- Dimensions of the base of each basin were assumed and iteratively adjusted to ensure the depth of flooding for the 1 in 100 year event is less than 1.2m. PC Sump was used for this exercise and an infiltration rate of 5m/day was adopted. Preliminary volumes and flooded areas were derived for each basin,
- Preliminary volumes and flooded areas were provided to Plan E, the project's Landscape Architect, along with preliminary design levels for each POS including surrounding roads,
- Using the preliminary volumes derived by Cossill & Webley, Plan E prepared indicative conceptual designs for each POS to confirm drainage could be stored and disposed within each POS without compromising the integrity, functionality or usability of POS. Plan E's conceptual designs are included in Appendix E.
- Based upon Plan E's conceptual designs, Cossill & Webley remodelled drainage in each POS using PC Sump to ensure the 1 in 100 year ARI event could be accommodated to City of Wanneroo requirements and to ascertain the extent of flooding for each event. The extent of flooding associated with the 1 in 5 year event was used to inform POS calculations being undertaken by the Town Planning Consultant. Based upon work undertaken to date the extent of Restricted Open Space is less than 20% of the total area of POS associated with the LSP.

It is proposed as much of the 1 year 1 hour storm as practical will be retained at-source in roadside swales and tree pits. In a practical sense a target of retaining a 4 EY event has been set with the portion of the 1 in 1 year event not retained at-source to be directed to small basins in POS.

Actual basin sizes, locations and layouts are to be set as part of the detailed UWMP prepared for each stage of the development. Further consultation will also be undertaken with the City of Wanneroo during this process taking into account their drainage and maintenance requirements for integrated drainage/POS areas.

6.5 Stormwater Treatment Trains

WSUD and BMP strategies aim to minimise the impacts of urban development on flooding and water quality whilst realising the greatest potential for the use of stormwater as a resource.

WSUD and BMP strategies involve the implementation of structural and non-structural controls. Structural controls are constructed systems that treat or divert stormwater to achieve a desired objective. Non-structural controls are institutionally managed practices that prevent or minimise pollutants from entering the stormwater system or reduce the volume of stormwater requiring management.

Controls may be located at source, in transit or at end-of-pipe. To protect the receiving environments, the preference is to locate the controls at source and as high up in the catchment as possible. The following stormwater management hierarchy applies:

- Implement source controls (structural and non-structural) to prevent pollution or treat stormwater as high in the catchment as possible.
- Install in transit measures to treat stormwater throughout the conveyance systems.
- Implement end-of-pipe measures to mitigate any contaminants remaining in the stormwater prior to discharging to receiving environments.

Source controls may be either structural or non-structural BMPs designed to minimise the generation of excessive stormwater runoff and/or pollution of stormwater at or near the source. The Stormwater Management Manual for Western Australia (DoW, 2007) encourages a treatment train approach, where combinations of measures (structural and non-structural) are implemented in parallel or sequence to achieve best management of stormwater.

The implementation of structural BMPs into an urban landform has multiple environmental benefits including reducing pollutant export, retarding storm flows, maintaining and improving urban landscape, protecting receiving environments and reducing irrigation requirements.

6.6 Surface Water Quality Management

Structural BMPs will be implemented to achieve the water quality objectives outlined in this document. The following structural BMPs will be considered to treat runoff from regular storm events:

- Lot runoff will be infiltrated at source via soakwells contained within each lot.
- Implement bio-retention swales at appropriate locations within street verges to treat runoff from storm events up to and including part of the 1 year 1 hour ARI.
- A combination of stormwater gully pits and the retention of regular events (up to 1 year 1 hour ARI) on site will ensure that there is at least a 70% reduction in gross pollutants. The gully pits and the riser/orifice structures in the infiltration basins will behave as a series of gross pollutant traps.

  Alternatively, Gross Pollutant Traps (GPTs) can be installed at outlet locations prior to discharging into POS.
- Other treatments such as verge swales, permeable paving and non-structural control measures will also be identified and determined at the UWMP stage.

6.7 Surface Water Quality

The quality of recharge water will be managed by applying structural and non-structural source controls. In transit and end-of-pipe controls may also be incorporated into the drainage design to enhance the quality of aquifer recharge water.

7. GROUNDWATER MANAGEMENT

7.1 General

As discussed in Section 2, the existing groundwater is well below the existing and proposed development levels. Due to the depth to the groundwater, the proximity to the coast and the highly permeable insitu soils, it is unlikely that the existing groundwater levels or quality will be affected by the proposed development.

7.2 Subsurface Drainage

Due to the depth to the groundwater and the highly permeable insitu soils, subsurface drainage to control groundwater levels will not be required for the development.

7.3 Groundwater Quality Management

The following strategy will be adopted to satisfy groundwater quality related conceptual design objectives:

- Where practical, bio-retention swales will be used to treat infiltrated runoff within the road reserves,
- Landowners will be encouraged to minimise turfed areas and to landscape their gardens using native vegetation where practicable,
- Landowners will be encouraged to use loamy topsoil to improve the efficiency of fertilisers and retain phosphorous that would otherwise percolate through the sand limestone subsurface to the water table,

In addition to the above structural initiatives, non-structural BMPs will also be encouraged to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management. Chapter 7 of the Stormwater Management Manual for Western Australia (DoW, 2007) provides guidance on the use of non-structural BMPs. Initiatives to be implemented for this project include:

- Construction practices that incorporate drainage, erosion, sediment and dust controls
- Maintenance practices, including
    - Regular maintenance of bio-retention and vegetated swales (e.g. removing accumulated litter),
    - Street sweeping,
    - Manual litter collections,
    - Repairing roads and pavements,
    - Education and participation programs,
    - Focused stormwater education at new estates (e.g. promoting xeriscaping, responsible fertiliser use, and shallow groundwater reuse)

8. THE NEXT STAGE: SUBDIVISION AND URBAN WATER MANAGEMENT PLANS

8.1 General

Water quality management for the site will be in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007), and the City of Wanneroo's City Water Management Strategy. BMPs such as verge swales, bio-retention areas, permeable pavement and open based pit and pipe structures (where not under roads) will all be considered at the detailed design and UWMP stage. Specific BMPs appropriate to the structure plan will be determined as part of the UWMP study when final subdivision layouts are available, enabling necessary further investigations to determine the suitability of BMPs based on site conditions (groundwater levels, geotechnical conditions etc.) and site constraints to be carried out.

8.2 Issues to Address at UWMP

It is expected that an UWMP will be required as a condition of subdivision development. The UWMP will be consistent with the requirements of this LWMS. An UWMP is an extension to an LWMS in that it provides objectives and guidelines applicable to detailed subdivision design.

The UWMP should address the following (where relevant):

- Compliance with the design objectives in the LWMS. Demonstration of compliance should be achieved through appropriate calculations or assessments.
- Characterisation of the soil stratigraphy and geotechnical conditions through formal geotechnical investigations across the site.
- Identification of measures to achieve water conservation and efficiencies of use.
- Detailed design of the stormwater management system, including the size, location and design of POS areas to best manage flood events.
- Specific structural and non-structural BMPs and treatment trains.
- Management of groundwater contamination (hot spots) and other specific site conditions.
- Management of subdivision works (to ensure no impact on regional conservation areas and management of any dewatering and soil sediment including dust).
- Management of disease vector and nuisance insects (mosquitoes and midges).
- Monitoring program and or contribution.
- Implementation including roles, responsibilities, funding and maintenance arrangements.

