YANCHEP CITY STRUCTURE PLAN LOCAL WATER MANAGEMENT STRATEGY

Prepared for:

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ABBREVIATIONS

AAMGL	Average Annual Maximum Groundwater Level
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soils
BGL	Below Ground Level
DEC	Department of Environment and Conservation (formerly Department of Environment)
DEWHA	Department of Environment, Water, Heritage and Arts
DoW	Department of Water
EPA	[Western Australian] Environmental Protection Authority
ER	Environmental Review
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
P3 UWPCA	Perth Coastal (Priority 3) Underground Water Pollution Control Area
Swale	An isolated, confined and vegetated or grassed drainage basin
SPP	Statement of Planning Policy
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TPS	Town Planning Scheme
UWMP	Urban Water Management Plan
WAPC	Western Australian Planning Commission
WSUD	Water Sensitive Urban Design
YBJV	Yanchep Beach Joint Venture

ABBREVIATIONS

YCSP	Yanchep City Structure Plan
YTR	Yanchep-Two Rocks

1 INTRODUCTION

This Local Water Management Strategy (LWMS) has been prepared to support the Yanchep City (previously St Andrews) Structure Plan.

The principal objective of this LWMS is to maintain site water balance and protect groundwater quality within the Yanchep City Structure Plan (YCSP) area.

1.1 Background

The proponent, Yanchep Beach Joint Venture (YBJV) is proposing to develop a 621ha parcel of land located approximately 50km northwest of the Perth Central Business District. The YBJV was formed to progress the planning of the subject site as a future primary regional centre for the Northwest corridor, and lies within the Yanchep-Two Rocks (YTR) district area (Figure 1).

The YTR district area was the subject of the City of Wanneroo Town Planning Scheme (TPS) No.1 Amendment 787. This Amendment requested to rezone the YTR areas from 'Rural' and 'Residential' to 'Urban Development,' 'Centre' and 'Industrial Development' and this required the preparation of an Environmental Review (ER). The TPS Amendment 787 and ER were formally assessed by the Environmental Protection Agency (EPA) under Section 48 of the *Environmental Protection Act 1986*. The EPA recommended that the rezoning be gazetted subject to a number of environmental conditions detailed in Ministerial Statement 538 (2000) (Appendix A).

The Minister for the Environment gazetted TPS Amendment 787 subject to the incorporation of a number of environmental conditions as stated in Ministerial Statement 538 Attachment 1 Environmental Condition 2.1 (2000). In effect, Local Structure Plans within the TPS Amendment 787 area are to be prepared in accordance with Ministerial Statement 538 and are to include (amongst other management plans/strategies) a Local Water Management Strategy (LWMS).

Furthermore, the *WA State Water Strategy* (Government of WA, 2003) identifies the need for an increased focus on total water cycle management and Water Sensitive Urban Design (WSUD) to improve the management of stormwater, particularly nutrients, and increase the efficiency of the use of water. Groundwater under the Swan Coastal Plain is vulnerable to contamination due to the unconfined, sand aquifer which allows rapid infiltration of runoff. Total water cycle management supported by WSUD has been proposed as the most effective way to manage water resources in an urban development context (PDC, 2006).

Statement of Planning Policy (SPP) 2.9 Water Resources (Western Australian Planning Commission, 2006) notes the importance of integrating water resources into structure planning and the need for preparation of an "integrated land use and water management strategy" or "urban water management strategy".

In 2008 the West Australia Planning Commission published *Better Urban Water Management* which provides guidance on the implementation of SPP 2.9 which is a requirement of the *WA State Water Strategy* (Gov of WA, 2003). It describes how water resources should be considered at each planning stage. For example, at the regional or district planning level, a Regional or District Water Management Strategy is required; at the local planning stage an LWMS is required, and; at subdivision stage an Urban Water Management Plan should be prepared.

1.2 Scope of Works

This report outlines the proposed approach to urban water management within the YCSP area as required in part, to comply with Statutory Provision 8.0 of the YTR District Structure Plan 2008, stating that an LWMS must be included at time of lodgement of an LSP.

This LWMS addresses, at a strategic level, stormwater and nutrient management throughout the YCSP area based on the guidelines provided in the *Stormwater Management Manual for Western Australia* (DoW, 2007), the *City of Wanneroo's District Planning Scheme No. 2* and the *National Guidelines for Evaluating Water Sensitive Urban Design (WSUD)*, ensuring WSUD principles Best Management Practices are employed.

Details not covered by this LWMS will be outlined in an Urban Water Management Plan (UWMP), prepared at the subdivision stage as a likely condition of subdivision approval. The UWMP will be consistent with this LWMS and to the satisfaction of the relevant authorities. It will be implemented as part of the development. A general structure for which the UWMP should follow is included as Appendix B.

A District Water Management Strategy (DWMS) has not yet been prepared for the Yanchep-Two Rocks area. Following the endorsement of a Yanchep-Two Rocks DWMS, where there is any inconsistency between the provisions, standards or requirements of the DWMS and the LWMS, the provisions, standards or requirements of the DWMS shall prevail.

1.3 Total water cycle management – Principles and objectives

Management of the water cycle is very complex issue involving a variety of factors that need to be taken into consideration such as rainfall, evapo-transpiration and overland and groundwater flows. The linkages between the water cycle and urban development are very clear with impacts from urbanization affecting stormwater systems and the quality of downstream ecosystems.

Within the YCSP area there are a variety of policies that need to be adhered to in order to determine desired environmental guidelines. These policies are listed in Section 1.4.

1.4 Local Water Management Strategy Objectives

This LWMS has been prepared to the requirements of the City of Wanneroo on the advice of the Department of Environment and Conservation (DEC) and Department of Water to:

- Identify the environmental outcomes (including sustainability indicators) to be achieved through the implementation of this strategy;
- Ensure surface and groundwater are managed to the minimum requirements of Perth Coastal (Priority 3) Underground Water Pollution Control Area;
- Include provisions for the connection of all areas of development to the deep sewerage system; and
- Demonstrate that best practices WSUD principles are incorporated to maximise on-site water infiltration generally.

This LWMS uses the following documents to define its key principles and objectives:

1.4.1 Perth Coastal (Priority 3) Underground Water Pollution Control Area (P3 UWPCA)

Priority 3 areas are defined to minimise the risk of pollution to the water source and declared over land where water supply sources need to co-exist with other land uses such as residential, commercial and light industrial developments (Water and Rivers Commission, 1998).

The following minimum requirements of development of residential areas within P3 areas include:

- Installation of reticulated sewage in new urban centres with appropriate disposal of waste water effluent, preferably off catchment;
- Ensure the septic tank densities and location in non-urban area complies with Water Corporation or Water and Rivers Commission recommendations;
- Observe restrictions on development of industries handling or processing noxious or polluting substances;
- Commercial areas are designed to prevent catchment contamination through stormwater runoff or discharge of wastes;
- Observe restrictions on intensive agriculture; and
- Restriction of disposal sites for polluting wastes (sites with suitable location, construction and management to ensure no significant pollution can occur may be acceptable).

1.4.2 Water Sensitive Urban Design (WSUD)

WSUD aims to bring consideration of the water environment and infrastructure service design and management opportunities into the earliest stages of the decision making processes associated with urban planning and design (*National Guidelines for Evaluating Water Sensitive Urban Design,* BMT, 2007). It is designed to help maintain a healthier ecosystem downstream, to protect people and developments from harm or damage and to maintain an appropriate water balance.

The water resource management issues that are incorporated within WSUD are at the catchment, suburb and individual allotment scale. Key principles of total water cycle management should address the issues that need to be maintained for the integration of domestic and rural uses and the environment. These key principles include:

- Making use of a variety of water sources to minimise the dependence on potable water;
- Using all water resources sustainably;
- Integrating domestic use with needs from natural water processes;
- Flood mitigation to protect built up areas;
- Stormwater infrastructure as a function of the road hierarchy;
- Stormwater quality management;
- Ground water management; and
- Landscape design.

WSUD guidelines have the objective of managing water balance, maintaining water quality and encouraging water conservation when undertaking statutory and strategic planning. The goals of WSUD are to:

- minimise impact on existing natural features and ecological processes;
- minimise impact on natural hydrologic behaviour of catchments;
- protect water quality of surface and ground waters;
- minimise demand on the reticulated water supply system;
- improve the quality of, and minimise polluted water discharges to, the natural environment;

- collect, treat, store and/or reuse runoff, including roof water and other storm water (while ensuring natural processes are maintained);
- reuse treated effluent and minimise wastewater generation;
- increase social amenity in urban areas through multi-purpose green space, landscaping and integrating water into the landscape to enhance visual, social, cultural and ecological values;
- add value while minimising development costs – minimise the stormwater infrastructure cost of the development; and
- take into account the nexus between water use and wider social and resource issues.

1.4.3 Statement of Planning Policy 2.9 Water Resources

Statement of Planning Policy (SPP) 2.9 Water Resources (WAPC, 2006) is made under Section 26 of the *Planning and Development Act 2005*. The objectives of SPP 2.9 are to:

- Protect, conserve and enhance water resources, that are identified as having significant economic, social, cultural and/ or environmental values;
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and all other biological life with attention to maintaining or improving the quality and quantity of water resources; and
- Promote and assist in the management and sustainable use of water resources.

1.4.4 Western Australian State Water Strategy

A framework for providing a multi-faceted approach to secure Western Australia's water future that combines new sources, new efficiency measures and innovative ways of re-using our wastewater.

Water resource management in accordance with the *Western Australian State Water Strategy* (Government of Western Australia, 2003) incorporates:

- Minimising water requirements for the establishment of POS areas;
- Minimising water requirements for POS maintenance; and
- Minimising water requirements within each allotment.

1.4.5 Stormwater Management Manual for Western Australia

The Department of Water's (DoW's) current position on urban stormwater management in Western Australia is outlined in *Chapter 2: 'Understanding the Context'* of the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007) which details the management objectives, principles and a stormwater delivery approach for Western Australia. Principle objectives for managing urban water in Western Australia are:

- Water Quality: To maintain or improve the surface and groundwater quality in the development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance in the development area relative to the pre-development conditions.
- Water Conservation: To maximise the re-use of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.

- Economic Viability: To implement stormwater management systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life, to the community.
- Protection of Property: To protect the built environment from flooding and water logging.
- Social Values: To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

1.4.5.1 Decision Process for Stormwater Management (DoW, 2009)

The Department of Water released the Decision Process for Stormwater Management in Western Australia to provide updated version of a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives outlined above. The desired outcome of the decision process methodology is to minimise potential changes in the volume of surface water flows and peak flows resulting from the urbanisation of an area (i.e. residential, rural-residential, commercial and industrial development). A copy of the Decision Process Flowchart is provided in Appendix C.

1.4.6 Liveable Neighbourhoods

This policy seeks to promote opportunities for linking water management infrastructure with the urban built form and landscape design and aims at achieving a more sustainable development through:

- reducing the amount of water transported between catchments, both in water supply and wastewater export;
- optimising the use of rainwater that falls in urban areas;
- achieving appropriate quality and quantity targets with respect to stormwater run-off; and
- achieving sustainable urban structure and form.

1.4.7 City of Wanneroo Smart Growth Strategy

Developed in 2005, the *Smart Growth Strategy* represents a local approach to state sustainability. Its aim is to “value, protect and enhance our natural environment in harmony with the growth and progress of our City”, by promoting more efficient use of water, energy and other resources. The City now assesses the environmental component of planning and building applications using the Smart Growth Assessment Tool.

In reference to water management, the strategy includes such commitments as to:

- approve appropriate household grey water recycling systems in order to help reduce scheme water demand; and
- support the State government in implementing the re-use of treated wastewater and stormwater.

2 PROPOSED DEVELOPMENT

2.1 Location

The subject area is bounded by the Mitchell Freeway Road Reserve and Yanchep National Park to the east; Yanchep Beach Road to the south and the Marmion Avenue extension to the west. The northern boundary is as established in an existing approved plan of subdivision (WAPC 131632) (Figure 1).

2.2 Subject Area

The majority of the YCSP area is zoned 'Urban Development' in the City of Wanneroo TPS and comprises Lots 9500, 9501 and 609 Yanchep Beach Road, Yanchep; Lot 603 Toreopango Avenue, Two Rocks; Lot 904 and part of Lot 903 Rail Reserve (Figure 2).

The subject area consists of predominantly cleared land and areas of remnant native vegetation. Land adjoining and surrounding the subject area is zoned either "Urban" or "Urban Deferred" or reserved as Parks and Recreation and supports remnant vegetation under the current MRS (Figure 3).

The proposed development includes the provision for approximately 9,000 serviced residential dwellings of R20, 40, 60 and 100 coding that provide for a range of market demand housing product types. The development also identifies zoned precincts including 'Centre', 'Mixed Use', 'Business' and 'Service Industry' as well as key areas of Public Open Space (POS) (Figure 4).

The subject area has several adjoining land uses that provide interface opportunities and constraints. To the south, west and north-west, there is existing and/or proposed residential development. Further west, in relatively close proximity is the coast, which provides lifestyle and recreational amenity, as well as visual amenity from the most elevated parts of the subject area. There is a significant Bush Forever site to the north east containing high quality vegetation and the eastern boundary of the subject area is flanked by the future Mitchell Freeway reserve and Yanchep National Park further east (in the long term the freeway will create a barrier). The southern part of the subject area envelopes a golf course and adjacent residential development.

2.3 Key Elements of Yanchep City Structure Plan

The vision, as presented in the YCSP is as follows:

"*Yanchep City Centre, and its environs, as the primary regional centre for the North-West Corridor, will be a city for the new millennium, adapting the tested principles of traditional urban form to the rapidly evolving needs of a modern population, recognizing that new cities must lead the way in the pursuit of sustainable living; YSC will be a healthy city built around using transit, cycling and walking as the dominant transport forms, where health, education and recreation are key social elements, and where urban structure is balanced with natural landscape and heritage values*."

Key elements of the development design related to urban water management include:

- Location of POS areas and how they will be managed to minimise leaching of nutrients into the environment off site;
- A stormwater management approach that incorporates a fully integrated stormwater system within the landscaped design of the streetscape network and environs that maximises onsite detention and minimises runoff;
- The practice for re-use of stormwater runoff into the design of the development such that it facilitates environmental and sustainability success;

- Selection of street tree and shrub species that require minimal irrigation or hand watering after the initial two year watering establishment period; and
- The use of endemic indigenous and low water use plants that assist with filtration and absorption of stormwater.

3 EXISTING ENVIRONMENT

3.1 Climate

The Yanchep-Two Rocks (YTR) area experiences a warm Mediterranean climate characterised by hot dry summers and mild wet winters. Most rain falls during the winter months with an average precipitation level of between 600-1000mm (Beard, 1990). Air temperatures are similar to those experienced in Perth, the mean daily maximum temperature ranges from 31.8°C in summer to 17.8°C in winter; and the mean daily minimum temperature ranges from 17.4°C in summer to 8.0°C in winter (Bureau of Meteorology, 2009). In summer, the area is affected by local sea breezes whilst in winter, major storms affect the area and are characterised by north-westerly storm winds that move to the west and southwest, interspersed with calmer periods.

3.2 Topography

The subject area is on the western portion of the Swan Coastal Plain and comprises gently undulating landforms containing valleys and ridges. Two ridges form perpendicular to the coastline in the southern portion of the YCSP area and are elevated between 30 – 45m Australian Height Datum (AHD). Flat areas with low points 20-30m AHD exist between these ridges. A number of conical hills occur in the north and east, adjacent to the basin area and are up to 50m AHD. Typically elevation at the subject area ranges from 25mAHD to 45m AHD and is indicated on Figure 5.

3.3 Geomorphology and Soils

The subject area is located on the Swan Coastal Plain and is composed of Quaternary continental sediments (Churchward & McArthur, 1980). Two major geological units are present in the YTR area, Tamala Limestone and Safety Bay Sand. Tamala Limestone is the older geological unit and forms a series of rounded ridgelines and intervening depressions known as the Spearwood Dune System. Safety Bay Sand is the younger geological unit and forms a large variety of landforms known as the Quindalup Dune System. It includes tall dunes that are either covered with vegetation or consist of loose mobile sand. Spearwood sand, limestone and cap rock are predominantly found to depths of 40m BGL or more.

3.3.1 Karstic Terrain

Karstic (limestone) terrain is influenced by water chemistry and depth to groundwater from the surface. Fluctuations in surface and groundwater quality and levels as a result of stormwater management may contribute to the collapse or subsidence of these structures. As such not all land uses and development will be compatible over or in the vicinity of limestone terrain. The water management approach, where karst is concerned, is to ensure that drainage into areas that may have Karstic formations is avoided, or at least minimised (refer Section 6.3.3).

The size of potential karst features within the zone and thus their significance in terms of constraints to development varies according to a variety of factors including water chemistry, the strength of the limestone, and depth to groundwater from the surface.