Further guidance on how to address urban water management at subdivision is contained within Liveable Neighbourhoods Edition 3 (WAPC, 2004), the DoW's Stormwater Management Manual for WA (2007), the Australian Runoff Quality Guidelines (IEA, 2006) and Australian Rainfall and Runoff (IEA, 2001).

The work undertaken in this LWMS was based on a draft structure plan for the site and on high level, estate scale drainage concepts. Hence the water management strategy proposed in this document will still apply should there be minor adjustments to the structure plan layout.

At the next phase of planning (the UWMP subdivision phase) the final structure plan will be modelled in further detail to consolidate the water management concepts outlined in this report.

8.3 Detailed Hydraulic Design

More detailed hydrologic and hydraulic modelling will be undertaken during the subdivision design phase (UWMP) to enable the drainage design to be implemented.

Specifically, the following drainage design components will need to be specified:

- Finished levels will be gradually refined to maintain the approximate catchment boundaries as illustrated in Appendix D.
- The drainage pipe system will be designed to convey a 5 year ARI rainfall event,
- Lot level infiltration structures will be designed to infiltrate all rainfall events,

8.4 Assessment and Review

Technical review of the water quality and quantity data will be completed by a qualified consultant. The outcomes of these reviews will be used to guide the WSUD strategies, and choice and sizing of BMPs. The LWMS should be reviewed by the developer in consultation with the relevant government bodies and planning agencies. The LWMS should receive periodic review so that it remains applicable to the site following any changes to the regional and local planning and development process.

9. MONITORING AND IMPLEMENTATION

9.1 General

The monitoring programs described in this section will be funded by the Developer. A suitably qualified environmental consultant will be engaged to complete the monitoring exercises and report on the outcomes of the monitoring programs.

9.2 Recommended Program for UWMP

It is proposed the following be undertaken at the UWMP stage of the project –

Undertake hydraulic conductivity tests at basin locations, after bulk earthworks have been completed, to confirm actual hydraulic conductivity values measured are equal to or exceed hydraulic conductivity values assumed in modelling basin sizes,

Establish a contingency plan in the event actual hydraulic conductivity values measured are less than or exceed hydraulic conductivity values assumed in the modelling and design of infrastructure,

Utilise monitoring by the Alkimos Eglinton Land Owners (AELO) Group and adopt this as the basis for pre-development monitoring.

9.3 Recommended Program for Post Development

It is proposed the following be undertaken at the UWMP stage of the project –

Monitor swales, tree wells, and bio-filters to demonstrate their performance is adequate including monitoring of vegetation condition and check stormwater is infiltration is adequate ,

Undertake testing for nutrients and metals 2 years after the last lot is created, but only if there is reason to suggest levels may be more than one standard deviation higher than typical levels experienced in the north-west corridor.

9.4 Roles, Responsibilities and Funding

The key stakeholders to whom responsibility for implementing Urban Water Management Plans can be assigned are:

- Developer
- City of Wanneroo
- Water Corporation
- Landowners
- Department of Water

The roles, responsibilities and funding for each of stakeholder is summarised in Table 5.

Table 5 – Roles, responsibilities and funding for the Water Management Strategy

Organisation	Role	Funding
Developer	▪ Satisfy the relevant WAPC conditions relating to the preparation of a UWMP ▪ Designs and constructs the potable water supply and sewer supply to Water Corporation standards. ▪ Designs, constructs and maintains POS's (maintenance period to be negotiated with City of Wanneroo) ▪ Undertakes post-development activities for the submission to regulatory authorities for a period of 2 years following Practical Completion (As part of the UMWP). ▪ Construction and management consistent with UWMP.	Developer
Department of Water	▪ Issue and condition of Groundwater Licences	Developer
City of Wanneroo	▪ Assumes responsibility for roads and stormwater drainage infrastructure constructed including the ongoing operations and maintenance. ▪ Maintains the public open space (including irrigation) at the completion of the Developer's maintenance period.	Rates
Water Corporation	▪ Assumes responsibility for the potable and non-potable water supply and sewerage infrastructure constructed including the ongoing operations and maintenance.	Rates
Land Owner	▪ Responsible for meeting all requirements of the relevant City of Wanneroo building codes during the built form phase (including construction and maintenance of soakwells for onsite stormwater disposal). ▪ Compliance with the Water Corporation's Waterwise program	Land Owner

10. REFERENCES

Department of Water (Dec 2008), Interim: Developing a local water management strategy

Department of Water (2007), Stormwater Management Manual for Western Australia, Department of Water, Perth, Western Australia

Essential Environmental Services (2007), Achieving Integrated Water Cycle Management, A framework to integrate land use planning with water resources management on the Swan Coastal Plan, DRAFT

Institution of Engineers Australia (2000), Australian Rainfall and Runoff, A Guide to Flood Estimation, Institution of Engineers Australia

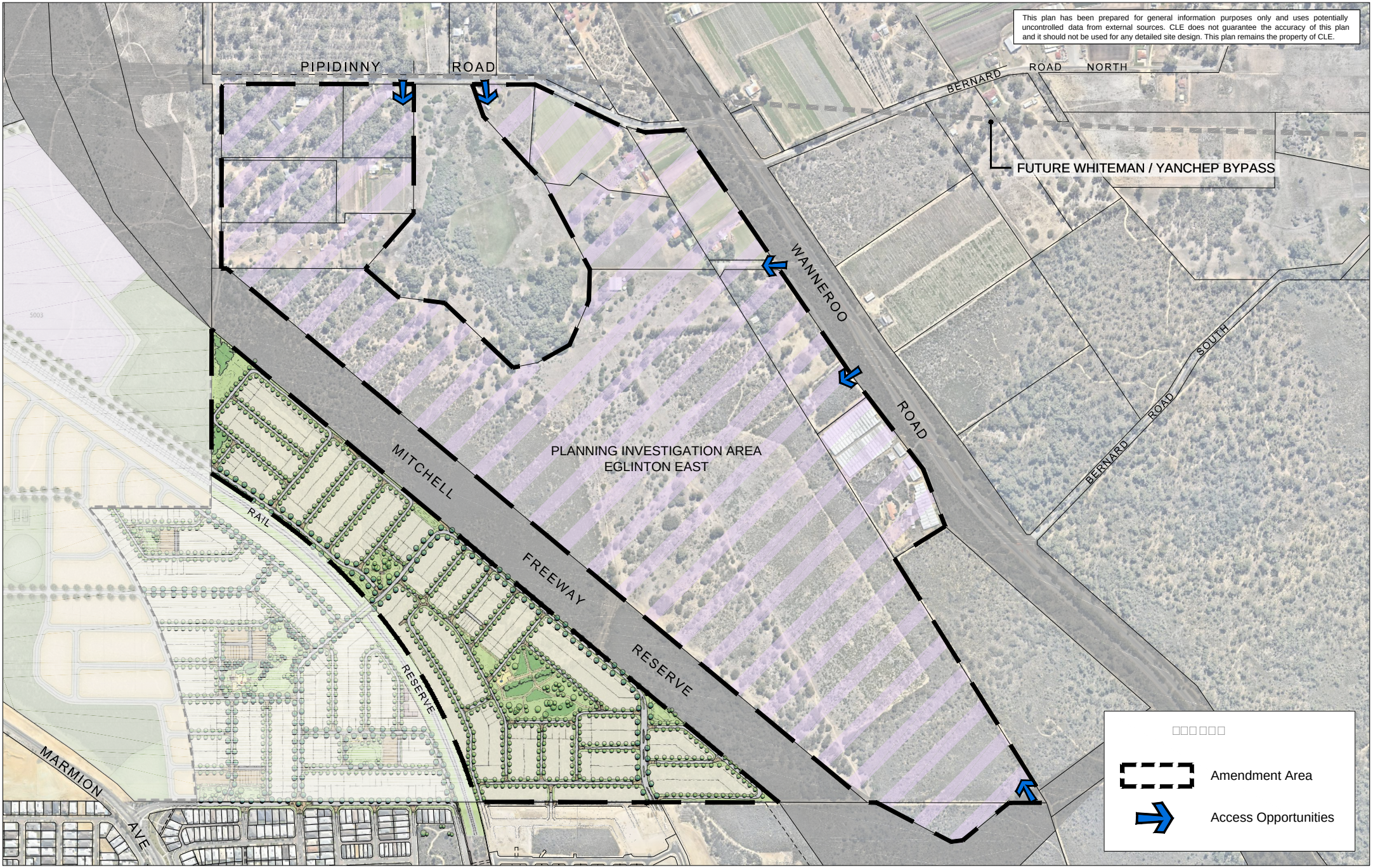
Water Corporation, 2003, Domestic Water Use Study in Perth, Western Australia 1998 -2007

WA State Planning Policy 2.9 (2006) Water Resources

11. CHECKLIST

The Department of Water's Checklist is included in Appendix F, for information. The required deliverables have been cross-referenced with this LWMS to assist in its evaluation.

APPENDIX A – Lot 6 Taronga Place, Eglinton Local Structure Plan (Prepared by CLE Town Planning Consultants)



CLE Town Planning + Design
www.cleplan.com.au

CONCEPT PLAN

Eglinton-Alkimos DSP Plan No.18 Amendment 2

plan no:
date: 10 September 2018
scale: Not to scale

N

APPENDIX B – North West Corridor Water Supply Strategy Compliance Schedule (Prepared by Plan E)

1612805 TARONGA ESTATE - EASTERN DSP. IRRIGATION SCHEDULE

POS Name	POS Type	Total Area (ha)	% Irrigated Long Term	Irrigated Area	Irrigation Rate (kL/yr)	Long- term Volume	% Irrigated Establishment	Establishment Irrigated Area	Establishment Irrigation Rate (kL/yr)	Establishment Volume	Responsibility
POS 1	Local Park - Passive Recreation	0.0781	33%	0.0258	6750	173.97	70%	0.0547	6750	369.02	Developer
POS 2	Pocket Park - Passive Rec	0.0189	33%	0.0062	6750	42.10	70%	0.0132	6750	89.30	Developer
POS 3	Local Park - Passive Rec	0.4810	33%	0.1587	6750	1071.43	70%	0.3367	6750	2272.73	Developer
POS 4	Pocket Park - Passive Rec	0.1730	33%	0.0571	6750	385.36	70%	0.1211	6750	817.43	Developer
POS 5	Pocket Park - Passive Rec	0.1640	30%	0.0492	6750	332.10	70%	0.1148	6750	774.90	Developer
POS 6	Pocket Park - Passive Rec	0.5230	33%	0.1726	6750	1164.98	70%	0.3661	6750	2471.18	Developer
POS 7	Neighbourhood Park - Passive Rec	1.9400	33%	0.6402	6750	4321.35	70%	1.3580	6750	9166.50	Developer
POS 8	Pocket Park - Passive Rec	0.3771	33%	0.1244	6750	839.99	70%	0.2640	6750	1781.80	Developer
Streetscapes 09	Verges and Street Trees	0.8480	0%	0.0000	6750	0.00	100%	0.8480	6750	5724.00	Developer
Streetscapes 10	Street Trees and Buffer Planting	0.7350	0%	0.0000	6750	0.00	100%	0.7350	6750	4961.25	Developer
Total		5.3381		1.2343	6750	8331.28		1.3737	6750	23466.85	Developer

APPENDIX C– Preliminary Karst Landform Management Report (Prepared by CMW)

CMW Geosciences Pty Ltd
Chapman Morton Woodward

9 August 2016

LOT 19 TARONGA PLACE, CARABOODA

PRELIMINARY KARST LANDFORM MANAGEMENT METHODOLOGY

Urban Quarter WA

Ref. PER2016-0480AB Rev1

Unit 19 Wembley Green Offices,
127 Herdsman Parade, Wembley, WA 6014

www.cmwgeosciences.com

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Figures

Appendices

1 INTRODUCTION

This report outlines recommended development strategies to manage potential risks associated with karst landforms within Lot 19 Taronga Place, Carabooda. The work was commissioned by Mr Jason Wallis of Urban Quarter WA (Urban Quarter) on 2 August 2016.

It is understood that the 150ha site is proposed for urban development comprising a mixture of residential and commercial subdivision. The strategies in this report are aimed at providing an outline of tasks that will be performed as a precursor to development of a Karst Landform Management Strategy. It also outlines engineering design elements that can be adopted during construction of the subdivision in order to limit the risks associated with karst landforms to a level no greater than those acceptable for other developments on the Swan Coastal Plain. These strategies will be confirmed following detailed site investigations.

2 AVAILABLE INFORMATION

CMW has previously undertaken a desktop and reconnaissance study at the site. Information available for the previous study comprised the following:

- 1:50,000 scale geological mapping (Yanchep Sheet - 2034 IV) produced by the Geological Survey of Western Australia (GSWA) including 1:100,000 scale geomorphology mapping.
- A Western Australian Speleolgical Group field survey report dated 12 December 2007.
- Various project drawings including vegetation mapping, concept plan, existing ground surface contours and proposed finished levels.
- Observations of the site during a reconnaissance drive/walk over.

The available information has been incorporated with our experience of karst areas on the Swan Coastal Plain to allow consideration of development strategies with respect to potential karst ground conditions.

It is noted that the author has extensive knowledge and experience of urban development within areas of potential karst landform risk within the Swan Coastal Plain and has published technical papers on the subject including Mather P.J, 2013. Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia. Australian Geomechanics, Vol. 48 No. 2, a copy of which is attached to this letter for reference.

3 DISCUSSION

The eastern part of the site is within a recognised zone of potential karst features as outlined by previous GSWA mapping. The location of the western extent of this potential karst zone has been slightly modified on the basis of local geomorphology observed during site reconnaissance. The inferred western extent of the potential karst zone is shown on the attached Figure 1. Within the areas west of the line shown in Figure 1, the risks associated with potential karst are considered to be very low and therefore can be managed by normal geotechnical investigation and design processes.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce and manage the risks to acceptable levels. The extent of remediation and modification of foundations to reduce the risk of karst is dependent on the severity of karst phenomenon and sensitivity of proposed development. By international standards karst occurrence on the Swan Coastal Plain is at the lower end of severity. Some internationally accepted design strategies to manage karst risk, in general order of increasing

severity, are as follows:

- Drainage control
- Grout/fill open fissures
- Stiffen footings (rafts or ground beams)
- Geogrids
- Driven piles to rock head
- Cap grouting at rock head
- Groundwater abstraction control
- Bored piles to rock head
- Combinations of the above techniques

The key trigger mechanisms for karst collapse on the Swan Coastal Plain is concentrated storm water runoff. The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for previous developments within karst areas of CoW (e.g. Lots 201 and 202 Breakwater Drive) have included the provision for domestic soak wells to be located no less than 10m from footings and road drainage basins to include a 30m development exclusion zone around their perimeter. Additional strategies that have been adopted locally include the stiffening of residential footings.