Assessment of Stages 1-3 of the YTR DSP including the area comprising the YCSP indicates that no major karstic features are present over the area (Coffey Geotechnics, 2007). A shallow void was identified at 30m in the central eastern portion of the YCSP area (Figure 6). Although initial geotechnical assessment indicates that shallow voids at this depth do not pose any constraints to development, management of some areas of loose sand and pinnacle formations associated with the limestone in the south eastern portion of the YCSP area will be required. It is anticipated that the definition and

management of these areas will comprise engineering works to be determined during general geotechnical assessment of the YCSP area at the detailed design stage.

3.4 Vegetation and Flora

3.4.1 Vegetation Complexes and Types

Approximately half of the YCSP area contains native vegetation belonging to three vegetation complexes: the Old Quindalup Dune Heath, Limestone Heath and Sand over Limestone Vegetation (ATA Environmental, 2007a).

Quindalup Dune vegetation is not common within the YCSP area and is restricted to long dune ridges and occasional conical dunes intermixed with Spearwood vegetation types. The main vegetation in the YCSP area occurs on Spearwood dune soils. The shallow sand over limestone and outcropping vegetation types are mainly distributed in the central and eastern regions of the subject site.

Dryandra sessilis (now *Banksia sessilis*) Heath occurs on flat areas of limestone and low hills while the tall jagged limestone hills support *Melaleuca huegelli* and Mallee eucalypt species. The deeper sand over limestone vegetation types are located in the central and eastern regions of the subject site and include the Banksia Woodlands and isolated stands of Tuart trees.

3.4.2 Vegetation Condition

The condition of the vegetation in the YCSP area ranges from Very Good to Completely Degraded. Historically, approximately half of the YCSP area has been cleared or degraded as a result of agricultural and plantation land use practices and grazing of stock. Evidence of grazing occurs in most areas of native vegetation including the most remote and least accessible terrain and vegetation types. Areas easily accessible for grazing are most degraded with a large reduction in understory shrub density and a high number of introduced species.

3.5 Surface Water Hydrology

There are no surface water features present within the YCSP area including no rivers or creek lines running through the subject area or nearby.

The nearest surface water feature is Loch McNess Lake, a fresh water lake that forms part of a chain of lakes approximately 1km to the east of the YCSP area (Kranostein & Oldham, 2004).

3.6 Groundwater Hydrology

The DoW identifies three distinct aquifers beneath the YCSP area (*pers. comms.* Claire Hammersley, 25 June 2010). From natural surface level in descending order, the hydrological units are:

- Perth Superficial Swan aquifer (unconfined);
- Leederville aquifer (confined); and
- Yarragadee aquifer (confined).

3.6.1 Perth Superficial Swan

The Perth Superficial Swan or Tamala Limestone aquifer is the shallowest and most productive of the three. It is overlain in western parts by calcareous dunal sands with exposed areas in the east comprising dune sands and solid limestone outcrop. Groundwater recharge is derived from direct winter rainfall infiltration or flows from the Gnangara Mound.

The height of the top of the groundwater across the YCSP area ranges from 1.09mAHD at the eastern edge of the subject area to 0.77mAHD in the western part of the subject area. Groundwater flows in a westerly direction toward the Indian Ocean. Depth to groundwater ranges from approximately 19m below ground level (BGL) to 49mBGL.

Hydrological studies conducted in 1991 conservatively estimated flow through to the coast at ~365ml/yr/km, water hardness ~220mg/L, and salinity ~400mg/L. Salt water intrusion occurs in parts of the aquifer near the coast (Alan Tingay & Associates and Peck, 1991).

Section 4 contains further information on groundwater levels and quality.

3.6.2 Leederville Aquifer

The Leederville Aquifer is the hydrological unit underlying the Tamala Limestone. The majority of water is contained in discontinuous lenticular bands of sand, generally less than 10m thick. These bands vary considerably in sorting, grain size and clay content. Groundwater recharge is derived from the overlying Tamala Limestone aquifer in areas to the north near Gingin and upward leakage from the Yarragadee Aquifer where intervening formations are absent or sandy and direct hydraulic connection occurs (Alan Tingay & Associates and Peck, 1991).

3.6.3 Yarragadee Aquifer

The Yarragadee Aquifer is a massive confined hydrological unit that underlies much of the Swan Coastal Plain. The aquifer is a Jurassic fluviate deposit with minor shallow marine and continental components that consists of an inter-bedded sequence of sandstone, siltstone and shale. The majority of water is contained in sandstone beds composed of medium to very course, sub-angular, weakly cemented feldspathic sand that is up to 30m thick. Groundwater recharge is derived from downward leakage from the two overlying units where intervening sediments are absent.

3.6.4 Groundwater extraction

The YTR area is serviced by the Water Corporation's local groundwater supply system, comprising of bores and water facilities located to the south of Yanchep Beach Road. Appendix D shows the location of existing Water Corporation bores that service the area.

3.7 Wetlands

There are no wetlands, creeklines or groundwater dependent ecosystems in the YCSP area or downstream of the proposed development. The nearest wetland is Lake Loch McNess within Yanchep National Park, approximately 1km east of the YCSP area and hydrologically up-gradient of the subject area.

3.8 Acid Sulphate Soils (ASS)

The Western Australian Planning Commission (WAPC) has mapped a significant portion of the Swan Coastal Plain for ASS risk. ASS risk mapping by the WAPC provides the following three risk categories:

- High to moderate risk of ASS occurring within 3m of the natural soil surface;
- Moderate to low risk of ASS occurring within 3m of the natural soil surface; and
- No known risk of ASS occurring within 3m of natural soil surface (or deeper).

WAPC ASS risk mapping identifies the subject area as having no known risk of ASS occurring.

3.9 Existing Land Use

The area is currently used for cattle grazing on cleared and partially cleared parts of the site. The area also contains native vegetation and tree plantations.

3.9.1 Potential Contamination

According to the Department of Environment and Conservation's *Contaminated Sites Database* there are no known contaminated sites in the subject area.

The YCSP site is located within a Priority 3 groundwater protection area and should be managed according to directions outlined in the management sections of this report.

4 GROUNDWATER INVESTIGATIONS

4.1 Groundwater Levels and Average Annual Maximum Groundwater Level (AAMGL)

Groundwater levels beneath the YCSP area range from 1.09m AHD within the eastern part of the subject area to 0.77m AHD within the western part of the subject area. The direction of flow of groundwater is to the west with discharge in to the ocean (Coffey Geotechnics, 2007). An estimated seasonal groundwater variation of 1.5m is based on regional trends in surrounding bores (DoW's WIN Database).

Data obtained recently (27 September 2009) by Coffey Environments from three groundwater monitoring bores installed onsite in August 2009 is presented in the following Table 2 below. Bores were installed at low points across the subject area and are presented in Figure 7. Standing water levels (SWL) in Table 2 are indicative of winter maximums.

TABLE 2

ONSITE BORES GROUNDWATER LEVEL DATA

Bore ID	Bore Depth (from TOC)	SWL (from TOC	Ground surface Elevation (mAHD)	SWL (mAHD)	SWL (mBGL)
MB1	21.9m	19.27m	19.92	1.09	18.83
MB2	25.05m	23.05m	23.46	0.87	22.59
MB3	27.5m	25.15m	25.47	0.774	24.70

According to existing DoW monitoring bores within close proximity to the YCSP area (Table 1) groundwater level in the area is declining (Appendix E). In general, a notable decline in groundwater levels has occurred across the Perth metropolitan region (post 1994) and is indicative of declining rainfall and possibly increased groundwater consumption since the late 1990s.

TABLE 1

SELECTED DoW BORE MONITORS

DoW Site ID & Name	Reference	Monitoring Period	AAMGL (mAHD)	Location
6271 (BD7)	61710025	1974 - 2008	0.88	~83.26m east of the subject site
4923 (YB11)	61610582	1975 - 2005	2.34	~1200m south east of the subject site
6361 (GA33)	61710117	1975 - 2005	2.03	~1505m northwest of the subject site

Regional annual average maximum groundwater levels (AAMGL) (1975-2009) is calculated to be 2.3m AHD (DoW Hydrographs, WIN database 2009).

While regional AAMGL is marginally higher than winter groundwater level at the YCSP site, still adequate separation of the groundwater resource and the proposed urban development area exists. Based on available data for site elevation and seasonal groundwater variation, depth to groundwater is

unlikely to rise higher than 19m below ground level (BGL) across the YCSP area using current rainfall data.

4.2 Groundwater Quality

In 1992 Alan Tingay & Associates carried out a chemical analysis of groundwater from existing production bores in the YTR area. Results indicated the concentration of potential contaminants is within the recommended range for drinking water as published by the National Health and Medical Research Centre (NHMRC, 1987). The hardness of the water, expressed as $CoCO_{3,}$ was found to be about 200mg/L indicating that the water may need to be treated before use for certain purposes. The salinity of water within the superficial aquifer was about 200mg/L (TDS). Salt water from the ocean intrudes low parts of the aquifer near the coast (ATA, 1992).

Depending on regional groundwater allocation, groundwater from the superficial aquifer may be available for use for onsite irrigation and/or public water supplies. Existing onsite groundwater monitoring bores can be used to generate groundwater quality data to determine any necessary treatment requirements for water for certain purposes such as irrigation.

5 MANAGEMENT CONSIDERATIONS

5.1 Potential Alteration to Existing Water Cycle and Nutrient Inputs

The development of the YCSP area primarily for residential purposes is likely to cause alterations to the balance between runoff, infiltration and evapo-transpiration and therefore alter the underlying groundwater regime.

5.1.1 Groundwater Levels

At present, due to the sandy soils, there is no overland flow of water at the subject area. Under the current regime most of the rainfall would either be intercepted and used by the vegetation, or infiltrated into the subsoil and groundwater system.

An increase in impervious surfaces (reduced infiltration) resulting in increased runoff is particularly relevant to the large City Centre area. The density of buildings, roads and car parks will results in a high percentage of impervious surface area. Irrigation of POS areas including ovals, private gardens and institutional landscaping will likely be sourced from within the YCSP area from the underlying superficial aquifer. Whilst most of the irrigation water will re-infiltrate through the sandy sub-soils and into the groundwater, the increased impervious surfaces will result in an increase in water recharge to the groundwater and a potential rise in groundwater levels.

Development at the YCSP site is expected to have minimal impact on water levels. The water table is at a depth of 19-49m BGL across the subject area and is therefore not a primary consideration for finished earthworks levels or design of stormwater treatment systems. Variations in the water table also present no risk to development.

5.1.2 Groundwater Quality

Groundwater quality beneath urban development can be adversely affected in a number of ways. Groundwater under the Swan Coastal Plain is vulnerable to contamination as the unconfined, sand aquifer allows rapid infiltration of surface runoff (Western Australian Legislative Assembly, 1994). Sources of contamination associated with urban development have the potential to pollute surface runoff or discharges and may adversely affect water quality of the superficial aquifer.

Common contamination sources associated with urban development include:

- Fertiliser application and pesticide use;
- Septic tank leachate;
- Leachate from waste disposal sites;
- Chemical and hazardous material leakage and spills;
- Sewer overflow;
- Impervious surface runoff (oil, grease, heavy metals, etc.); and
- Liquid and solid waste disposal (biological contamination).

While there are no groundwater dependent ecosystems or wetlands in the YCSP area or down gradient, these groundwater contaminants may impact groundwater quality in the unlikely event that attenuation through the deep soil profile is hindered. It is important that activities that may impact adversely on groundwater quality are carefully sited and managed. For example, stormwater runoff from roads and hard surfaces will need to be captured and treated before being infiltrated back into the groundwater or, preferably, re-used for other purposes such as irrigation. A significant depth to

groundwater at the subject area increases the likelihood of attenuation of nutrients and contaminants before runoff infiltrates the groundwater.

The principal sources of nutrients and contaminants within the proposed development will be lawns and gardens and road runoff. Landscape concept plans will be developed for POS areas by the proponent in consultation with the City of Wanneroo. Future residents should be provided with information relating to appropriate fertiliser use at the land sales office.

The EPA's objective in relation to groundwater quality is to '*minimise the risk of loss of groundwater quality'*. Management guidelines are also necessary to protect the subject site as a result of the north eastern corner of the subject area being within a Priority 3 (P3) groundwater source protection area (Department of Environment, 2005). P3 areas are declared over land where water supply sources need to coexist with other land uses such as residential, commercial and light industrial developments. Protection of P3 areas is achieved through management guidelines rather than restrictions on land use. If the water source does become contaminated, then water may need to be treated or an alternative water source found (Department of Water website, 2009).

The chemical composition of water from existing nearby production bores meets guidelines for drinking water quality, although the hardness of the water, expressed as calcium carbonate, is about 200 mg/L indicating that the water may need to be treated before use for certain purposes.

As the subject area will be connected to mains sewerage systems it is not anticipated that any additional nutrients will enter the environment as a result of effluent treatment and disposal.

5.2 Other Hydrological Opportunities & Constraints

The characteristics of the pre-development environment of the subject area provide for key opportunities and constraints for the management of water in relation to the proposed development in addition to those included in the sections above.

5.2.1 Opportunities

- The YCSP area does not contain any surface water bodies; as such nutrient management is restricted to the protection of groundwater quality;
- No highly environmentally sensitive areas such as wetlands or groundwater dependent ecosystems are present within the YCSP area;
- The water table is at a depth of 19-49m BGL;
- There is no known risk of shallow ASS (ASS or potential ASS <3m below ground surface) occurring in the YCSP area;
- Effluent treatment is currently being carried out on a site to the northwest of the YCSP area. In the future, wastewater from the YTR area will be piped to the Alkimos Waste Water Treatment Plant currently under construction south of the YTR area and expected to be operational by late 2010;
- Groundwater bores installed to upgrade the capacity of the existing water supply system will ultimately become a part of the longer term permanent scheme, to be advised by the Water Corporation; and
- A water supply capacity upgrade is proposed by Water Corporation to facilitate and support development in the area.

5.2.2 Constraints

- The developable area is relatively large and the magnitude of the development means that the volumes of stormwater likely to be generated from the subject area may be substantial;
- Formalised landscaping of open space areas and ovals will require the use of fertilisers;
- Groundwater availability for irrigation or open space and fit-for-purpose schemes (more POS required with less active areas)
- Protection of regionally significant vegetation and threatened species habitat;
- Nutrient holding capacity of the soil is likely to be minimal due to the subject area being characterised by course sands; and
- Although geotechnical investigations have indicated a low risk of karst features within the YCSP area, an area requiring further consideration was identified in the south eastern portion of the YCSP area which will need to be managed.

6 MANAGEMENT STRATEGY

The risk of contamination of the groundwater beneath the YCSP area, as a result of urbanisation will be minimised by adopting WSUD guidelines. The guidelines have the objective of managing water balance, maintaining water quality and encouraging water conservation.

Management measures applicable to stormwater, nutrient and groundwater management are outlined below.

6.1 Demand Reduction

In general, urban growth will result in a significant increase in demand for water supply. Given the current changes in climatic factors including a decline in rainfall it is increasingly important to focus on the conservation of water resources.

Furthermore, the cost of water is expected to increase over the coming years due to declining supply in relation to a growing population and the need for alternative infrastructure to increase the amount of fresh water available such as desalination plants.

Water resource management in accordance with the *Western Australian State Water Strategy* (Government of Western Australia, 2003) incorporates:

- Minimising water requirements for the establishment of POS areas;
- Minimising water requirements for POS maintenance; and
- Minimising water requirements within each allotment.

6.1.1 Domestic Water Reductions

In 2007 residential water use averaged 106 kilolitres per person per year. The Western Australian Government is urging households to conserve more water to further reduce Perth's demand to less than 100 kilolitres a person a year (Gov of WA, 2007). The consumption target indicated in *Better Urban Water Management* (WAPC, 2008) for water is of 100 kL/person/yr, (*State Water Plan* target) including not more than 40-60 kL/person/yr scheme water. An alternative water source is required to supply water for external use to meet this objective. Achieving this target will reduce total water use for the residential sector by 20% from 2001 levels (Gov of WA, 2007). This requires current outside watering practices and other improvements in household water use efficiency to be maintained and improved.

Within the YCSP development, water conservation measures will be applied including the installation of waterwise fittings and appliances in house to achieve water efficiency. *5 Star Plus* Energy has been introduced by the state government (2006) and all houses built after 1 September 2007 must comply with *5 Star Plus* provisions. These Provisions are based around two codes: the Water Use in Houses Code and the Energy Use in Houses Code. Implementing the *5 Star Plus* provisions (through the local authority building licence application process) will result in reduced water consumption as well as improved energy efficiency in houses constructed after. The Water Use in Houses Code requires:

- The installation of water efficient fixtures and fittings in new houses. All tap fittings (other than bath outlets and garden taps) must be a minimum of 4 star WELS rated, all showerheads must be a minimum of 3 star WELS rated, and all toilet systems must be a minimum of 4 star WELS rated dual flush; and
- Outdoor private swimming pools and spas must be supplied with a cover or a blanket to reduce evaporative losses.

Future residents within the development area could achieve further reductions in potable water demand with the installation of rainwater tanks that are reticulated to the dwelling for non-potable uses including toilet and laundry uses. Extra efficient water sustainability would see a cyclic approach to water use such as treating rain water to potable standard and grey water from laundry, showers and basins also treated and for use in toilets and on gardens.