Other strategies that could be adopted to adequately reduce the risks in susceptible areas include large scale earthworks involving over excavation and replacement with a 2m thick layer of crushed limestone covered with a 1m thick surface layer of free draining sand. The 2m thick layer of compacted crushed limestone will act as a stiffened raft/geogrid layer in addition to attenuating concentrated stormwater inflows from the surface.

4 PROPOSED MEASURES TO MANAGE KARST

Subject to further, more detailed investigations, we believe the following measures or combination of measures would reduce the karst risk associated with this site to equal or less than that associated with other developments on the Swan Coastal Plain:

- Any exposed fissures should be over-excavated and backfilled in accordance with the geotechnical engineer's requirements;
- During cut-to-fill earthworks, areas in excess of 10m fill require no further mitigation, as the material above potential karst features will form an adequate raft to spread loads and dissipate stormwater infiltration;
- Areas of fill up to 3m thick should include a 2m thick crushed limestone layer as described in Section 3 above;
- Areas of fill less than 3m thick or areas of cut should be over-excavated to 3m below finished design levels, and backfilled to incorporate a 2m thick crushed limestone layer as described in Section 3 above; and,
- Further geotechnical investigations such as EFCPT probes should be undertaken upon completion to assess the presence of karst features at an inter-allotment scale prior to development

Some variation to the excavation and replacement option outlined above is likely to be appropriate based on the anticipated range of ground conditions. For example, in areas of cut which expose a limestone surface that is free of any indication of voids, the required thickness of crushed limestone could be reduced to 1m. Other variations such as backfilling exposed voids and heavy compaction of loose sand zones prior to fill placement may be appropriate depending on the local ground conditions and thickness of fill prosed within specific areas.

Prior to development, further geotechnical site investigation will be required to assess the extent of potential karst risk within the site and refine appropriate remediation options for urban development. It is likely that the results of detailed investigation will identify significant areas of very low risk within the potential karst risk zone, allowing remedial options to be targeted towards areas of higher potential risk.

It is anticipated that the adoption of a range of engineering design strategies as outlined above, targeted across the site on the basis of further detailed geotechnical investigation will result in the reduction of risks associated with karst to a level compatible with development outside of karst areas.

5 SUMMARY

Lot 19 Taronga Place, Carabooda is located partially across an area of the Swan Coastal Plain which has the potential for karst landforms. By international standards the karst risk is relatively low but will need to be addressed as part of the urban residential and commercial development proposed at the site. A range of engineering strategies are available to limit the risks associated with karst. Information obtained from further detailed geotechnical site investigation across the site can be incorporated into an assessment of suitable risk reduction strategies. Appropriate strategies will vary across the site depending on the severity of the ground conditions and proposed land uses. The aim of the design modifications will be to limit the risks associated with development at this site to those applicable to other developments on the Swan Coastal Plain that are outside the zone of potential karst.

6 CLOSURE

We trust this report meets your current project requirements. If you have any queries or require additional information please contact the undersigned.

For and on behalf of
CMW Geosciences Pty Ltd

Philip Mather

Principal

Distribution: 1 copy to Urban Quarter WA (electronic) Original held by CMW Geosciences Pty Ltd

Figures

LEGEND:

INFERRED WESTERN EDGE OF POTENTIAL KARST RISK ZONE

SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM: ROBERTS DAY CONCEPT PLAN, DRAWING NO. RD1 016, REV A, DATED 29.06.15

1:7500 0 75 150 225 300 375 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: URBAN QUARTER WA		DRAWN: DE	PROJECT: PER2016-0780
PROJECT: LOT 19 TARONGA PLACE, CARABOODA, WA		CHECKED: PJM	FIGURE: 01
		REVISION: 0	SCALE: 1:7500
TITLE: PRELIMINARY KARST LANDFORM MANAGEMENT		DATE: 09/08/2016	SHEET: A3 L

Appendix A

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia.

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia

Philip Mather

Coffey Geotechnics Pty Ltd – Perth, Western Australia

ABSTRACT

The occurrence of karst limestone conditions within Western Australia is not well recognised within the general community but can be of major engineering significance for developments that are impacted by it. The presence and engineering significance of karstic limestone on the Swan Coastal Plain has been recorded by local Engineering Geologists with the first officially published recognition presented in the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet in 1986. The Geological Survey of Western Australia (GSWA) mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks. Increasing pressure from urban development along Perth's northern corridor lead to several "near miss" incidents which precipitated the incorporation of a requirement for all development applications within the City of Wanneroo to include consideration of the potential for karst.

To date, the published literature relating to karst on the Swan Coastal Plain has been limited to geological descriptions of the phenomena. Although the potential karst hazard is now widely recognised within the geotechnical community there has been very little published information relating to geotechnical design considerations and strategies for urban development within areas affected by karstic limestone relating specifically to the Swan Coastal Plain. Considerable work has been completed over the past decade relating to the identification of karstic ground conditions and geotechnical design strategies to manage potential risks. In addition, the existence of additional areas of karstic limestone has been identified within the City of Cockburn and City of Mandurah.

1 INTRODUCTION

The occurrence of karst limestone conditions within Swan Coastal Plain of Western Australia is restricted to specific localised areas that, for many years, were of limited interest to those other than speleologists and caving enthusiasts. The coincidence of low lying swales with shallow groundwater and interdunal lakes resulted in karstic zones often being amongst areas of market garden and semi rural land uses. The pressure from urban expansion on the coastal plain has increasingly resulted in urban development encroaching into these previously less intensely developed areas. Although often not well recognised by property developers and the general public, the presence of karstic limestone can be of major engineering significance for developments that are impacted by it.

The occurrence of karst limestone was recognized by local Engineering Geologists such as Ray Gordon (2003) who was involved with local authorities to study and assess the potential risks/liabilities associated with this geohazard. These studies were greatly assisted by the work of local Speleologists such as Lex Bastion. Later work by Bob Gozzard with the resources of the Geological Survey of Western Australia (GSWA) resulted in the first official engineering recognition of the occurrence of karst within the Swan Coastal Plain presented on the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet published by the GSWA in 1982. The initial mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks.

Increasing pressure from urban development along Perth's northern corridor resulted in several sink hole occurrences associated with residential developments. In recognition of this potential hazard the City of Wanneroo has developed a draft of new requirements for all development applications to include consideration of the potential for karst.

Geotechnical investigations over the last decade have identified additional areas within the Swan Coastal Plain where karstic conditions occur and has focussed consideration of geotechnical design strategies to limit risks for developments.

The purpose of this paper is to provide an introduction to the geotechnical aspects of karst as follows:

- Case studies of karst collapse that have occurred within the Swan Coastal Plain that demonstrate the main features of sink holes and common trigger events.
- Updated geology map outlining two additional zones of significant karst, within the southern part of the Swan Coastal Plain and Mandurah that have never been published.

- Current geological/geomorphological hypotheses relating to the formation of karst environments within the Swan Coastal Plain.
- The effectiveness of various geotechnical investigation techniques available to identify the presence and significance of karstic limestone.
- Geotechnical design issues for development within areas of karst and potential options/solutions to limit associated risks.

2 CASE STUDIES

2.1 REGATTA DRIVE, EDGEWATER

Several sinkhole collapse features occurred within a road drainage basin following a significant rainfall event (Figure 1). The road basin is located within an urban residential development characterised by sand overlying pinnacled limestone at shallow depth. The collapses occurred in the mid 1990's and were investigated by Ray Gordon (2003) who has presented a schematic cross section of the site. No damage to the adjacent houses was reported. Remediation work included replacement of some sections of the boundary fences and precautionary underpinning of the foundations on one of the neighbouring residences.

Figure 1 – Road drainage basin at Regatta Drive, Edgewater showing sinkholes on left and at rear.

2.2 EMERALD DRIVE, CARABOODA

Sinkhole collapse occurred within a road runoff discharge area following winter rainfall soon after construction for a Special Rural subdivision (Figure 2). The collapse occurred in the early 2000's within an area of sand overlying shallow limestone between areas of scattered limestone outcrop. There was no damage reported, however, this example further highlights the potential risks associated with large volumes of concentrated runoff from road drainage basins triggering collapse events.

Figure 2 - Sinkhole within road drainage discharge area, Emerald Drive, Carabooda.

2.3 SWIMMING POOL COLLAPSE, WOODVALE

Undermining of a swimming pool due to sinkhole collapse occurred in March 2007 (Figure 3). The contribution of uncontrolled water discharge from a range of possible sources adjacent to the pool was suspected of contributing to progressive development of the sinkhole over many years which finally resulted in sudden collapse of the pool. Limited investigation at the site indicated a ground profile comprising sand overlying limestone at a depth of approximately 6 m.

Figure 3 - Woodvale swimming pool with bracing following collapse

2.4 BREAKWATER DRIVE, TWO ROCKS

Sinkhole collapse about 4 m wide and 3 m to 4 m deep occurred in December 2007 located approximately 12 m from the edge of a residence within a Special Rural subdivision (Figures 4a and 4b). The site is underlain by a 3 m to 6 m thick surface sand layer overlying limestone. A combination of CPT and air core borehole investigation identified loose

ground conditions within and overlying the limestone and the original building envelope was relocated away from an area within the Lot where numerous small voids had been encountered within the limestone at depths of between 11 m and 15 m.

The collapse occurred at the location of a bore water discharge point within the Lot. The bore discharge arrangement comprised of two child paddle pools. One pool received water from the bore which overflowed into the second pool. The bore was run for about an hour approximately 3 times per week. Water from the pools was bucketed out and distributed around the yard.

This arrangement had been in place for over a year prior to the collapse occurring. On the day of the collapse the owner had turned on the bore pump and then been distracted at the front of the property for between half to one hour with the pump running and pools overflowing. On his return to collect water from the pools they had "disappeared" down the sinkhole. One pool was completely gone and the corner of the second pool was visible at the base of the sinkhole.

Figure 4a – Breakwater Drive, Two Rocks. View of sinkhole from balcony of residence

Figure 4b - Breakwater Drive, Two Rocks. Close up view of sinkhole. Note tension crack around edge of failure zone

Common features with the case studies presented above include a surface layer of sand approximately 5 m thick and, more significantly, the action of concentrated surface water discharge providing a trigger mechanism for sudden sinkhole collapse.

3 GEOLOGY OF THE SWAN COASTAL PLAIN

A broad outline of the geology of the Swan Coastal Plain as presented by Davidson 1995 is shown in Figure 5. The existing 1:50,000 Geological Survey of Western Australia, Yanchep Sheet (Gozzard, 1982) outlines a zone referred to as "Interbarrier depression with prominent karst phenomena" extending between Joondalup and Two Rocks. This zone has been well documented and is well recognised throughout the geotechnical community and includes tourist features and cave systems within the Yanchep National Park.

Field experience from geotechnical site investigations and studies over the years has revealed additional, similar zones with karstic limestone conditions in the Lake Coogee – Munster area and further south along the western margins of the Peel Inlet at Dawesville and Mandurah. Additional isolated occurrences have also been encountered at Gwelup and Warwick. More localised occurrences are likely within similar geomorphological environments that have been revealed in the past and /or will be encountered in the future.

Figure 6 outlines a useful cross section presented by Grimes (2006) based on work by Lex Bastian in the Yanchep area. Meteoric water and groundwater undersaturated in $CaCO_3$ migrating west out of the Bassendean Sand dissolves the carbonate matrix to form "slots" within the limestone at the groundwater interface which enlarge over time through roof collapse to form caves.

Karst on the Swan Coastal Plain is considered to fit into Grimes's category of syngenetic karst which has formed within a soft, porous, soluble sediment at the same time as it has been cemented into a rock. This is quite different to the classical "hardrock" karst which involves dissolution of carbonate along pre-existing joints and fractures within a previously formed limestone or dolomite rock mass.

On the Swan Coastal Plain there appears to be a spatial association with low lying wetland areas where the water table is exposed at the surface and significant deposits of organic rich and peaty soils occur. The association with these wetlands introduces a possible influence of organic acids from peat deposits reducing the pH of groundwater and enhancing/"reinvigorating" the dissolution of carbonates within the adjacent or underlying limestone.