Water Corporation rebates are available to householders for waterwise fixtures and fittings. Installation of rainwater tanks and grey water reuse systems also qualify for subsidies. The promotion of available rebate programs to future residents should be conducted during the marketing phase of the development. 'Waterwise' educational material should also be provided regarding other aspects of water efficiency including gardening practices, species selection, grey water reuse and fertiliser application.

Water savings within the YCSP area can be achieved through the application of 'waterwise' landscaping in areas of POS using native species, minimising turf areas and the selection of shrub planting species that require minimal irrigation or hand watering after the initial two year watering period required for establishment.

The Proponent will give consideration to a waterwise package, which could include the provision of a rain water tank within each lot, waterwise landscaping and/or waterwise educational material.

Some further examples of water savings initiatives to maximise efficient use and re-use of water can be found on Water Corporation and DoW websites. These sites include such recommendations as waterwise garden and subsurface irrigation systems, swimming pool covers, flow regulators and domestic garden bores.

6.1.2 Commercial Water Demand

The YCSP city centre area will be principally comprised of commercial activities. The main opportunity for reuse in this type of development would be stormwater capture and reuse on-site. This can be achieved through the installation of below ground storage devices for both roof top catchments and impervious surface catchments, which have different filtration systems for primary treatment and some have a secondary filter. A pump returns collected water to provide a non-potable supply for uses such as irrigation, toilet flushing and vehicle washing.

Table 5 below outlines the maximum volumes of rainwater that could be captured taking into account annual rainfall and roof area. Given the average annual rainfall for the area is 642mm (Two Rocks Weather Station, BOM website, February 2010), the figures for the 600mm annual rainfall category would be the most useful for estimating the volume of water that could be collected and reused for buildings in the YCSP city centre area.

TABLE 5
MAXIMUM VOLUME OF WATER COLLECTED BASED ON ROOF AREA AND ANNUAL RAINFALL.

Annual rainfall (mm)	**Maximum Volumes of Rainwater per Year (kL)**						
	Roof area (m^2)						
	100	150	200	250	300	400	500
400	30	45	60	75	90	120	150
500	38	57	76	95	114	152	191
600	**46**	**69**	**92**	**115**	**138**	**184**	**230**

800	62	93	124	155	186	248	310
1000	78	117	156	195	234	312	390

Modified from: *enHealth Council (2004)*

The new water efficiency measures for WA will encourage participation by businesses in the Waterwise Business Program. Since July 2007 businesses state-wide who consume above 20,000kL of scheme water per meter reading year will be required to join the Water Corporation's Waterwise Businesses Program. This Program involves undertaking a one hour water management assessment annually with the Water Corporation and developing a Water Efficiency Management Plan.

The Water Efficiency Management Plan will contain, but not be limited to, the following information:

- A profile and description of the person submitting the plan;
- Results of the Water Management Assessment;
- Water savings opportunities, including an estimate of the likely savings;
- Estimate of increased water use through business growth; and
- Details of a water savings action plan, including timeframes.

The Management Plan will need to be endorsed by the Water Corporation. Following Water Corporation approval the Water Efficiency Management Plan, is required to be implemented over a five year period.

More information about the Waterwise Business program is available from the Water Corporation's 'Being Waterwise' Section:

(http://www.watercorporation.com.au/W/waterwise_efficiency_measures.cfm).

At this stage it is not known if any of the future businesses that will ultimately be located in the subdivision area would fall into this category.

Abstraction of the superficial aquifer by private users, including commercial and industrial operations associated with development in the YCSP area will need to be managed to ensure that the forecasted requirements for future groundwater extraction for public supply are not impacted. Dependant on capacity of the superficial aquifer and availability to private users at the time of subdivision, it may be necessary to place memorials on titles to prohibit groundwater abstraction. Other management measures can be explored in the UWMPs which will be developed for the various stages of development within the subject area.

6.1.3 POS and Landscaping Demand Management

Groundwater resources of the Perth Superficial Swan aquifer are extremely limited with uncertainty over the sustainability of groundwater resources available. Landscape water initiatives will therefore be necessary to minimise the use of scheme water for irrigation of public landscape areas.

The proposed strategy for water efficiency is as follows:

- Where possible transfer groundwater entitlements to obtain a partial or fully non-potable irrigation supply;
- Native plants will constitute the majority of the total landscaped areas of POS and streetscapes;
- Waterwise gardens will be advocated for residential lots including guidelines, education and incentives provided to residents;

- Irrigated amenity grassland will be minimised and integration with drainage management will provide passive recreation where practical.

Section 6.4 provides further information on water usage in POS and landscaped areas.

For the purpose of future demand for public supply, the Water Corporation plans supplement the extraction of water from the Tamala Limestone aquifer with a connection to the proposed Barragoon borefield, north east of Two Rocks (Water Authority of Western Australia, 1990). Further information on water source is provided in Section 6.4.

6.2 Stormwater Management

It is a requirement of the City of Wanneroo to design the stormwater drainage system such that all stormwater generated from the development is retained within the development site through the use of infiltration / retention basins. In general, infiltration of stormwater at source is highly recommended using WSUD guidelines.

6.2.1 Design Criteria

The following City of Wanneroo design criteria will be implemented in at the YCSP area:

- The one-year one-hour average recurrence interval ARI event to be retained at source through the use of retention (soakage) or storage devices;
- The post-development critical one-year average recurrence interval peak flow and volume to be consistent with pre-development flows at the discharge points of all strategy and/or plan areas;
- Floodways are to be defined and are to contain the regional 100 year ARI event flow. Floodways may not be developed or obstructed in any way, and are entirely separate from the required storage volumes to maintain predevelopment flows;
- Flood detention/storage areas to be incorporated into POS and located outside defined floodways;
- Residential development not to occur within floodways;
- Minimum habitable floor levels to be a minimum of 0.5m above the 100 year ARI flood level in rivers or main drainage networks;
- Minimum habitable floor levels be a minimum of 0.3m above the 100 year ARI flood level in local drainage networks;
- Defined major arterial roads will remain passable in the 100 year ARI event and minor roads passable in the 5 year ARI event;
- Swales/vegetated bioretention systems (also referred to as rain gardens) are to be sized at 2% of the constructed impervious area from which they receive runoff;
- Where it is proposed to use a computer stormwater modelling tool to assess the impacts of urban development and to size structural controls for protection of downstream surface water quality, the following pollutant reduction targets are to be achieved (as compared with past urban development practices that did not actively manage water quality):
    - at least 80% reduction of total suspended solids
    - at least 60% reduction of total phosphorus
    - at least 45% reduction of total nitrogen

  - at least 70% reduction of gross pollutants.

- To reduce health risk from mosquitos, retention and detention treatments will be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours;
- Clean fill imported onto the site is to have the capacity to reduce phosphorous export via soil leaching, while also meeting soil permeability and soil compaction criteria specified by the City of Wanneroo;
- Manage groundwater quality at pre-development levels (winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the catchment; and
- If the pollutant outputs of development (measured or modelled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements within the development area. If catchment ambient conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the *National Water Quality Management Strategy* (ARMCANZ & ANZECC, 2000).

Drainage measures have been designed for the subject area are discussed below, incorporating the management of ARI stormwater events. Hydrology and hydraulic design of the stormwater collection and conveyance system will be in accordance with the approved standards and specifications of the City of Wanneroo and the *Australian Rainfall and Runoff (2001)*.

6.2.2 Stormwater Collection and Conveyance

A concept stormwater management strategy has been prepared by Serling civil engineers for the YCSP. The stormwater management system for the YCSP area is designed to maximise the benefits of WSUD by capturing and infiltrating the stormwater generated on site including for 100 year ARI storm events via progressive infiltration within the drainage network. The proposed progressive piped system is designed to collect storm runoff and dispose of (leak) the majority of the runoff (usually at least the 1 in 1 storm first flush) thus infiltrating stormwater close to the area of runoff capture. This causes infiltration to occur over a wider area and reduces the storm concentration at the basin. This system is proposed within road swales where the road reserve is wide enough. Where open end pipes have the capacity to infiltrate and store the 1 in 1 year events and greater, stormwater will ultimately flow into the basins through the StormTech system. In minor storms it would be expected that there would be no flow or very little flow into the basin as the drainage network caters for the storm flow.

A StormTech system primarily collects and infiltrates the stormwater rather than piping it further downstream to an infiltration basin. This approach satisfies the 1 in 1 year “first flush” infiltration at source. This system can be parallel to or form part of the piped drainage system. Refer to Detail B on Figure 8 for how StormTech can perform this function. The progressive infiltration system is also presented in Figure 8.

The benefits of Stormtech are:

- It has initial first flush treatment capabilities due to the micro biology that is set up within the filter material surrounding it;
- It allows the first flush to infiltrate into the soil and (given the great depth to the water table at Yanchep) provide nutrient stripping before it gets to the water table;
- The surrounding material can be treated to improve the PRI if deemed necessary;
- It provides a below ground storage and detention capability that can be used to take the peak off the storm hydrograph and then either infiltrate into the ground or discharge back into the drainage system after the peak of the storm has passed;
- It can be visually inspected and jetted for ease of maintenance;

- It can and has been used as the main conduit to transport the stormwater along the drainage system (eg Burns Beach Road, Pinjar Road, at Equis Lake adjacent to Ellenbrook ,and at the City of Rockingham.

The StormTech system incorporates sand traps prior to the entrance to the StormTech segments and each Access Pit is also proposed to be trapped. The bulk of the pollutants including nutrients, heavy metals, etc tend to be attracted to and adhere to the suspended solids held in suspension within the stormwater. By trapping and collecting suspended solids these pollutants are removed from the system. The geofabric that separates the StormTech segments from the crushed rock medium surrounding the segments prevents the suspended solids from migrating into and clogging the filter medium. These pollutant laden suspended solids tend to accumulate into the sand traps as well as on the woven geotextile placed on the invert of the StormTech.

The use of split P gravel, high PRI soils and additives to the soil in the sand traps can increase the nutrient stripping capabilities of the Stormtech system without reducing the permeability of the system.

Pollutants and suspended solids need to be removed from both the sand traps and from the base of the StormTech through a maintenance program. Access for jetting of the StormTech segments to remove the suspended solids and pollutants into the sand traps is provided at the Access Pits and the StormTech system can be visually inspected from the Access Pits.

Swales and basins in POS areas are located in the lower areas of the development. These basins will need to contain a 1:10 ARI from the piped system and 1:100 ARI from the development when forming part of the overall flood routing stormwater strategy. The piped system and the infiltration basins are designed to cater for 1:5 and 1:10 ARI storm durations respectively. A cross section of drainage basin design is included as Figure 8.

The 1:1 ARI is not so much a constraint as it will be managed on site through measures such as drainpipes directed to soak wells. The engineering design allows for the 1:10 ARI to be accommodated and infiltrated into infiltration basins located at the low points (normally within the POS areas). A 1:100 ARI storm event is to be accommodated such that there is a minimum of 300mm between the flood level and the finished floor levels of the buildings. In the coastal dune country there is much less need for flood routing, inflows / outflows as these are easily infiltrated into the dunal sands.

The main objectives of the stormwater management design are to maintain site water balance and protect surface and groundwater quality within the YCSP area. Based upon the topography of the land, the landholding has been divided into natural stormwater catchments and a preliminary drainage strategy plan has been produced (Figure 9).

Features included in the design of the stormwater management system are:

- Water re-use and efficiency options such as capturing and re-using stormwater included as part of engineering designs at the subdivision stage;
- Surface stormwater swales located within the areas of lower density development will be designed to the 1:5 ARI event specifications;
- Stormwater from roads and other public facilities will be detained via a combination of gullies, underground pipes and surface swales located within road medians and verges. Designed to 1:10 ARI event specifications;

- Runoff from less frequent storms up to 1:100 ARI event will be detained via overland flow in roads and open space areas with surface levels designed to ensure that buildings are flood free for the 1:100 ARI event; and

- Runoff from building roofs and paved areas within private lots will be detained via onsite containment with soakwells or below ground infiltration systems for larger commercial/grouped housing developments.

A karst investigation will be undertaken prior to subdivision to ensure that the main stormwater infiltration areas are not located in areas of known karst formation.

Within the city centre area, the use of "no-flow" piped systems and below ground infiltration systems are proposed to minimise the land take and to provide a system sensitive to the amenity of the land use zoning. A "no flow" system refers to the fact that stormwater that enters the system is held and infiltrated (close to the point of impact) in keeping with the Water Sensitive Urban Design (WSUD) principles, rather than being collected and being transported further down the system to a single point of discharge into the environment. The StormTech technology achieves this purpose. As each length fills it overflows into the next length of StormTech and so on down the system. The "first flush" volume is caught and infiltrated within the StormTech system with no flow into the next chamber, hence "no flow".

6.2.3 Stormwater Disposal

A WSUD approach will be adopted to maximise stormwater recharge of the groundwater aquifer. Infiltration sites will comprise a combination of landscaped basins and swales as incorporated into areas of POS as well as progressive infiltration throughout the drainage network. Bio-retention systems will be used and sized at 2% of the constructed impervious area from which they receive runoff. The strategic location of these infiltration sites through areas of development is designed to maximise groundwater recharge at point of capture, where piped networks with an open base conduit arrangement has the capacity to infiltrate the 1 in 1 ARI storm (first flush) thus infiltrating close to the site where the runoff is captured within stormwater catchments. Figure 9 shows the correlation between proposed locations of the primary stormwater disposal sites and associated catchment boundaries.

The YCSP area is comprised of free draining Spearwood Sands and an adequate separation from the water table exists. Coffey Environments considers that natural filtration is sufficient to remove nutrient loads from stormwater runoff prior to recharge of the aquifer without additional nutrient stripping facilities (assuming PRI values are less than 10). The incorporation of such facilities can be staged later if necessary.

6.2.4 Stormwater and Public Open Space

Areas of stormwater catchment have been designed to be located within POS areas and in low relief topographic areas including depressions and valleys between ridgelines to capture stormwater for reuse. The total area of stormwater catchment in the YCSP area is 18.6592ha and complies with the 3% provision requirement for such land use areas. The following measures to manage stormwater will be incorporated into stormwater management design:

- Infiltration basins and swales will be unfenced with a maximum 1 in 8 side slopes and will be designed to 1:100 ARI storm runoff specifications. The basins will be designed with a maximum inundation depth of 900mm for 1 in 10 ARI storm and 1200mm for 1 in 100 ARI storm;

- 1:100 ARI designed stormwater features are applicable for a full percentage area of storage credit or concession. 100% of the total area of the stormwater feature is applicable to be calculated towards the cumulative total area of the required provision of POS;

- Drainage Basins and swales will be designed as areas of storage for 1:10 ARI stormwater runoff. In accordance with the guidelines of the City of Wanneroo, a partial credit maybe applicable for such areas;

- Risk management approach for 100 ARI & 500 ARI storms and above – Road Overland Flow is the stormwater methodology used to manage storm runoff for events larger than the 10ARI storms. Overland flow is such that all road grades shall be designed to provide an overland flow path, using the road section profile as a channel flow, to the drainage basins and POS locations where all properties shall have a 300mm freeboard to the controlling high point along the road and lots surrounding basins; POS areas have a 500mm freeboard to the 1 in 100 ARI storm top water level.

- Swales or vegetated bio-retention systems are to be sized at 2% of the constructed impervious area from which they receive runoff. In addition, all outflows from subsoils will receive treatment prior to discharge to the stormwater system;

- Landscape treatments in POS areas will incorporate native plantings where practicable with low nutrient and water requirements;

- Gross Pollutant Traps (GPT) will be installed in areas in which stormwater discharges into open swales and basins; and

- All runoff contained within the stormwater infrastructure network will receive treatment prior to being discharged to a receiving environment consistent with the *Stormwater management manual for Western Australia* (2004-07).

Detailed stormwater management design will occur at the stage of subdivision to the specification and design requirements of the City of Wanneroo.

6.2.5 Stormwater System Operation & Maintenance

The stormwater management system will require regular maintenance to ensure efficient operation. The design and construction of the system is with regard to the minimisation of ongoing maintenance of bio-infiltration areas to be undertaken by the City of Wanneroo.

Features of the system design and construction include:

- Design of the collection and conveyance system with bio-infiltration mechanisms (plantings and micro-organism);

- Incorporation of silt and gross pollutant traps upstream of outlets to open basins and swales; and

- Suitable plantings that require minimal maintenance of bio-infiltration areas.

The following operating and maintenance practices will be implemented on a periodic basis and are outlined below:

- Removal of debris to prevent blockages;

- Street sweeping to reduce particulate build-up on road surfaces and gutters;

- Cleaning of sediment build up and litter layer on the bottom of the swale;

- Maintenance of bio-filtration areas

- Mowing of turf areas monthly and appropriate disposal of grass clippings;

- Application of slow release/zero phosphate fertilisers for maintenance of turf areas; and

- Undertaking of an education campaign regarding source control practices to minimise pollutant run off into stormwater management system.

6.3 Groundwater Management

Urbanisation generally results in rises in the water table due to increased run off to infiltration basins and lower evapo-transpiration as a result of the clearing of vegetation. These impacts will be offset by the use of water for domestic irrigation and public water supply purposes.

6.3.1 Water levels

No groundwater level controls are proposed for this development as there will be sufficient freeboard between the final lot levels and groundwater levels (>15m separation compared to a required minimum of 1.2m separation).

6.3.2 Water Quality

The consideration of nutrient sources from an urban environment is needed to ensure that nutrient loads are sufficiently managed. The YCSP development will incorporate best management practices as detailed in the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007). More specifically, this will include 'at source' control techniques in order to maintain or improve water quality. Objectives to maintain water quality need to be considered at all stages of development planning and implementation. Refer to Table 3 for management strategies designed to protect water quality.

Application of the approach as specified in Table 3 will ensure that nutrient input source control is a key objective. This approach will ensure that nutrient export from the YCSP area is minimised and groundwater resources are protected. It should be noted that the efficiency of infiltration basins at removing nutrients is dependent on the vegetation used in the landscaping and the Phosphorus Retention Index (PRI) of the soil or infiltration medium used (DoW, 2004-2007).

PRI values provide an indication of how well the soil can retain nutrients. A low PRI indicates that the soil has a very low capacity to retain nutrients and a high PRI indicates the soil has a good capacity to retain nutrients. As WA soils typically have a low PRI, it is proposed that PRI testing is undertaken in infiltration basin areas, and soil amendment applied where PRI values are less than 10. Caution when applying soil amendments is needed to ensure adequate soil permeability is maintained. PRI testing will be undertaken prior to subdivision in proposed drainage basins to determine whether soil amendment within the basins is required.

Infiltration systems can be expected to trap more than 90% of litter, 65-99% of total suspended solids, 50-70% of total nitrogen, 40-80% of total phosphorous, 90-100% of coarse sediment, and 50-95% of heavy metals (DoW, 2004-2007).

Nutrient Management measures will be incorporated into UWMPs to be approved at the subdivision stage to manage fertiliser application and treatment of soils with low PRI values.

Other water sustainability initiatives which will be implemented prior to, during and post-construction:

- Specially designed landscaping for conveying and treating run-off including the use of infiltration trenches and swales instead of kerb and gutter in roadway designs where applicable;
- Use of porous paving in appropriate areas to increase infiltration rates;
- Minimisation of site disturbance (including cut and fill) to protect native vegetation; and
- Maintaining water quality by locating public water supply bores adjacent to POS reserve areas.

6.3.3 Karst

Further investigation into the risk associated with karstic features is warranted prior to development with additional investigations being aimed at assessing the presence of near surface loose sand zones or voids within shallow limestone and providing data for input into engineering design to accommodate subsurface conditions that may (or may not) be present within the south eastern edge of the subject area. Further investigations will be undertaken as part of normal geotechnical investigations undertaken for engineering design prior to the subdivision stage of development (Coffey Geotechnics, 2007).

6.4 Management of Water Use in POS, Landscaped Areas and Schools

The following measures shall be applied to assist with minimising water use and maintaining water quality of the groundwater:

- Where practicable, mature trees will be retained in road reserves and POS areas. Trees to be retained within the development will be identified for retention during detailed subdivision design stages;
- Native plant species will be utilised in revegetation of POS areas. In more formalised landscaped areas, an emphasis will be placed on the selection of species that have a low water and fertiliser demand;
- Planting of POS areas will occur in winter months to take advantage of winter rainfall and if required, hand watering of species during the first summer will be undertaken to assist establishment; and
- Fertiliser application will use slow-release, low-water soluble fertilisers applied [preferably] in spring and ideally at reduced rates. This approach will maximise fertiliser uptake by plants, thereby reducing the risk of nutrient export from the subject area.

The City of Wanneroo *Draft Landscape Policy* contains criteria, which determines the purpose and elements for each POS type. The distribution and intended function of POS areas in the YCSP area is shown in Appendix G.

6.4.1 Water Use

Landscaped areas and ovals will require watering during the establishment phase (two summers) and turf will require ongoing irrigation if not allowed to dry out over summer. Use of the underlying (Perth Superficial Swan) aquifer as a source of irrigation will require an application for a groundwater extraction licence from Department of Water (DoW) as there iscurrently no groundwater bore licenced in the LSP area. ThePerth Superficial Swan aquifer is currently between 90% and 100% allocated (*pers. comms.* DoW*,* 25 February 2011), although water availability is subject to change.

Two groundwater abstraction licences have been applied for in the LSP area and are currently being assessed by the DoW.

An application for 94,360kL/yr has been submitted for irrigating the first stage of development in the landholding owned by the Yanchep Beach Joint Venture. The decision on whether to grant the licence will depend on the capacity of this aquifer and the intended use of the water. A licence to construct a groundwater abstraction bore has also been submitted to the DoW.

The Peet syndicated landholding in the south-east portion of the LSP area has also applied for a groundwater abstraction licence for their development.

An estimate of the predicted water demand in POS,landscaped areas and schools within the YBJV landholding has been provided by consultant landscape architects PlanE (Appendix H). A summary of the predicted water usage follows:

- 2 Primary Schools and 1 High School at an irrigation percentage of 50%. Irrigation required at 750L/m^2/yr = 75,171kL/yr
- Two Ovals and Active Open Space at an irrigation percentage of 90%. Irrigation required at 750L/m^2/yr = 56,878kL/yr
- Landform and Vegetation Retention at an irrigation percentage of 10%. Irrigation required at 750L/m^2/yr = 18,491kL/yr
- Town Squares and Civic Spaces at an irrigation percentage of 50%. Irrigation required at 750L/m^2/yr = 18,3131kL/yr
- Neighbourhood and Town Parks at an irrigation percentage of 40%. Irrigation required at 750L/m^2/yr = 34,5776kL/yr
- Linear Parks and Boulevards at an irrigation percentage of 80%. Irrigation required at 750L/m^2/yr = 34,549kL/yr

Water will also be required for dust suppression during construction works. An estimate of the volume required has not been made yet as that is dependent on the amount of bare sand requiring stabilisation. The amount varies for each stage of development and the phase of the development (eg. More is required immediately after land clearing but decreases as construction works increase).

The annual volume of water that will be required for the development will depend on the staging of development and the particular land uses that need to be irrigated in each stage. For example, the highest demand for water use is for playing fields in the two primary schools and one high school sites and the active open space area. These land uses will not all be developed at the same time.An estimate of the water demand as it relates to staging is shown in Appendix H and is summarised below:

- Stage 1 (0-5 years) 99,144 kL/yr (includes the active recreational ovals)
- Stage 2 (5-7 years) 14,039 kL/yr
- Stage 3 (7-10 years) 65,277 kL/yr (includes two primary schools)
- Stage 4 (10-15 years) 59,518 kL/yr (includes one high school)

The priority for irrigation will be the active recreational ovals in the first stage and the primary and high school ovals in stages 3 and 4. The current licence application for 94,360kL/yr will allow the active open space ovals in the first stage to be developed. As the primary schools are not anticipated to be developed for at least 7 years, the balance of the water applied for will be used in irrigating the Stage 1 landscaping works (0-5 years – see Appendix H for details).

If water is not available when the future stages are ready to be developed, or an alternative water supply has not been identified (see section 6.4.2), then priority will be given to maintaining the active open space in stage 1 and the future school ovals when they are created. In this situation, other areas of passive open space may then need to be non-irrigated and either be maintained as dry grass in summer, stay as undeveloped native vegetation or be revegetated with native species where earthworks of stage do not allow the retention of native vegetation in POS.

A groundwater abstraction licence application has been submitted by the Peet landholding syndicate to irrigate the development for the first 5 years, in which time it is anticipated the development will be completed.

The annual water demand for the Peet syndicate land is 112,427kL/yr and has been calculated based on the following:

- 12 areas of POS (Neighbourhood and Town Parks) at an irrigation percentage of 40% of the POS area = 28,960kL/yr;
- 1 oval at an irrigation percentage of 100% of the POS area = 34,880kL/yr;
- 2 areas of native vegetation at an irrigation percentage of 10% of the POS area = 3,994kL/yr;
- 1 Primary Schools at 50% irrigation = 13,993kL/yr; and
- 5.1ha of streetscape at 80% irrigation = 30,600kL/yr.

Water will also be required for dust suppression during construction works.

An estimate of the water demand on the Peet landholding as it relates to staging is shown in Appendix I and is summarised below:

- Stage 1 (0-2 years) 67,543kL/yr (includes the oval and school site)
- Stage 2 (2-5 years) 14,283kL/yr
- Streetscapes (0-5 years) 30,600kL/yr

The areas requiring irrigation are shown in Appendix I.

A decision on the granting of that licence has yet to be made.

Upon completion of the development, any current licences will be handed over to the City of Wanneroo.

6.4.2 Alternative Water Supply

Should the underlying aquifer be fully allocated at the time of application to DoW, a further option to source water for irrigation from the deeper Leederville aquifer will be explored. The DoW's *Policy on accessing the Leederville and Yarragadee Aquifers in Perth* (DoW, 2006) states further applications to extract water from these aquifers are unlikely to result in a licence being granted. This is due a decline in the potentiometric heads of both aquifers across the region, over a number of years in response to pumping and a drying climate across the region (DoW, 2006). However, it also states that the DoW may consider further applications for accessing the fresh groundwater resources of the Leederville aquifer if:

- there is a significant public benefit;
- the volume requested is small (up to 50 000 kL/year); and
- the applicant demonstrates that there are no other suitable alternative water sources available.

Any application submitted to the DoW would be considered and an outcome determined with the current aquifer allocation being considered at the time, along with DoW guidelines and policy at that time. At the time of writing the LWMS, information from the DoW indicates that the Leederville aquifer is nearly fully allocated with only around 40,000 kL available.

The use of a third pipe system to irrigate domestic gardens and public open space with non-potable water is a possibility but has some major obstacles to overcome. There are two potential sources of non-potable water for the third-pipe system which are untreated groundwater and treated wastewater. As discussed above, the amount of groundwater is severely limiting in the Yanchep sub-catchment and therefore may not be available. The use of treated wastewater has not yet been approved in Western Australia and is not considered favourable in a Priority 3 drinking water area by the Department of Health due to concerns about health risk.

The availability of water for irrigation is a district level issue in the Yanchep-Two Rocks area and requires a co-ordinated approach to identify suitable solutions. The Yanchep Beach Joint Venture is willing to participate in discussions and workshops to address this issue.

6.5 Mosquito Management

The infiltration basins will be ‘dry basins’, meaning that they will not hold water for extended periods. Each basin will drain within three and a half days (Consistent with Australian Runoff Quality) in order to reduce the risks associated with mosquito breeding in infiltration basins.

7 MONITORING AND REPORTING

7.1 Pre-development Monitoring

Three groundwater monitoring bores were installed at the subject area in August 2009 for the purposes of obtaining pre-development groundwater level data. To ensure an adequate representation of water levels across the YCSP area a bore was placed on the eastern boundary to monitor upstream groundwater level, in the centre of the YCSP area and on the western boundary to monitor downstream groundwater level. Locations were based on groundwater contour information in the Perth Groundwater Atlas (2009). Figure 7 presents locations of the three existing onsite groundwater monitoring bores (MB1, MB2 and MB3).

Bores were sunk at low points within the subject area and groundwater levels taken at predicted winter maximum in the month of September. Groundwater levels were measured at between 18.5m and 24.7m below ground level depending on elevation.

The Department of Water (DoW), Swan Avon Region (21 July 2009), verified that three water monitoring bores in the existing locations would suffice to indicate overall depth to groundwater across the subject area. It was also advised that there is significant depth to groundwater beneath the subject area (>5-10m below ground level) to negate the requirement for post-development monitoring as at source infiltration will be possible.

More recently the DoW has advised that post-development monitoring is required (relation to the P3 PDWSA over which the subject area lies) to ensure that the proposed development does not adversely affect the quality of groundwater beneath the subject area (*pers comms*. DoW, 6 June 2010). Water quality sampling will therefore use existing bores onsite and include quarterly sampling of water quality parameters.

In order to formulate a baseline against which post-development monitoring can be evaluated, the existing three monitoring bores on the subject area will be monitored for groundwater quality on a quarterly basis pre-development. This monitoring will collect two winters worth of data prior to construction of the subject area.

7.2 Post-development Monitoring

Post-development monitoring will continue during the development at the relevant stage within the subject area to monitor potential impacts to groundwater from construction activities. Following development of the subject area, groundwater bores relevant to that particular stage will be monitored quarterly for a period of 24 months after practical completion with an annual report of the results submitted to the City of Wanneroo and the DoW. Parameters to be monitored are as follows:

- pH and Electrical Conductivity (EC);
- Total Nitrogen (TN);
- Total Kjeldahl Nitrogen (TKN);
- Nitrate/Nitrite-Nitrogen (NOx-N);
- Ammonium-Nitrogen (NH4-N);
- Total Phosphorus (TP); and
- Reactive Phosphorus.

Analysis of pH and electrical conductivity are, and will be completed onsite by a qualified technician or professional, with all other parameters measured by a sample submitted to a NATA accredited

laboratory. All groundwater sampling will be in accordance with Australian Standard AS/NZS 5667.11:1998.

Surface water monitoring of stormwater runoff into infiltration basins is not proposed as the emphasis of the drainage system is to retain and infiltrate stormwater. Therefore, if monitoring of surface water quality was undertaken, it would need to be event-based, which can be difficult to resource and implement with significant limitations on the quality of the data collected. However, all bio-retention areas will be managed through quarterly visual inspections for a period of not less than the adjoining stages and consistent with the overall development time span.

8 SUMMARY OF ACTIONS AND RESPONSIBILITIES

The developer will be responsible for the implementation of the management actions presented in this Management Strategy, as well as the ongoing management and maintenance to the satisfaction of the City of Wanneroo for a minimum of two years following the initial clearing and site works.

Following this period, the City of Wanneroo will assume responsibility for the management and the ongoing implementation of this Management Strategy. Table 3 outlines the management actions that have been identified as key components of this Vegetation and Fauna Management Strategy within the YCSP area.

TABLE 3

SUMMARY OF MANAGEMENT ACTIONS

Management Controls	Specific Information	Timing	Responsibility	Status
Water Levels	Further investigation into and management of the risk associated with potential karstic features in identified area in the south eastern corner of the development	Prior to construction	YBJV	
	Use of porous paving in appropriate areas to increase infiltration rates	During construction	YBJV	
	Surface levels designed so that private building and infrastructure is flood free during these events 1:100 ARI events	Prior to construction	YBJV	
	Offset potential rises in the water table by the use of water for domestic irrigation and public water supply purposes (if available)	Post construction	YBJV	

	Identify mature tress to be retained in road reserves, POS areas or private lots	Subdivision design stage	YBJV	
	Utilise native plant species in revegetation of POS areas. Selection species that have a low water and fertiliser demand in more formalised landscaped areas	Post construction	YBJV	
Demand Reduction	Include water re-use and efficiency options as part of engineering designs	Subdivision design stage	YBJV	
	Employing a 'water wise' approach for single lot residential households through improved efficiencies such as fixtures and fittings including water wise taps, showerheads and appliances, and measures such as the re-use of rainwater for toilet flushing, washing machines, garden watering and car washing	Post construction	YBJV and then CoW	
	Employ water wise landscaping in areas of POS using native species (low nutrient and water requirements), minimising turf areas and selecting shrub planting species that require minimal irrigation or hand watering after the initial two year watering period required for establishment	Post construction	YBJV	
	Carryout planting in POS areas in winter months to take advantage of winter rainfall and if required, hand water species during the first summer to assist establishment	Post construction	YBJV	
Other	Preparation of an Urban Water Management Plan	Subdivision stage	YBJV	
	Installation of groundwater extractions bores to permanently upgrade the capacity of the existing water supply system, supplemented with a connection to the proposed Barragoon borefield, north east of Two Rocks	During construction	Water Corporation	

	Ensure infiltration basins are 'dry basins' – drain within 4 days in order to reduce the risks associated with mosquito breeding	Prior to construction	YBJV	
	Implement contingency actions (Section 9) if the performance of the stormwater management system is assessed as not meeting criteria set in this report	Post construction	YBJV and then CoW	
Water Quality	Collect pre-development site-specific groundwater level data.	Prior to construction	YBJV	Completed September 2009
	Gross Pollutant Traps installed upstream of outlets to open basins and swales	Prior to construction	YBJV	
	Design of the collection and conveyance system with self cleansing biofiltration mechanisms (plantings and micro-organism)	Prior to construction	YBJV	
	PRI testing in proposed drainage basins to determine whether soil amendment within the basins is required	Prior to construction	YBJV	
	Construction management including street sweeping during construction phase	During construction	YBJV	
	Provision of reticulated sewerage infrastructure for off-site disposal of black and grey water	Prior to construction	YBJV	