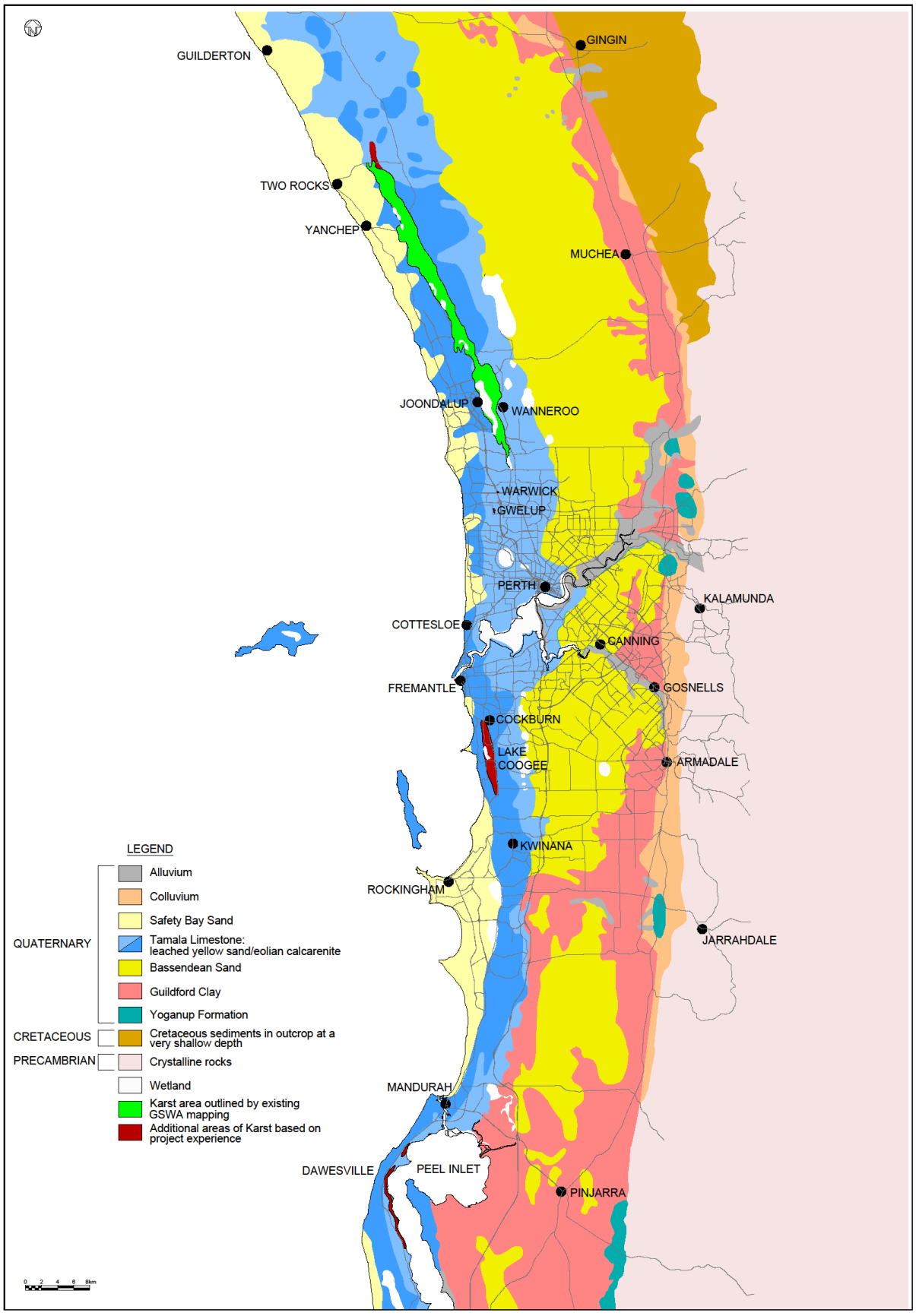

Figure 5 – Geology of the Swan Coastal Plain (from Davidson 1995)

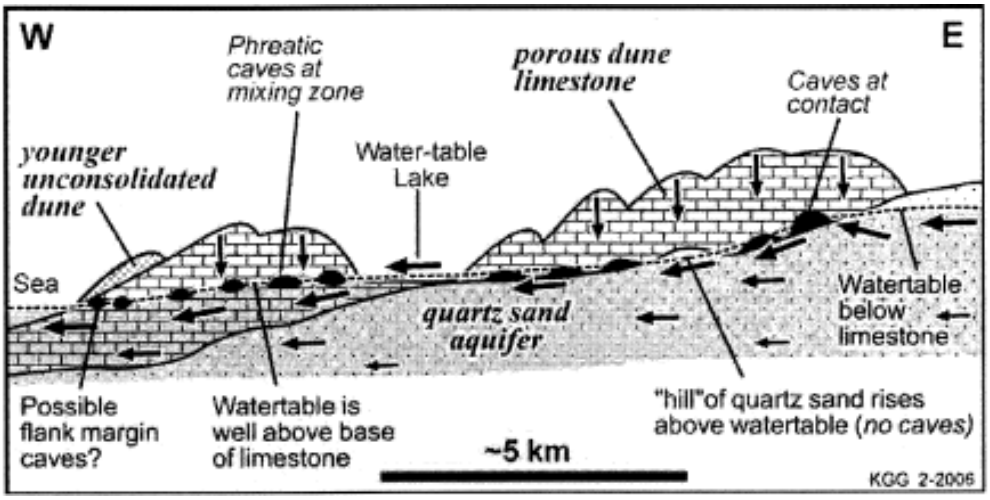

Figure 6 – Hydrology of the Yanchep Area (Grimes 2006 after Bastian)

Karst manifests itself as loose sand near the surface and cavities within the underlying limestone. Surface features include dolines, closed depressions and sinkholes. It is common to observe a characteristic topographic signature of closed depressions on surface contour maps and in particular from surface reconnaissance and field mapping within localised areas where the form of the ground surface appears inconsistent or disrupted within the broader landscape.

Waltham and Fookes (2003) present a classification of sinkholes as shown on Figure 7. Within the Swan Coastal Plain the occurrence of Waltham's Collapse sinkholes and Caprock sinkholes are rare. A more common occurrence highlighted by the case histories and author's experience are Buried sinkholes and Suffusion sinkholes which occur in areas of sand cover over the limestone.

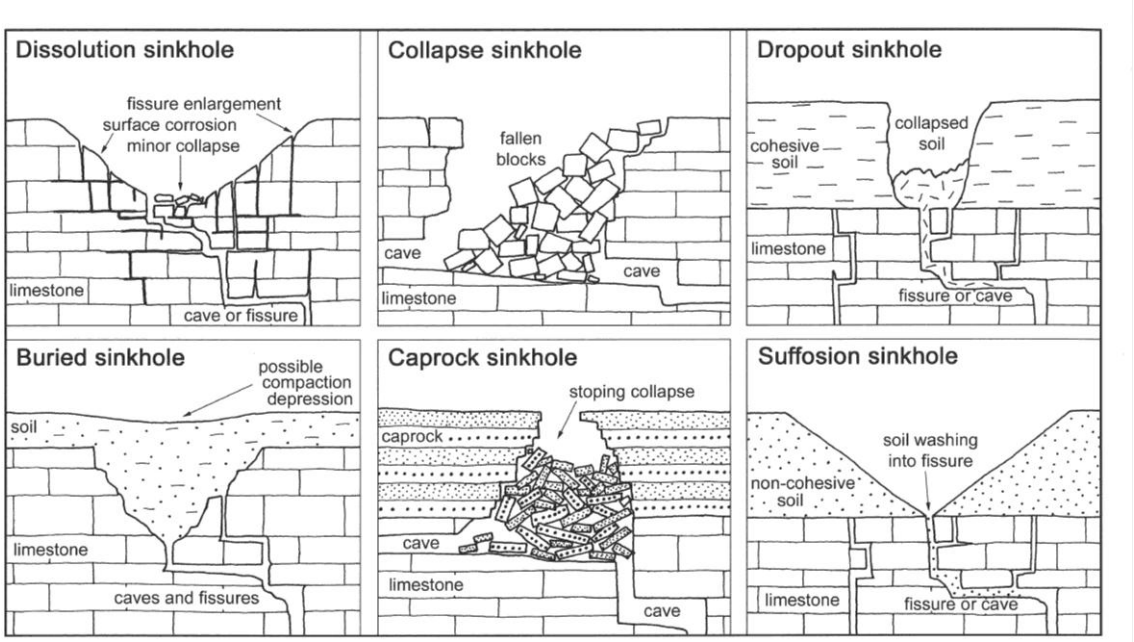

Figure 7 – Classification of Sinkholes via Mechanism of Ground Failure (Waltham and Fookes 2003).

Experience of sinkhole collapse on the Swan Coastal Plain suggests an increased hazard exists where the thickness of sand cover above limestone is in the order of 5 m. It is possible that when the thickness of sand cover exceeds 10m to 15 m it is sufficient to allow bridging of voids within the limestone and distribute any loss of ground over a broader soil zone thereby attenuating the magnitude and timing of ground movements experienced at the surface. In addition the influence of concentrated surface water infiltration is greatly diminished with depth. In areas where the thickness of sand cover is limited to a few metres it appears that the potentially significant sinkhole collapses have already occurred. In addition there is often clear surface evidence to alert the geologist to the presence of voids within the underlying limestone when it is at shallow depth.

Very loose zones within the overlying sand represent an additional hazard within areas of karst. Fortunately loose sand is relatively easy to identify and manage during development. The difficult hazard to manage results from "hidden" features where sudden collapse may be triggered by disturbance and/or changed conditions arising from new development.

4 GEOTECHNICAL INVESTIGATION TECHNIQUES

Extensive loose and very loose sand zones are a common feature of karst areas on the Swan Coastal Plain. Cone Penetrometer Testing (CPT) is an excellent technique to assess the condition of overlying sand and will sometimes penetrate the limestone to encounter voids at depth below the rock head. CPT is relatively quick and cost effective compared to drilling and provides continuous data about the ground conditions. A disadvantage of the CPT is that it can refuse on the limestone rock head. Drilling techniques are limited to the provision of less reliable data due to issues arising from ground disturbance at the bit face, core loss and discontinuous SPT test intervals. Drilling of all techniques is a relatively crude tool from which it is often difficult to distinguish between very loose sand, core loss and voids. However, within areas of very shallow limestone drilling to investigate the near surface ground conditions represents a method of overcoming early CPT refusal to obtain direct information.