	To reduce the risk of nutrient export from the subject area, use slow-release, apply low-water soluble fertilisers, preferably in spring and ideally at reduced rates	Post construction	YBJV and then CoW	
	A landscape design that conveys and treats run-off including the use of infiltration trenches and grass swales instead of kerb and gutter in roadway designs, with the retention and integration of natural drainage corridors	Subdivision design stage	YBJV	
	Design a storm water management system that ensures all storm water generated from developments is retained within the development site through the use of infiltration / retention basins. Locate these infiltration sites strategically in areas of development to minimise the extent of underground piping and maximise recharge areas within storm water catchments. All new lots to retain/dispose of storm water on-site.	Prior to construction	YBJV	
	Design a storm water management system that ensures 1:100 ARI events and above are directed via overland flow routes as part of the road system into areas of POS containing infiltration basins and swales. Basins and swales will be unfenced with maximum 1 in 8 side slopes and a 900mm depth of inundation maximum.	Prior to construction	YBJV	
	Impervious lined lakes designed to contain the 1:100 ARI event above the static water level and will be incorporated into or surrounding areas of POS	Prior to construction	YBJV	
Stormwater Management	Design basins in areas not located near or within areas of POS to 1 in 100 year runoff specifications	During construction	YBJV	
	Removal of debris from drainage infrastructure including GPTs	On-going	YBJV and then CoW	

	Street sweeping to reduce particulate build-up on road surface and gutters	Monthly during construction and quarterly post construction	YBJV and then CoW	
	Mowing of turfed areas monthly and appropriate disposal of clippings	Ongoing monthly	YBJV and then CoW	
	Manual litter collections	Ongoing	YBJV and then CoW	
Maintenance	Cleaning of sediment build up and litter layer on the bottom of swales	During construction and ongoing	YBJV and then CoW	
	Maintenance of Stormtech systems	During construction and ongoing	YBJV and then CoW	
	Application of slow release/ zero phosphate fertilisers for maintenance of turf areas	Ongoing	YBJV and then CoW	
	Monitor and replace bio-retention plants as required for effectiveness	Ongoing until final stage of development is completed	YBJV	
	Application of soil amendment where appropriate, taking care to maintain permeability	Ongoing	YBJV and then CoW	

Education	Undertake an education campaign regarding source control practices to minimise pollutant run off into storm water catchment areas. It advised that an Environmental Officer be appointed (developer-funded) and or the provision of educational material regarding sustainable water practices and household methods to reduce potable water demand	Post construction	YBJV and the CoW	
	Provide pamphlets at the land sales office during the sales period, providing information on ways to reduce demand for potable water supplies (e.g. water wise gardening practices, rainwater tanks, water efficient appliances etc). This will include information on water conservation measures, water efficiency, appropriate fertiliser use, weed species and Water Corporation rebates	Post construction	YBJV	
Monitoring	All bio-retention areas will be visually inspected on a quarterly basis to determine success of plantings and soakage.	Post-construction	YBJV and then CoW	
	Groundwater will be monitored pre-development to define baseline conditions and post-development to ensure no impact to underlying P3 PDWSA	Pre-construction and up to 2 years post-development	YBJV	
Reporting	Provide a report annually to the City of Wanneroo indicating local water management actions that have been executed with reference to the current status of development.	Following approval of the LSP until end of construction or all LWMS requirements have been met.	YBJV	

Note: CoW = City of Wanneroo

9 CONTINGENCY ACTIONS

9.1 Performance of Stormwater Management System

Should the performance of the stormwater management system be assessed as not meeting the criteria as set in this report, the proposed process for contingency action in the assessment of performance compliance is:

1. Assess if an isolated, development area or regional occurrence.
2. Determine if due to the development or other external factors.
3. Perform appropriate contingency action as required, which may include:

   a) Identify and remove any point sources;

   b) Reinforce Community Education/Awareness program;

   c) Review constructional, operational and maintenance (e.g. fertilising) practices;

   d) Consider alterations to POS areas including landscape regimes and soil amendment;

   e) Consider modifications to the stormwater system;

   f) Consider initiation of community based projects.
4. Record in the annual report any action taken.
5. If necessary, inform residents of any required works and their purpose.

Water quality trigger values for the contingency actions outlined above will be inferred from baseline groundwater quality data generated during pre-development monitoring events. Alternatively, if these conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the National Water Quality Management Strategy (ANZECC and ARMCANZ, 2000).

Monitoring and reporting outcomes will be used in a continual improvement capacity to review proposed WSUD, and inform the planning and design approaches for subsequent stages of development.

9.2 Water Availability

This LWMS recognises that there will be limited groundwater availability in the region at the time of construction, potentially leading to insufficient water allocations to irrigate active spaces proposed by the YCSP. Examples of measures that could be implemented to still enable the establishment and maintenance of POS may include:

- The use of synthetic turf or alternative, non-irrigated material as ground cover in active spaces;
- Non-irrigation of grassed areas with turf ‘drying out’ in summer and regrowing in winter; and
- Planting established plants in landscaping of POS areas and streetscapes to minimise initial watering requirements

Contingency measures to provide active space in the absence of sufficient groundwater will be furthered explored prior to construction.

10 CONCLUSION

The stormwater management system for the subdivision of the YCSP area has been specifically designed in accordance with the principles and objectives of a Priority 3 Underground Water Pollution Control Area and to achieve EPA objectives for groundwater, and more specifically with WSUD and Better Urban Water Management guidelines.

The scale of the development is significant; the stormwater management system has been designed to detain stormwater within the YCSP area and minimise the impact on the water balance for the subject area and surrounding area.

The YCSP area will incorporate best management practices as detailed in the *Stormwater Management Manual for Western Australia* (DoW, 2007). This will include source control techniques in order to maintain or improve water quality. The following principles will be applied:

10.1.1 Non-structural controls

- **Planning practices:** strategic zoning in particular of Industrial areas with adequate separation to borefields to minimise exposure to potential pollutant plumes and POS areas that incorporate WSUD features designed with infiltration and biofiltration functions;
- **Construction practices:** construction management and guidelines relating to hazardous and non-hazardous materials; erosion, sediment and dust control; and housekeeping activities including washing of buildings and equipment;
- **Maintenance practices:** street sweeping and cleansing; stormwater network inspection, cleaning and repair; manual litter collections; litter bin design, positioning and cleaning; and fertiliser application rates in areas of POS; and
- **Education participation programs:** employment of a developer-funded Stormwater Management/ Environmental Officer and or the provision of educational material regarding sustainable water practices and household methods to reduce potable water demand.

10.1.2 Structural controls

- **Stormwater Storage and use:** rainwater storage systems and managed aquifer recharge
- **Infiltration systems:** soak wells, porous pavement, infiltration basins and Stormtech systems;
- **Conveyance systems:** swales and buffer strips; bio-retention systems; Stormtech systems; and
- **Pollutant control:** litter and sediment management.

The proponent will also prepare Urban Water Management Plans as required at the subdivision stage to provide more detail about the proposed storm water management for the YCSP area.

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Figures

Yanchep City Structure Plan
Local Water Management Strategy

ENVI/PERT/00234AA/Local Water Management Strategy/EP2009-039F01.dgn DATUM: MGA50 DRAWN: GLM/CR 09-07-10 CHECKED: AR 09-07-10 PRINTED: Fri 09 Jul 10

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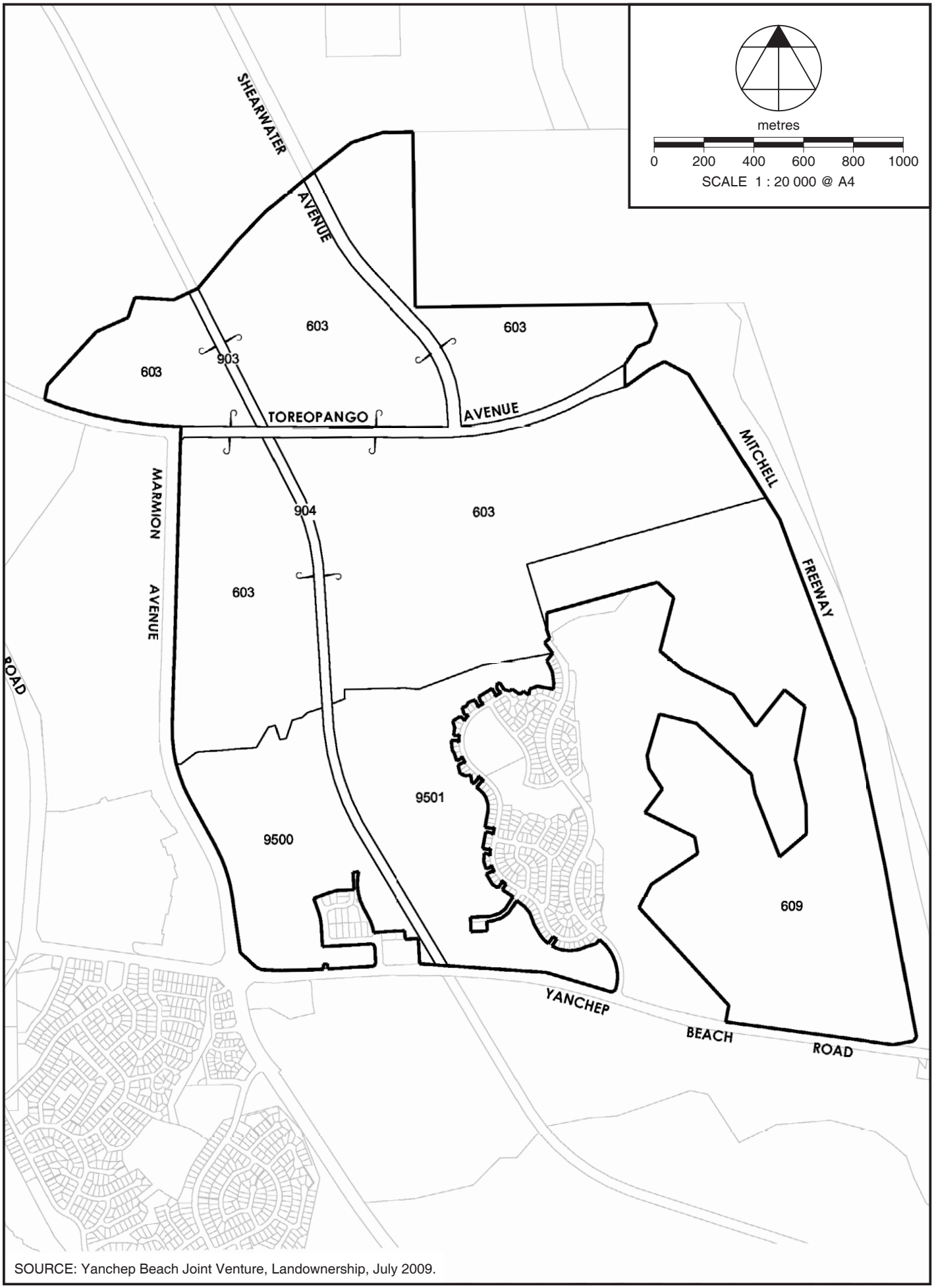
YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY
REGIONAL LOCATION
FIGURE 1



SOURCE: Yanchep Beach Joint Venture, Landownership, July 2009.

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YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

LOTS WITHIN YCSP AREA

FIGURE 2

SOURCE: Taylor Burrell Barnett, July 2009.

WSD

WSD

YANCHEP

SUBJECT LAND

TWO ROCKS ROAD

YANCHEP BEACH ROAD

SUN CITY COUNTRY CLUB

MOORPARK AVENUE

ANDREWS CT

YANCHEP

HS

LAGOON DRIVE

Surprise Cave

Marble Terrac Cave

LEGEND

SCHEME BOUNDARY

RESERVED LANDS

PARKS AND RECREATION

R — RESTRICTED PUBLIC ACCESS

RAILWAYS

PORT INSTALLATIONS

STATE FORESTS

WATER CATCHMENTS

CIVIC AND CULTURAL

WATERWAYS

ROADS

PRIMARY REGIONAL ROADS

OTHER REGIONAL ROADS

PUBLIC PURPOSES - DENOTED AS FOLLOWS:

H — HOSPITAL
HS — HIGH SCHOOL
TS — TECHNICAL SCHOOL
CP — CAR PARK
U — UNIVERSITY
CG — COMMONWEALTH GOVERNMENT
SEC — STATE ENERGY COMMISSION
SU — SPECIAL USES
WSD — WATER AUTHORITY OF WA
P — PRISON

ZONES

URBAN

URBAN DEFERRED

CENTRAL CITY AREA

INDUSTRIAL

SPECIAL INDUSTRIAL

RURAL

PRIVATE RECREATION

RURAL - WATER PROTECTION

metres

0 200 400 600 800 1000

SCALE 1 : 20 000 @ A3

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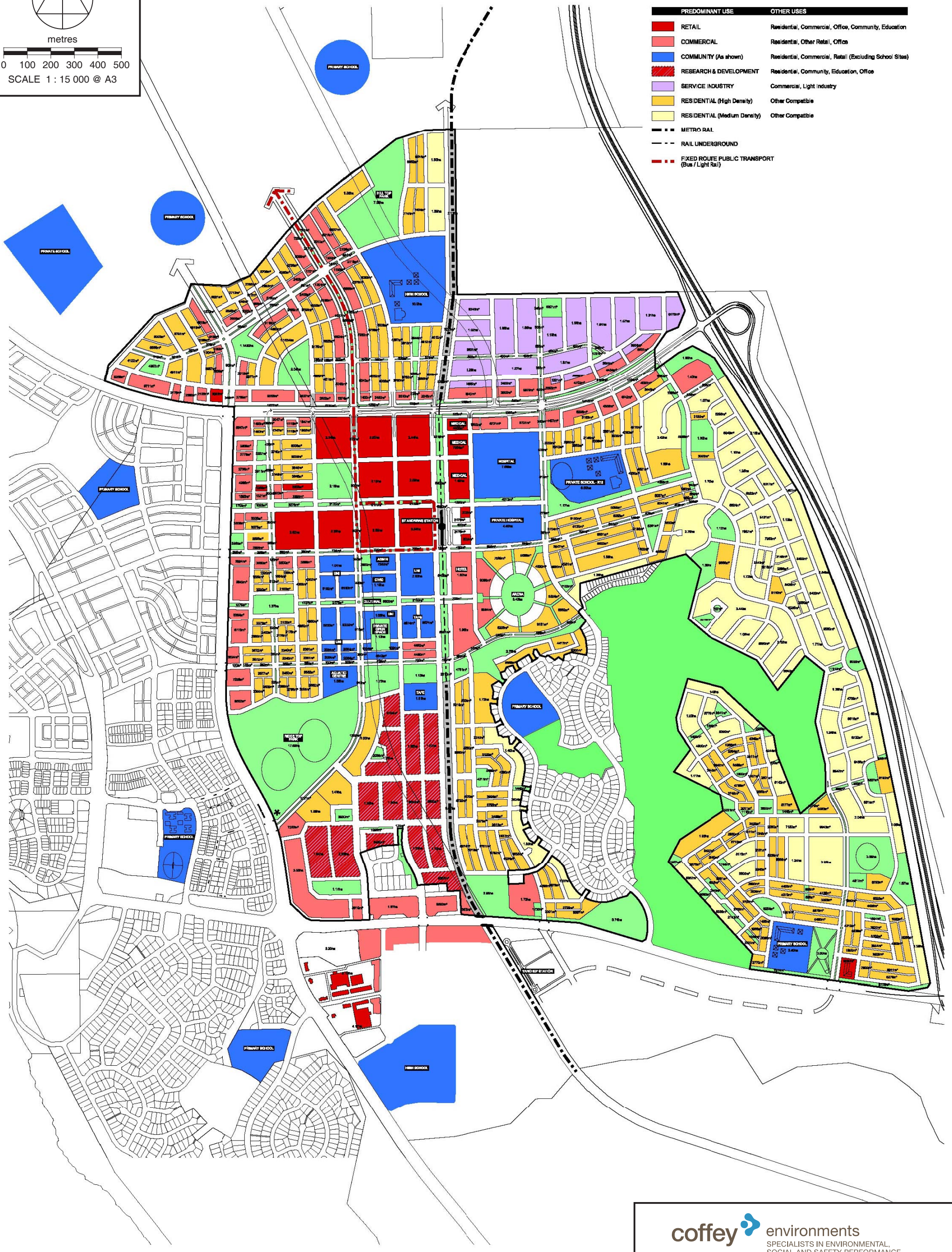
YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY
METROPOLITAN REGION SCHEME
FIGURE 3

metres

0 100 200 300 400 500

SCALE 1 : 15 000 @ A3

PREDOMINANT USE	OTHER USES
RETAIL	Residential, Commercial, Office, Community, Education
COMMERCIAL	Residential, Other Retail, Office
COMMUNITY (As shown)	Residential, Commercial, Retail (Excluding School Sites)
RESEARCH & DEVELOPMENT	Residential, Community, Education, Office
SERVICE INDUSTRY	Commercial, Light Industry
RESIDENTIAL (High Density)	Other Compatible
RESIDENTIAL (Medium Density)	Other Compatible
METRO RAIL	
RAIL UNDERGROUND	
FIXED ROUTE PUBLIC TRANSPORT (Bus / Light Rail)	



SOURCE: Taylor Burrell Barnett, Plan No. 07/004/004F, 07/07/2010.

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YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

YANCHEP CITY STRUCTURE PLAN

FIGURE 4

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metres

0 100 200 300 400 500

SCALE 1 : 15 000 @ A3

LEGEND

- Study Site Boundary
- Cadastral Boundary
- Topographic Contour (mAHD)

SHEARWATER

AVENUE

TOREOPANGO

AVENUE

MITCHELL

MARMION

AVENUE

FREEWAY

YANCHEP BEACH ROAD

CONTOUR SOURCE: Taylor Burrell Barnett, 2010.

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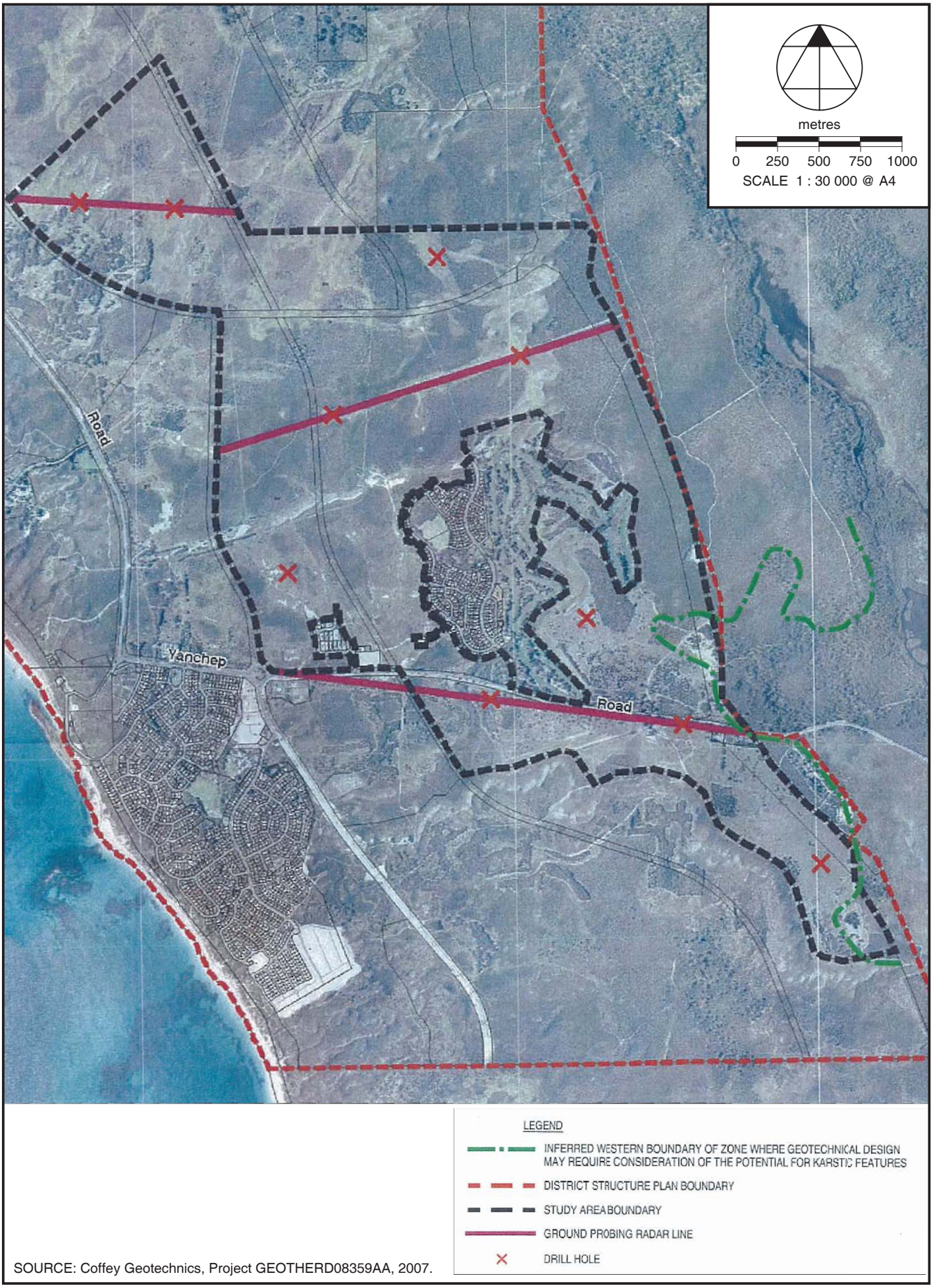
YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY
TOPOGRAPHY
FIGURE 5



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SOURCE: Coffey Geotechnics, Project GEOTHERD08359AA, 2007.

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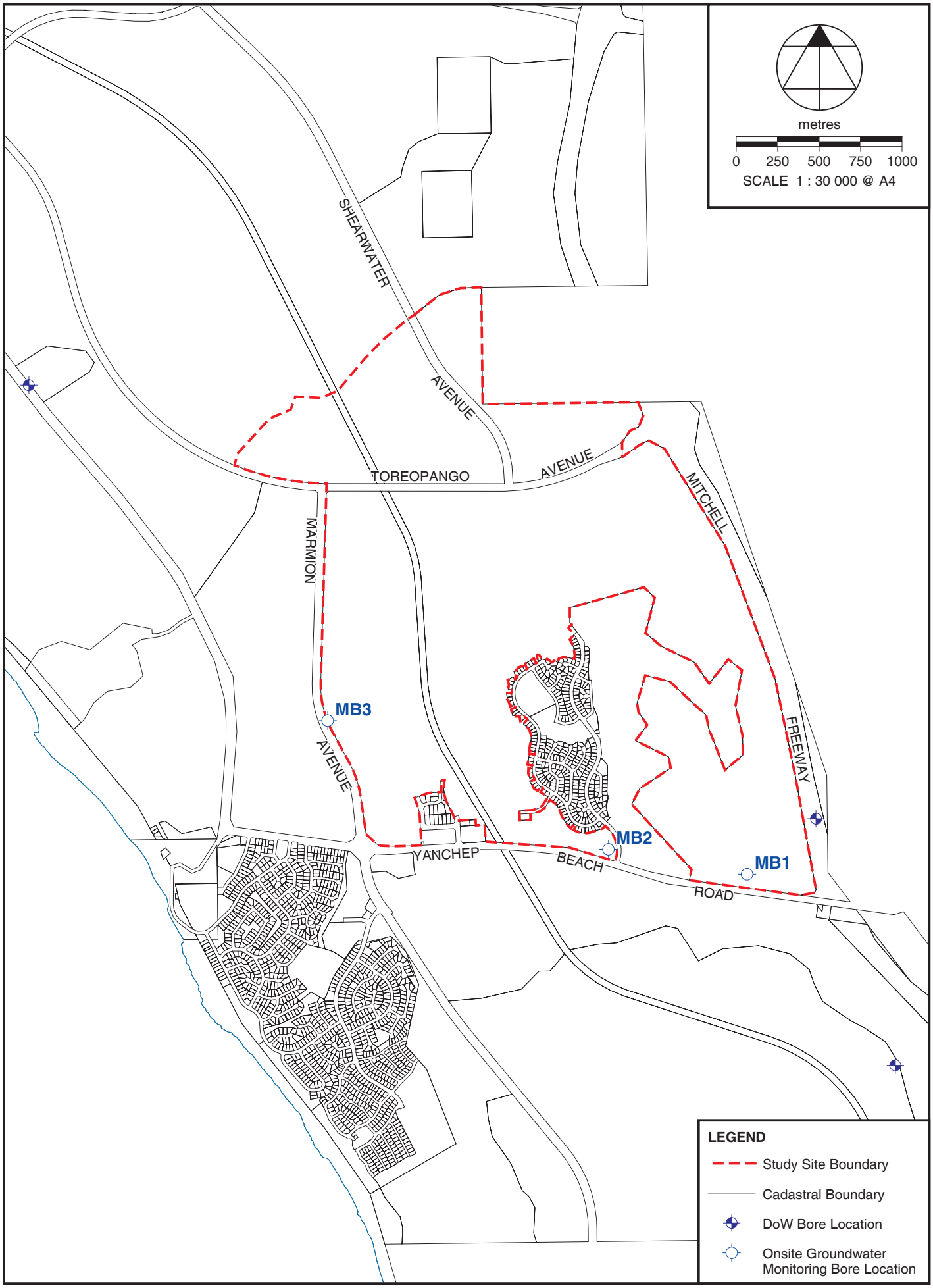
YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

KARSTIC BOUNDARIES

FIGURE 6



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YANCHEP CITY STRUCTURE PLAN - LOCAL WATER MANAGEMENT STRATEGY

REGIONAL DoW AND YCSP ONSITE GROUNDWATER MONITORING BORE LOCATIONS

FIGURE 7

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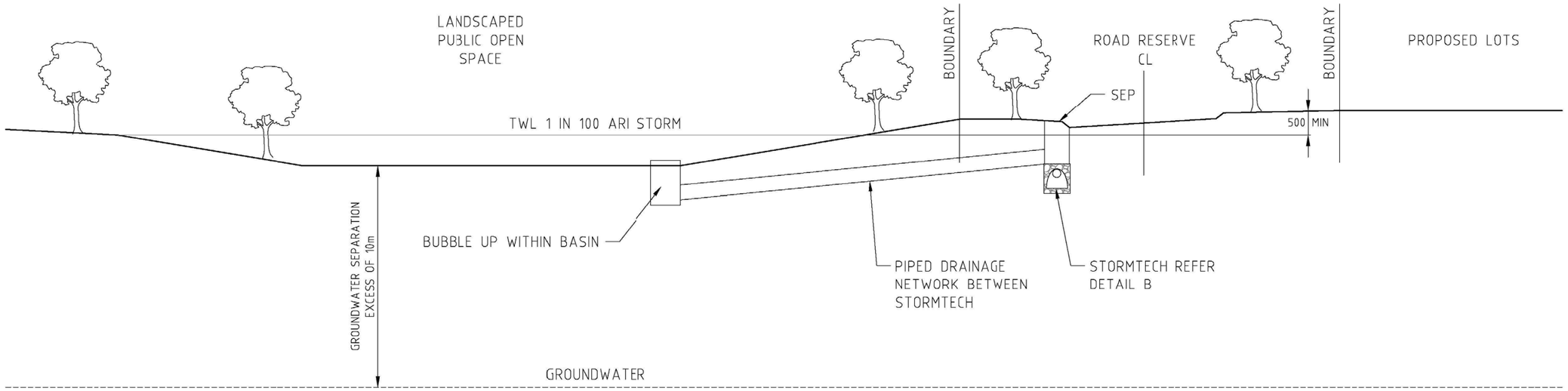
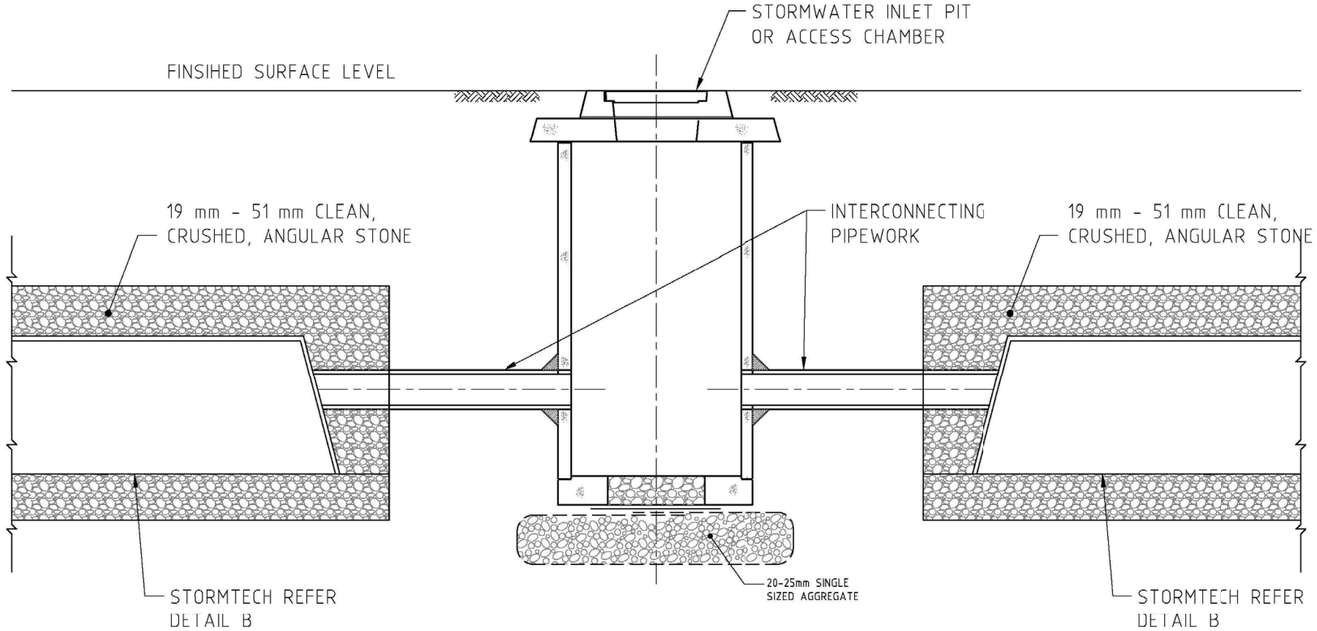
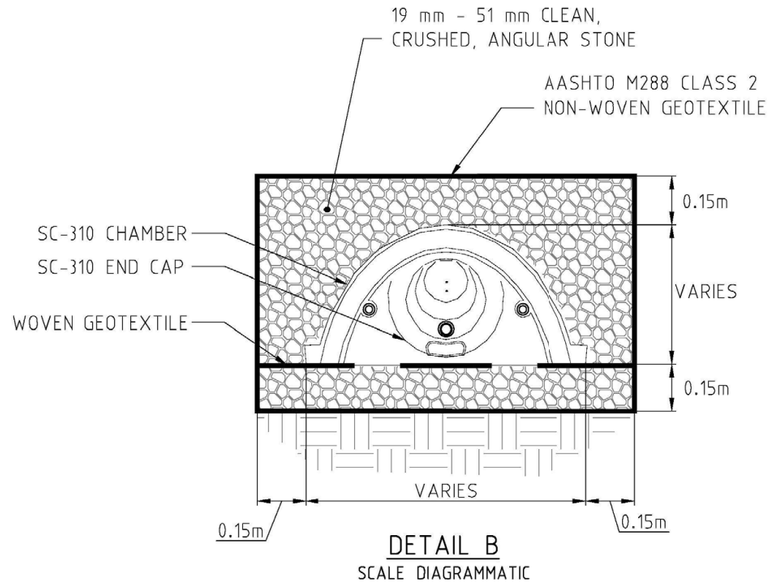
SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE



TYPICAL SECTION THROUGH BASIN WITHIN PUBLIC OPEN SPACE
SCALE DIAGRAMMATIC



TYPICAL SECTION THROUGH PROGRESSIVE INFILTRATION SYSTEM
SCALE DIAGRAMMATIC



DETAIL B
SCALE DIAGRAMMATIC

SERLING CONSULTING
INNOVATIVE ENGINEERING SOLUTIONS

SOURCE: SERLING CONSULTING, Dwg No. SK017, 03-07-2009.