Sinkholes are spectacular through their sudden and dramatic impact but are very isolated and, due to their association with concentrated surface water discharge, provide some scope to be managed through strict control of surface water drainage. Within areas of karst on the Swan Coastal Plain it is the loose sand zones overlying voided limestone that represents the significant risk to structures. These loose sand zones are inferred to have a general association with deeper voids and therefore can provide an indication of where hazards may exist within the underlying limestone. Individual voids within the limestone are extremely difficult to investigate. Drilling and probing is "hit and miss". A range of drilling techniques including auger, mud flush, diamond coring and air coring have been utilised. Despite careful observation of the drilling process it is often very difficult to distinguish reliably between air filled voids, sand filled voids, loose sand zones and very weakly cemented limestone. Compared to the crude data derived from drilling the use of intensive CPT testing to investigate the condition of the overlying sand, often penetrating the weaker and voided limestone at depth provides a valuable method to obtain reliable data on which to characterise the ground for input into geotechnical design.

Various geophysical techniques have been utilized with ground probing radar (GPR) typically being the most commonly adopted to assess karst on the Swan Coastal Plain. The author is not aware of any geophysical techniques that reliably indicate the presence, or not, of voids within limestone on the Swan Coastal Plain. Elsewhere surface and borehole seismic techniques have been used with some success to investigate voids at specific locations such as below a building foundation or for linear projects such as tunnel alignments (Whiteley, 2012). For larger areas geophysics can provide a generalised profile of ground conditions that may be useful to target more detailed investigation techniques, however, it provides very little useful information about the condition of the overlying sand which is often a more important factor for geotechnical design than knowing the specific location of voids. In the author's opinion, the use of geophysical techniques to conclusively demonstrate the absence of voids over large areas is unlikely to be practicable but they can provide complementary data for critical infrastructure at specific locations where investigation budgets allow.

5 GEOTECHNICAL DESIGN CONSIDERATIONS

The main considerations during geotechnical design within areas of potential karst are as follows:

- Excessive settlement within areas of loose sand under the load of structures.
- Sudden collapse of ground resulting from sinkholes.
- Concentrated surface and/or subsurface water flow which has been associated with every sinkhole occurrence observed by the author.
- Changes in land use which can concentrate surface water flows leading to a new generation of sinkholes to occur.
- The existence and effectiveness of geotechnical investigation guidelines. For example the City of Wanneroo has recently prepared a draft of new development guidelines for minimum geotechnical investigation requirements specifically related to karst. Other local Authorities are likely to follow.

6 CONCLUSIONS AND DESIGN STRATEGIES

The potential for sinkholes is a real and significant engineering issue within potential karst areas on the Swan Coastal Plain. The GSWA 1:50,000 mapping provides an excellent guide to the distribution of the potential karst zone north of Perth. Additional areas of karst have been encountered outside those shown on published geological mapping. Additional areas are likely to be revealed as urban development expands into areas of less intensive development. Investigation by drilling and probing is "hit and miss". The use of CPT has proved a reliable investigation technique on which to base engineering design within areas with a reasonable thickness of sand cover and can provide some indication of the strength of the underlying limestone sometimes penetrating the rock layer and intersecting voids to provide direct evidence of their existence. In the absence of any investigation techniques that can reliably detect the location of voids within limestone it is considered prudent that once karst conditions have been identified through surface mapping, drilling and probing, geotechnical design is based on the assumption that voids are present within the underlying limestone. For critical structures more specifically targeted techniques incorporating geophysics and intensive, close spaced drilling/probing may be justified.

The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for developments typically include the provision for soak wells to be located no less than 10m from footings. Road drainage basins are typically recommended to include a 30m development exclusion zone around their perimeter. Other design strategies include stiffening of footings to accommodate potential settlements associated with loose zones within sand and loss of ground above sinkholes. Structural assessments indicate that under typical loads associated with masonry residential structures a stiffened beam adopted for a site classification of M in accordance with AS2870-2011 will span a 1.8m wide void.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce the risks.

7 ACKNOWLEDGEMENTS

The author gratefully acknowledges the contribution and assistance from Geoff Cocks and Alan Moon during the preparation of this paper.

8 REFERENCES

AS2870-2011 Australian Standard Residential Slabs and Footings, Standards Australia

Bastian L.V., 2003, Hydrogeology and Speleogenesis Update, The Yanchep Cave Area, Western Australia. *in* Poulter N., [ed] Proceedings of the 24th Biennial Speleological Conference. Australian Speleological Federation, Bunbury. pp 36-44.

Davidson, W. A., 1995, Hydrogeology and groundwater resources of the Perth Region, Western Australia: Western Australia Geological Survey, Bulletin142.

Gordon, R., 2003, Coastal Limestones - Engineering Geology of Perth Part 2: Australian Geomechanics Vol 38, No 4, pp 7-24.

Gozzard, J. R., 1982, Yanchep Sheet 2034 IV, Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.

Grimes, K. G., 2006, Syngenetic Karst in Australia: a review: Helictite Vol.39, No 2, pp 27-38.

Waltham, A. C. & Fookes P.G., 2003, Engineering Classification of Karst Ground Conditions: Quarterly Journal of Engineering Geology and Hydrogeology, Vol 36

Whiteley, R. J., 2012. Surface and Borehole Seismic Imaging of Soft Rock, Karst Eolianites at Coastal Engineering Construction Sites: Case Studies from Australia: The Leading Edge Vol 31, No 1, pp76-81.

APPENDIX D – Drainage Catchment Plan and Drainage Calculations (Prepared by Cossill & Webley)

REV	DATE	DRN	CKD	APP	AMENDMENT
A	24.05.18	DPM			ISSUED FOR INFORMATION

Cossill & Webley CONSULTING ENGINEERS
Mailing Address: PO Box 680, Subiaco WA 6904
Street Address: B12 (Level 2) 431 Roberts Road, Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: URBAN QUARTER

APPROVED: 24.05.18

DESIGNED: DPM

SCALE: 1:2000

PROJECT: LOT 19 TARONGA PLACE, EGLINTON

TITLE: CENTRAL CELL DRAINAGE CATCHMENT PLAN

WAPC No.

DRAWING No.: 5826-00-SK42

REVISION: A

ORIGINAL SIZE: A1

APPENDIX E – Lot 6 Taronga Place, Eglinton Conceptual POS Designs (Prepared by Plan E)

LEGEND

- PATHWAY
- SHADE STRUCTURE
- PLAYGROUND
- TURF (IRRIGATED)
- GARDEN BED
- POS TREES
- STREET TREES (INSTALLED BY THE DEVELOPER, IRRIGATED FOR ESTABLISHMENT ONLY)
- EXISTING VEGETATION TO BE RETAINED
- INDICATIVE 1:1 YEAR TOP WATER LEVEL
- INDICATIVE 1:5 YEAR TOP WATER LEVEL

01

POS 01 - LOCAL PARK

- TOTAL AREA 7,810m2
- ESTABLISHMENT IRRIGATION ALLOWANCE 5,467m2
- LONG TERM IRRIGATION ALLOWANCE 2,577m2

NATURE POS TO INCLUDE DAMPLAND PLANTING WITH MEANDERING PATHWAY, SEATING OPPORTUNITIES AND REVEGETATION PLANTING AS A BUFFER TO EXISTING BUSHLAND TO THE NORTH. SOME TURF OPEN SPACES. ALLOWANCE HAS BEEN MADE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

02

POS 02 - POCKET PARK

- TOTAL AREA 1,893m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 1,325m2
- LONG TERM IRRIGATION ALLOWANCE 624m2

NATURE POS TO INCLUDE NATIVE PLANTING AND VEGETATED BUFFER TO PROPOSED RAIL EXTENSION. INTERNAL PATH NETWORK THROUGH NEW BUSHLAND AND TURF OPEN SPACES.