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SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY
DRAINAGE CROSS SECTIONS
FIGURE 8

metres
0 100 200 300 400 500
SCALE 1 : 12 500 @ A3

AREA=7.5ha
A IMP=2.25ha
BASIN=0.10ha

AREA=19.9ha
A IMP=6.0ha
BASIN=0.24ha

AREA=20.6ha
A IMP=6.2ha
BASIN=0.24ha

AREA=20.9ha
A IMP=6.3ha
BASIN=0.25ha

AREA=10.0ha
A IMP=3.0ha
BASIN=0.13ha

AREA=8.2ha
A IMP=2.5ha
BASIN=0.11ha

AREA=24.0ha
A IMP=7.2ha
BASIN=0.28ha

AREA=12.1ha
A IMP=3.6ha
BASIN=0.15ha

AREA=10.8ha
A IMP=3.2ha
BASIN=0.14ha

AREA=26.4ha
A IMP=7.9ha
BASIN=0.3ha

AREA=29.3ha
A IMP=8.8ha
BASIN=0.34ha

AREA=12.7ha
A IMP=3.8ha
BASIN=0.16ha

AREA=6.0ha
A IMP=1.8ha
BASIN=0.08ha

AREA=19.0ha
A IMP=5.7ha
BASIN=0.22ha

AREA=18.6ha
A IMP=5.6ha
BASIN=0.23ha

AREA=21.7ha
A IMP=6.5ha
BASIN=0.26ha

AREA=9.1ha
A IMP=2.7ha
BASIN=0.12ha

AREA=14.8ha
A IMP=4.5ha
BASIN=0.18ha

AREA=5.8ha
A IMP=1.7ha
BASIN=0.08ha

AREA=9.0ha
A IMP=2.7ha
BASIN=0.12ha

AREA=24.5ha
A IMP=7.4ha
BASIN=0.29ha

AREA=26.8ha
A IMP=8.0ha
BASIN=0.31ha

AREA=26.1ha
A IMP=7.8ha
BASIN=0.30ha

AREA=7.6ha
A IMP=2.3ha
BASIN=0.10ha

AREA=12.6ha
A IMP=3.8ha
BASIN=0.16ha

AREA=5.2ha
A IMP=1.6ha
BASIN=0.07ha

AREA=9.9ha
A IMP=3.0ha
BASIN=0.13ha

AREA=15.3ha
A IMP=4.6ha
BASIN=0.19ha

AREA=16.6ha
A IMP=5.0ha
BASIN=0.20ha

AREA=24.8ha
A IMP=7.4ha
BASIN=0.29ha

AREA=9.3ha
A IMP=2.8ha
BASIN=0.12ha

AREA=3.2ha
A IMP=0.96ha
BASIN=0.05ha

AREA=2.3ha
A IMP=0.7ha
BASIN=0.04ha

AREA=12.9ha
A IMP=3.9ha
BASIN=0.16ha

AREA=6.0ha
A IMP=1.8ha
BASIN=0.08ha

AREA=20.9ha
A IMP=6.3ha
BASIN=0.25ha

AREA=26.2ha
A IMP=7.8ha
BASIN=0.30ha

AREA=9.9ha
A IMP=3.0ha
BASIN=0.13ha

AREA=5.8ha
A IMP=1.7ha
BASIN=0.08ha

AREA=23ha
A IMP=6.9ha
BASIN=0.27ha

NORTHERN SUBURBS RAIL EXTENSION

FUTURE MITCHELL FREEWAY

FUTURE MARMION AVENUE

YANCHEP BEACH ROAD

APPROXIMATE KARST BOUNDARY

SERLING CONSULTING
INNOVATIVE ENGINEERING SOLUTIONS

DESIGN ASSUMPTIONS

1. IMPERVIOUS AREA EQUALS 30% OF TOTAL CATCHMENT AREA.
2. DRAINAGE SUMP 1 in 10 YEAR DEPTH 1.1m
3. DRAINAGE SUMP 1 in 100 YEAR DEPTH 1.25m
4. 1 in 10 STORM VOLUME EQUALS 600m^3 PER IMPERVIOUS HECTARE
5. 1 in 100 STORM VOLUME EQUALS 1330m^3 PER IMPERVIOUS HECTARE

LEGEND

- DRAINAGE CATCHMENT AREA
- BELOW GROUND INFILTRATION SYSTEM
- DENOTES DRAINAGE INFILTRATION BASIN. SHAPE TO BE DETERMINED AT DETAIL DESIGN
- AREA=9.9ha / A IMP=4.0ha / BASIN=0.33ha — DENOTES CATCHMENT AREA / DENOTES IMPERVIOUS AREA / DENOTES 1 in 1 YEAR TWL/INFILTRATION AREA REQUIRED FOR DRAINAGE
- DENOTES 1 in 1 STORM TWL
- DENOTES 1 in 10 STORM TWL
- DENOTES 1 in 100 STORM TWL
- DENOTES GENERAL OVERLAND FLOW DIRECTION FOR EVENTS 1 IN 100 AND ABOVE
- PROPOSED BELOW GROUND INFILTRATION SYSTEM

SOURCE: Serling Consulting, Dwg No. SK012, 03/07/2009.

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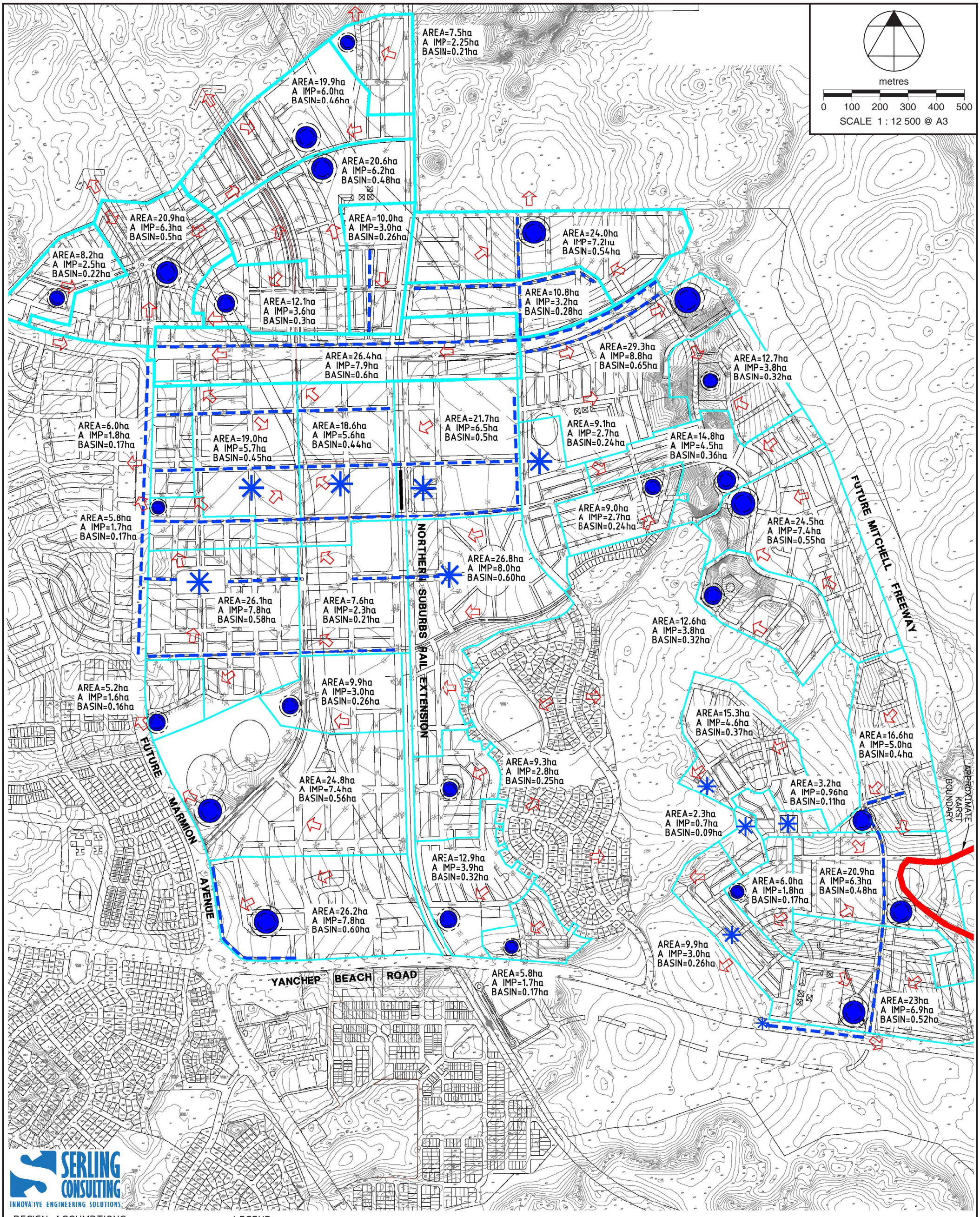
YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

CONCEPT DRAINAGE PLAN (1 IN 1 YEAR ARI)

FIGURE 9a



SERLING CONSULTING
INNOVATIVE ENGINEERING SOLUTIONS

DESIGN ASSUMPTIONS

1. IMPERVIOUS AREA EQUALS 30% OF TOTAL CATCHMENT AREA.
2. DRAINAGE SUMP 1 in 10 YEAR DEPTH 1.1m
3. DRAINAGE SUMP 1 in 100 YEAR DEPTH 1.25m
4. ' in 10 STORM VOLUME EQUALS 600m³ PER IMPERVIOUS HECTARE
5. ' in 100 STORM VOLUME EQUALS 1330m³ PER IMPERVIOUS HECTARE

LEGEND

- DRAINAGE CATCHMENT AREA
- DENOTES DRAINAGE INFILTRATION BASIN. SHAPE TO BE DETERMINED AT DETAIL DESIGN
- DENCTES 1 in 1 STORM TWL
- DENCTES 1 in 10 STORM TWL
- DENCTES 1 in 100 STORM TWL
- PROPOSED BELOW GROUND INFILTRATION SYSTEM
- BELOW GROUND INFILTRATION SYSTEM
- AREA=9.9ha A IMP=4.0ha BASIN=0.33ha — DENOTES CATCHMENT AREA, DENOTES IMPERVIOUS AREA, DENOTES 1 in 10 YEAR TWL/INFILTRATION AREA REQUIRED FOR DRAINAGE
- DENOTES GENERAL OVERLAND FLOW DIRECTION FOR EVENTS 1 IN 100 AND ABOVE

SOURCE: Serling Consulting, Dwg No. SK012B, 03/07/2009.

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YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

CONCEPT DRAINAGE PLAN (1 IN 10 YEAR ARI)

FIGURE 9b

metres
0 100 200 300 400 500
SCALE 1 : 12 500 @ A3

AREA=7.5ha
A IMP=2.25ha
BASIN=0.36ha

AREA=19.9ha
A IMP=6.0ha
BASIN=0.85ha

AREA=20.6ha
A IMP=6.2ha
BASIN=0.83ha

AREA=20.9ha
A IMP=6.3ha
BASIN=0.86ha

AREA=10.0ha
A IMP=3.0ha
BASIN=0.45ha

AREA=8.2ha
A IMP=2.5ha
BASIN=0.38ha

AREA=24.0ha
A IMP=7.2ha
BASIN=0.98ha

AREA=12.1ha
A IMP=3.6ha
BASIN=0.54ha

AREA=10.8ha
A IMP=3.2ha
BASIN=0.48ha

AREA=26.4ha
A IMP=7.9ha
BASIN=1.06ha

AREA=29.3ha
A IMP=8.8ha
BASIN=1.17ha

AREA=12.7ha
A IMP=3.8ha
BASIN=0.56ha

AREA=6.0ha
A IMP=1.8ha
BASIN=0.30ha

AREA=19.0ha
A IMP=5.7ha
BASIN=0.79ha

AREA=18.6ha
A IMP=5.6ha
BASIN=0.78ha

AREA=21.7ha
A IMP=6.5ha
BASIN=0.89ha

AREA=9.1ha
A IMP=2.7ha
BASIN=0.42ha

AREA=14.8ha
A IMP=4.5ha
BASIN=0.64ha

AREA=5.8ha
A IMP=1.7ha
BASIN=0.29ha

AREA=9.0ha
A IMP=2.7ha
BASIN=0.42ha

AREA=24.5ha
A IMP=7.4ha
BASIN=1.00ha

AREA=26.8ha
A IMP=8.0ha
BASIN=1.08ha

AREA=26.1ha
A IMP=7.8ha
BASIN=1.05ha

AREA=7.6ha
A IMP=2.3ha
BASIN=0.36ha

AREA=12.6ha
A IMP=3.8ha
BASIN=0.56ha

AREA=5.2ha
A IMP=1.6ha
BASIN=0.26ha

AREA=9.9ha
A IMP=3.0ha
BASIN=0.45ha

AREA=15.3ha
A IMP=4.6ha
BASIN=0.66ha

AREA=16.6ha
A IMP=5.0ha
BASIN=0.71ha

AREA=9.3ha
A IMP=2.8ha
BASIN=0.43ha

AREA=24.8ha
A IMP=7.4ha
BASIN=1.01ha

AREA=3.2ha
A IMP=0.96ha
BASIN=0.18ha

AREA=2.3ha
A IMP=0.7ha
BASIN=0.14ha

AREA=12.9ha
A IMP=3.9ha
BASIN=0.57ha

AREA=6.0ha
A IMP=1.8ha
BASIN=0.29ha

AREA=20.9ha
A IMP=6.3ha
BASIN=0.86ha

AREA=26.2ha
A IMP=7.8ha
BASIN=1.05ha

AREA=9.9ha
A IMP=3.0ha
BASIN=0.45ha

AREA=5.8ha
A IMP=1.7ha
BASIN=0.29ha

AREA=23ha
A IMP=6.9ha
BASIN=0.94ha

NORTHERN SUBURBS RAIL EXTENSION

FUTURE MITCHELL FREEWAY

FUTURE MARMION AVENUE

YANCHEP BEACH ROAD

APPROXIMATE KARST BOUNDARY

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INNOVATIVE ENGINEERING SOLUTIONS

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3. DRAINAGE SUMP 1 in 100 YEAR DEPTH 1.25m
4. 1 in 10 STORM VOLUME EQUALS 600m^3 PER IMPERVIOUS HECTARE
5. 1 in 100 STORM VOLUME EQUALS 1330m^3 PER IMPERVIOUS HECTARE

LEGEND

- DRAINAGE CATCHMENT AREA
- DENOTES DRAINAGE INFILTRATION BASIN. SHAPE TO BE DETERMINED AT DETAIL DESIGN
- DENOTES 1 in 1 STORM TWL
- DENOTES 1 in 10 STORM TWL
- DENOTES 1 in 100 STORM TWL
- PROPOSED BELOW GROUND INFILTRATION SYSTEM
- BELOW GROUND INFILTRATION SYSTEM
- AREA=9.9ha A IMP=4.0ha BASIN=0.33ha — DENOTES CATCHMENT AREA, DENOTES IMPERVIOUS AREA, DENOTES 1 in 100 YEAR TWL/INFILTRATION AREA REQUIRED FOR DRAINAGE
- DENOTES GENERAL OVERLAND FLOW DIRECTION FOR EVENTS 1 IN 100 AND ABOVE

SOURCE: Serling Consulting, Dwg No. SK012C, 03/07/2009.

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YANCHEP CITY STRUCTURE PLAN
LOCAL WATER MANAGEMENT STRATEGY

CONCEPT DRAINAGE PLAN (1 IN 100 YEAR ARI)

FIGURE 9c

Appendix A
Ministerial Statement 538

Yanchep City Structure Plan
Local Water Management Strategy

000538

MINISTER FOR THE ENVIRONMENT;
LABOUR RELATIONS

STATEMENT THAT A SCHEME MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF DIVISION 3 OF PART IV OF THE ENVIRONMENTAL PROTECTION ACT 1986)

CITY OF WANNEROO TOWN PLANNING SCHEME NO. 1,
AMENDMENT NO. 787

Scheme Purpose:

(a) to rezone the portion of the Yanchep-Two Rocks area zoned "Central City Area" on the Metropolitan Region Scheme, being portions of Pt Lot 8 and Pt Lot M1689 from "Rural" and "Residential Development" to "Centre" Zone;

(b) to rezone the portion of the Yanchep-Two Rocks area zoned "Industrial" on the Metropolitan Region Scheme being portion of Pt Lot M1689 from "Rural" to "Industrial Development" Zone; and

(c) to rezone Lots 1, 101, 102, 103, Pt lot 8, Lot 12, Pt Lot 9, Pt Lot M1689, Lot 200, Lot 201, Reserve 41479, Lot 16, lot 8, Portion Lot 35, Lot 1011 and Pt Lot M1688, being those portions of the Yanchep-Two Rocks area which are zoned "Urban" or "Urban Deferred" under the Metropolitan Region Scheme and zoned "Rural", "Service Station", "Special Zone (Additional Use) Video Hire" and "Residential Development" under the City of Wanneroo Town Planning Scheme No. 1 to "Urban Development" Zone.

Responsible Authority: City of Wanneroo

Responsible Authority Address: 11 Moolanda Boulevard
KINGSLEY WA 6026

Assessment Number: 1136

Report of the Environmental Protection Authority: Bulletin 959

Subject to the following conditions, there is no known environmental reason why the town planning scheme amendment to which the above report of the Environmental Protection Authority relates should not be implemented:

Published on

15 FEB 2000

18th FLOOR, ALLENDALE SQUARE, 77 ST. GEORGE'S TERRACE, PERTH 6000 TELEPHONE: (08) 9421 7777 FACSIMILE: (08) 9221 4665/8

1 Environmental Conditions

1-1 In accordance with Section 7A4 of the Town Planning and Development Act, the environmental conditions imposed by the Minister for the Environment on the Scheme or amendments to the Scheme and contained in Statements published under Section 48F of the Environmental Protection Act, are to be incorporated into the Scheme by appropriate changes to relevant provisions and appropriate modifications to the Scheme Maps as required.

1-2 Where appropriate, the environmental conditions are to be indicated on the Scheme Map by the symbol EC to indicate that environmental conditions apply to the land.

1-3 The Responsible Authority shall maintain a register of all the Statements published under Section 48F referred to in sub-clause X.X.1 which shall be made available for public inspection at the offices of the Responsible Authority.

2. ENVIRONMENTAL CONDITIONS TO BE INCORPORATED INTO THE SCHEME BY INSERTION OF PROVISIONS IN SCHEME TEXT

2.1 Responsible Authority scheme provisions

2.1-1 The Responsible Authority shall incorporate the following environmental conditions documented in this statement into the scheme, the subject of this statement.