03

POS 03 - LOCAL PARK

- TOTAL AREA 4,811m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 3,367m2
- LONG TERM IRRIGATION ALLOWANCE 1,587m2

POS AT THE WESTERN ENTRY TO THE SITE WILL INCLUDE A KEY ENTRY MARKER, MATURE TREES, A FOCAL FEATURE LOCATED CENTRAL TO THE PARK, AND ENTRY TREATMENT TO ROADWAYS . FORMAL AXIAL PATHWAY AND CENTRAL SHADE STRUCTURE PROVIDE PASSIVE RECREATIONAL AMENITY FOR INITIAL PHASES OF THE PROJECT.

04

POS 04 - POCKET PARK

- TOTAL AREA 1,737m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 1,215m2

WESTERN POS TO INCLUDE DAMPLAND PLANTING & PERIPHERAL PATH CONNECTIONS. ALLOWANCE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

05

POS 05 - RAIL DRAINAGE BASIN

- TOTAL AREA 1604m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 1,122m2
- LONG TERM IRRIGATION ALLOWANCE 529m2

POS TO INCLUDE PLANTING AS A VEGETATED BUFFER TO PROPOSED RAIL EXTENSION TO AND VERGE PATHWAY TO CONNECT TO GREATER PEDESTRIAN NETWORK.

06

POS 06 - POCKET PARK A & B

- TOTAL AREA 5,234m2 (INLCUDES 3,348m2 NORTHERN POS & 1886m2 SOUTHERN POS)
- ESTABLISHMENT IRRIGATION ALLOWANCE 3,663m2.
- PERMANENT IRRIGATION ALLOWANCE 1,727 m2.

POS LOCATED ALONG NEIGHBOURHOOD CONNECTOR ROAD TO PROVIDE VISUAL AND PEDESTRAIN CONNECTIONS TO CENTRAL NEIGHBOURHOOD POS. THE POS WILL INCORPORATE ARBOR AND SHADE STRUCTURES, GARDEN BED PLANTING AND TURF OPEN SPACES FOR LOCAL SCALE AMENITY TO RESIDENTS.

07

POS 07 - NEIGHBOURHOOD PARK

- TOTAL AREA 1.94 ha.
- ESTABLISHMENT IRRIGATION ALLOWANCE 13,583m2
- PERMANENT IRRIGATION ALLOWANCE 6,404m2

CENTRAL POS TO PROVIDE A FOCAL POINT FOR THE ESTATE. POS FUNCTION TO INCLUDE MULTI-USE TURF AREA, CENTRAL GATHERING HUB, NATURE PLAY ADVENTURE PLAYGROUND, MULTI USE HARD COURTS, MULTI USE BIKE TRACK AND EXISTING VEGETATION RESERVE. SIGNIFICANT EXISTING BUSHLAND TO BE RETAINED WITH ADDITIONAL HEALTHY TREES RETAINED WHERE APPROPRIATE. PEDESTRIAN PATH NETWORKS ARE LOCATED THROUGH THE PARK AND EXISTING BUSHLAND. ALLOWANCE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

08

POS 08 - POCKET PARK

- TOTAL AREA 3,771m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 2,639m2
- PERMANENT IRRIGATION ALLOWANCE 1,244m2

POS TO INCLUDE DAMPLAND PLANTING FORMING A BUFFER TO EXISTING BUSHLAND TO THE NORTH & FUTURE FREEWAY EXTENTIONS. PERIPHERAL PATH TO CONNECT TO GREATER PEDESTRIAN NETWORK. ALLOWANCE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

09

VERGES AND STREET TREES - EXTENT INDICATED DASHED

- **TOTAL AREA** 8,458m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 8,458m2. (Irrigated for establishment only)

10

STREET TREES & BUFFER PLANTING

- **TOTAL AREA** 7,375m2.
- ESTABLISHMENT IRRIGATION ALLOWANCE 7,375m2. (Irrigated for establishment only)

STREET TREES AND UNDERPLANTING TO FORM VEGETATED BUFFER AND INTERFACE.

TARONGA EAST, EGLINTON

PREPARED FOR URBAN QUARTER

DISTRICT STRUCTURE PLAN - LANDSCAPE MASTERPLAN

AUGUST 2018

JOB NO. 1612805

1:2000 @ A1

M1.101 REV A

0 20 40 80 120 200m

PLAN E

LANDSCAPE ARCHITECTS

414 ROKEBY RD SUBIACO WA 6008

T: (08) 9388 9566 E: mail@plane.com.au

SECTION A-A POS 1

SECTION B-B POS 4

SECTION C-C POS 8

TARONGA EAST, EGLINTON
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DISTRICT STRUCTURE PLAN - LANDSCAPE SECTIONS
AUGUST 2018

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1:100 @ A1

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LANDSCAPE ARCHITECTS
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SECTION D-D POS 7

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APPENDIX F – Department of Water Checklist

The following checklist has been taken from Appendix 2 of the Department of Water's Interim: Developing a local water management strategy to be used as a guide for items that should be addressed by relevant parties in the preparation of this Local Water Management Strategy. This checklist will aid in the assessment by the relevant authority when an application for the local structure plan is lodged.

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Executive Summary					
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMP's and critical control points	Section 3.2		☐	
Introduction					
Total water cycle management – principles & objectives Planning background Previous studies		Section 1		☐	
Proposed Development					
Structure plan, zoning and land use. Key landscape features Previous land use	Site Context Plan Structure Plan	Section 2.2 Section 2.3 Section 2.1		☐	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	Section 2.3, 5		☐	
Design Criteria					
Agreed design objectives and source of objective		Section 3		☐	
Pre-development Environment					
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 4		☐	
Site Conditions - existing topography / contours, aerial photo underlay, major physical features	Site Condition Plan	Section 4.1, 4.3		☐	

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical Plan	Sections 4.2, 4.4, 4.6		☐	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting datasets where appropriate	Sections 4.8, 4.9		☐	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 4.10		☐	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Sections 4.7, 4.10		☐	
Water Use Sustainability Initiatives					
Water efficiency measures – private and public open spaces including method of enforcement		Section 5		☐	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 5		☐	
Wastewater Management		Section 5		☐	
Stormwater Management Strategy					
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100 year Event Plan Long Section of critical points	Section 6		☐	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5 year Event Plan	Section 6		☐	

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Protect ecology – detention areas for the 1 yr. 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1 year Event Plan Typical Cross Sections	Section 6		☐	
Groundwater Management Strategy					
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/Subsoil Plan	Section 7		☐	
Actions to address acid sulfate soils or contamination		N/A - Section 4.6		☐	
The Next Stage – Subdivision and Urban Water Management Plans					
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		Section 8		☐	
Monitoring					
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		Section 9		☐	
Implementation					
Developer commitments		Section 9		☐	
Roles, responsibilities, funding for implementation		Section 9		☐	
Review		Section 9		☐	