2.2 Environmental Management Plans

2.2-1 The following Environmental Management Plans shall be prepared in accordance with the specifications set out in Attachment 1 of the Minister for the Environment's Statement that a Scheme may be implemented No. (insert relevant statement number) published on (insert date):

- Stygofauna and/or Troglobitic Fauna Management Plan
- Drainage, Nutrient and Water Management Plan
- Karst Management Strategy
- Solid and Liquid Waste Management Plan
- Aboriginal Culture and Heritage Management Plan

2.2-2 The Environmental Management Plans referred to in condition 2.2-1 shall be prepared and implemented in accordance with the provisions of the Plans, to the requirements of the Responsible Authority.

2.3 Vegetation and Fauna Management

2.3-1 Regionally significant vegetation (draft *Perth's Bushplan* sites) which surrounds the amendment area (as shown on Figure 1) shall be protected from indirect and direct impacts associated with the development of the amendment area by the following:

- Clear delineation of regionally significant areas of vegetation from the amendment area through the use of dual use paths, roads, public open space areas and the like.

- Control of off-road vehicle use and dumping of rubbish.
- Fire Management.
- Promotion of community awareness of bushland protection.

2.4 Stygofauna and Troglobitic Fauna Management

2.4-1 If studies in relation to karst and hydrology (see 2.5-1) indicate the likelihood of significant stygofauna and/or troglobitic fauna assemblages being present in or immediately adjacent to the amendment area, the landowner (with assistance from relevant scientific experts) shall undertake a survey (at the Local Structure Planning Stage) to assess the nature and extent of any population/s.

This survey shall be completed prior to finalisation of the Local Structure Plan and to the requirements of the Responsible Authority on advice from the Department of Conservation and Land Management and the University of Western Australia (Department of Zoology).

2.5 Assessment of Karst Landform

2.5-1 At the **District and Local Structure Planning Stage**, the landowner shall review existing geotechnical information and undertake further site investigations to confirm the nature and extent of karst landform within the amendment area.

This review shall be completed prior to finalisation of the District and Local Structure Plan and to the requirements of the Responsible Authority on advice from the Department of Environmental Protection.

2.6 Solid and Liquid Waste Management

2.6-1 The landowner shall ensure that lots within the industrial zone are connected to the deep sewerage system for the disposal of appropriate liquid wastes as approved by the relevant Government Agency/ies.

2.7 Environmental Reporting

2.7-1 The Responsible Authority shall provide a report to the Environmental Protection Authority every five years, or at the time of the review of the existing town planning scheme (whichever is the earlier), as per Section 48H of the Environmental Protection Act.

CHERYL EDWARDES (Mrs) MLA
MINISTER FOR THE ENVIRONMENT

15 FEB 2000

1. Stygofauna and Troglobitic Fauna Management Plan

1-1 The landowner shall prepare a Stygofauna and/or Troglobitic Fauna Management Plan to ensure the protection of stygofauna and/or troglobitic fauna that may be affected directly or indirectly by development of the amendment area, to the requirements of the Responsible Authority on advice from the Department of Conservation and Land Management and the University of Western Australia (Department of Zoology).

This plan shall include:

- The identification of the environmental outcome (including sustainability indicators) to be achieved through the implementation of this plan.
- Management strategies for the protection of stygofauna and/or troglobitic fauna within and immediately adjacent to the Amendment area.
- Recommendations for ongoing sampling, as required, of karstic areas to determine number and species diversity of stygofauna and/or troglobitic fauna.
- Provision of details of contingency plans in the event that the investigations and monitoring surveys indicate that the development is having an adverse impact upon populations of stygofauna and/or troglobitic fauna.
- Allocation of responsibilities and identification of timing and duration of implementation.

2. Drainage, Nutrient and Water Management Plan

2-1 At the **Local Structure Planning Stage**, the landowner shall prepare a Drainage, Nutrient and Water Management Plan to ensure that surface and groundwater are managed to the minimum requirements of a Priority 3 Underground Water Pollution Control Area, to the requirements of the Responsible Authority on the advice of the Water and Rivers Commission and the Water Corporation.

This plan shall include:

- Identify the environmental outcome (including sustainability indicators) to be achieved through the implementation of this plan.
- Include provisions for the connection of all areas of development to the deep sewerage.
- Demonstrate that best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally.
- Provide details of reporting mechanisms to demonstrate compliance with performance criteria specified in the Plan.

- Provide details of contingency plans in the event that the performance criteria specified in the plan are not achieved.

3 Karst Management Strategy

3-1 At the **Local Structure Planning Stage**, the landowner shall prepare a Karst Management Strategy to the requirements of the Responsible Authority on advice from the Department of Environmental Protection.

The Strategy shall include:

- The identification of the environmental outcome (including sustainability indicators) to be achieved through the implementation of this plan.

- Detailed geotechnical investigations in areas of karst or potential karst in accordance with the protocols described in Alan Tingay & Associates (1999) and summarised in Table 1 (attached).

- Provision to ensure that no development is permitted on areas immediately over large karstic structures unless approved by a qualified geotechnical consultant and environmental scientist and agreed to by the Responsible Authority.

- Provision for monitoring of high risk karstic features within the Amendment area to note enlargements in karstic features, new openings and recent collapse or subsidence.

- Provision of details of contingency plans in the event that the investigations and monitoring surveys indicate that the development has had an adverse impact upon karstic landforms.

- Allocation of responsibilities and identification of timing and duration of implementation.

4 Solid and Liquid Waste Management Plan

4-1 The landowner shall prepare a Solid and Liquid Waste Management Plan at the **Local Structure Planning Stage** to the requirements of the Responsible Authority on the advice of the Department of Environmental Protection.

This plan shall include:

- The identification of the environmental outcome to be achieved through the implementation of this plan.

- Options for recycling, and appropriate storage and disposal options for liquid and solid wastes from industry.

5 Aboriginal Culture and Heritage Management Plan

5-1 The landowner shall prepare an Aboriginal Culture and Heritage Management Plan at the **Local Structure Planning Stage** to the requirements of the Responsible Authority with the concurrence of the Aboriginal Affairs Department.

The plan shall include:

- The identification of the environmental outcome to be achieved through the implementation of this plan.
- Management strategies for the archaeological site (If it becomes necessary to disturb the archaeological site, the subdivider shall obtain the necessary clearances under the Aboriginal Heritage Act 1972).
- Management strategies to ensure that employees and workers involved in construction activities in the vicinity of the archaeological site receive training regarding protection of its values.
- Management strategies to ensure that prior to commencement of site works, staff undergo a briefing on Aboriginal Heritage issues, to enable staff to recognise materials that may constitute an Aboriginal Site. During earthworks, all contractors shall be supervised by a Site Manager, who shall seek specialist advice to confirm the identification of any suspected site.

TABLE 1

WORK SCHEDULE REQUIRED WITH RESPECT TO KARST TERRAIN APPRAISAL

	Structure Plan Assessment Prior to Subdivision	Placement of Building Envelopes/Drainage Design for Proposed Subdivision			Building Envelope Assessment Prior to Building				
	A further geotechnical appraisal of the high and medium risk karst areas with respect to the draft Local Structure Plan design **	Detailed interpretation of existing Ground Probing Radar (GPR) data	Detailed geotechnical inspection target location, drilling and possible remediation	Geotechnical inspection and recommendations for additional geotechnical site assessment prior to building [1]	Geotechnical Investigations for Foundation Assessment				
					Further GPR as recommended from the geotechnical evaluation	Drilling >1 borehole to total depth of 15m	Drilling at least 1 borehole to a total depth of no more than 15m	Testing Pitting to 3m depth[2]	Perth Sand Penetrometer Testing to 750mm[3]
					Further work on high risk only if specifically required/remediation work				
High	✔	✔	✔						
Medium	✔	✔		✔	✔*	✔		✔	✔
Low		✔		✔	✔*		✔	✔	✔
Very Low		✔		✔	✔*			✔	✔

* On the basis of advice from the geotechnical assessment.
** Geotechnical works likely to involve mapping and GPR. Program to be developed in consultation with City of Wanneroo and a geotechnical engineer.

1. Following the geotechnical assessment a reappraisal of the work program for building envelope assessment with respect to the risk rating may be required.
2. Test Pitting is generally carried out by a backhoe and refilled after logging and sampling.
3. The Perth Sand Penetrometer is a hand held portable device used for measuring the compaction of soils.

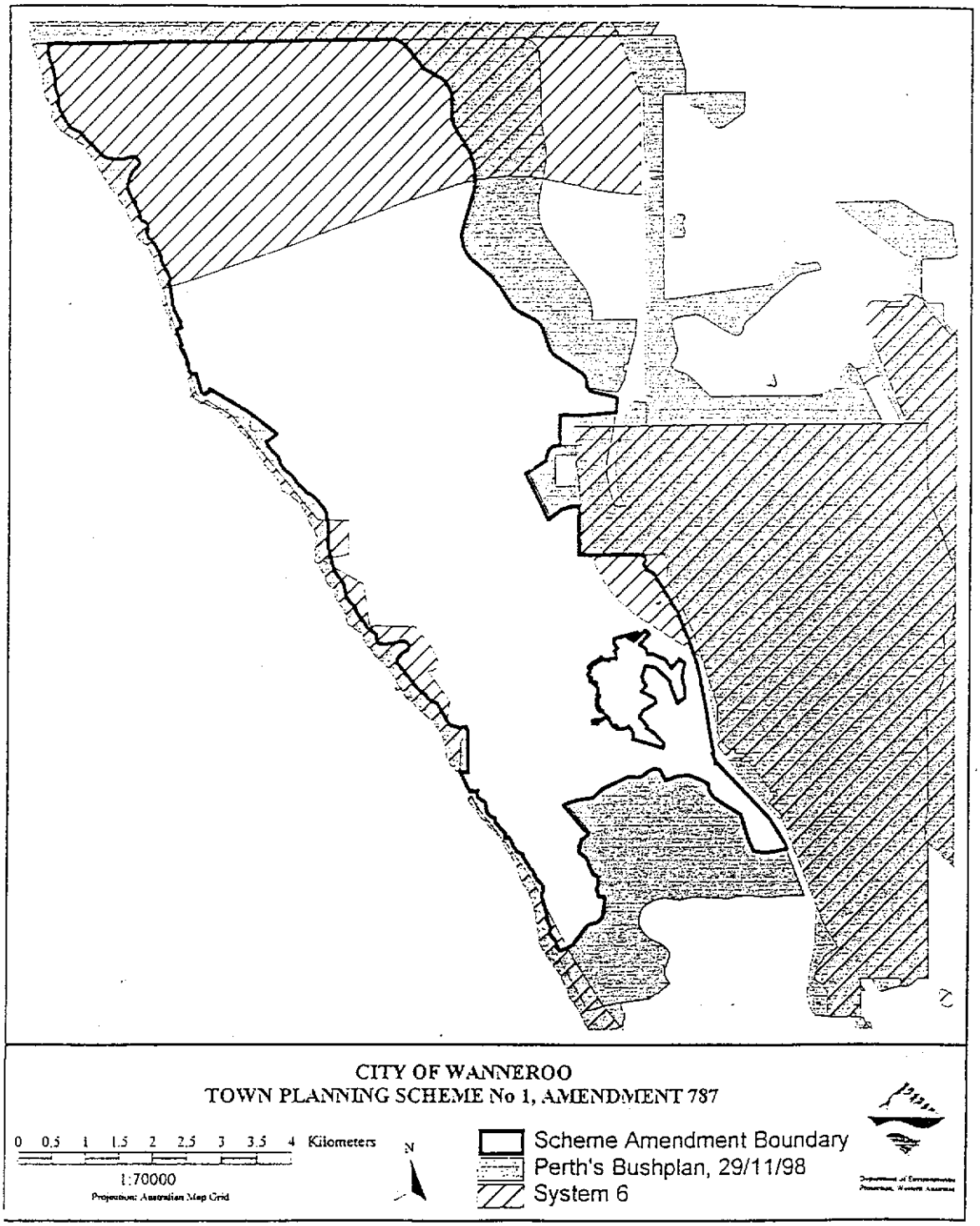


Figure 1. System Six Areas and Bushplan Sites.

Appendix B
General Structure for an Urban Water Management Plan

Yanchep City Structure Plan
Local Water Management Strategy

URBAN WATER MANAGEMENT PLAN

Appendix C
Stormwater Management Decision Process Flowchart

Yanchep City Structure Plan
Local Water Management Strategy

Decision Process for stormwater management in WA (Department of Water 2009)

A component of Chapter 4: Integrating stormwater management approaches, Stormwater management manual for Western Australia (Department of Water 2004-07)

The following process should be used to guide all stages of planning and designing stormwater management systems

1. Prior to and throughout the design process (including during structure planning), proponents shall consult with the Department of Water, Department of Environment and Conservation, local government authorities, the Swan River Trust (where applicable) and other relevant stakeholders.
2. Development should be planned in accordance with *Better urban water management* (Western Australian Planning Commission 2008) and applicable land and water planning guidance documents.
3. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater management manual for Western Australia* (Department of Water 2004–07). The objectives include: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; retaining natural drainage systems and protecting ecosystem health; implementing systems that are economically viable in the long term; ensuring that social, aesthetic and cultural values are maintained; maximising the reuse of stormwater; maintaining or improving surface and ground water quality; and maintaining the total water cycle balance.
4. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.
5. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include the following environments, as defined in *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008): natural areas of high conservation significance (chapter B1.2.1); native vegetation and flora of high conservation significance (chapter B2.2.2); areas of high conservation significance for native fauna (chapter B3.2.2); wetlands of high conservation significance (chapter B4.2.2); waterways of high conservation significance (chapter B5.2.2); waterways management areas (attachment B5-5); Swan and Canning Rivers Development Control Area (attachment B5-5); public drinking water source area wellhead protection zones and reservoir protection zones (chapter B6-1); landscapes and landforms of high conservation significance (chapter B8.2.1); and karst areas of high conservation significance (chapter B9.2.2).

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or a high acid sulfate soil risk area?
2. Does the soil or groundwater contain highly elevated nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxyhydroxide content) and local wetting and drying cycles.

Yes (to either question) →

Avoid mobilisation or disturbance of the in-situ contaminants

If yes to question 1 – seek further advice from the Department of Environment and Conservation.

If yes to question 2 – consult with the Department of Water about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions) and the Swan River Trust where the waters in the Trust Development Control Area are likely to be affected.

No (most situations) ↓

1. Maintain the pre-development annual discharge volume and peak flow, unless otherwise established through determination of ecological water requirements for sensitive receiving environments. For more information, see the *Guidelines for ecological water requirements for urban water management* (Department of Water, in preparation).
2. Hydrologic and hydraulic analyses, modelling and design shall incorporate the recommendations and methodology of *Australian rainfall and runoff – a guide to flood estimation* (Engineers Australia 2001).
3. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

Less than and equal to 1-year ARI events: →

Retain or detain stormwater runoff from constructed impervious surfaces generated by up to 1-year, 1-hour average recurrence interval (ARI) events on-site (i.e. as high in the catchment and as close to the source as possible).

Generally, detention systems should preserve the pre-development critical 1-year ARI peak flow rate and discharge volume for the catchment.

Greater than 1-year and up to 100-year ARI events: →

Manage runoff from constructed impervious areas for greater than 1-year, 1-hour ARI events in landscaped retention or detention areas in road reserves, public open space or linear multiple use corridors. Runoff into waterways and wetlands shall be by overland flow paths across vegetated surfaces.

Design for greater than 1-year and less than/equal to 5-year (residential/rural-residential) or 10-year (commercial/industrial) ARI events →

Minor system conveyance
(e.g. via swales and overflow pipes)

Design for greater than 5/10-year and up to 100-year ARI events →

Major system conveyance
(i.e. via overland flow paths)

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of pollutants toward receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and shallow groundwater aquifers.
2. The components of the water quality treatment train must be designed so that their combined effect contributes to meeting the water quality management objectives of the catchment. The objectives may be defined in a water quality improvement plan, regional water plan, drainage and water management plan, district or local water management strategy, urban water management plan, local government stormwater management plan, regional natural resource management strategy, the *Healthy rivers action plan* (Swan River Trust 2008), or the *Environmental protection (Peel Inlet–Harvey Estuary) policy 1992* (Environmental Protection Authority 1992). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of the Department of Water.
3. Practices to achieve water quality management objectives should be a combination of structural and non-structural controls.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach to protection and management should be consistent with the *River restoration manual* (Water and Rivers Commission/Department of Environment 1999–2003), *Foreshore policy 1 – identifying the foreshore area* (Water and Rivers Commission 2002), *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008) and, in the Swan and Canning catchments, *Riverplan* (Government of Western Australia 2004) as a guideline until completion of the *River protection strategy* (Swan River Trust, in preparation) and *Best management practices for shoreline stabilisation* (Swan River Trust, in publication). For wetlands, the approach to protection and management should be consistent with *A guide to managing and restoring wetlands in Western Australia* (Department of Environment and Conservation, in preparation), *Environmental protection of wetlands position statement no. 4* (Environmental Protection Authority 2004), *Wetlands conservation policy for Western Australia* (Government of Western Australia 1997), *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008), *Position statement: wetlands* (Water and Rivers Commission 2001) and relevant environmental protection policies.
2. There shall be no new constructed stormwater infrastructure (e.g. no pipes or constructed channels) within conservation category wetlands and their buffers, or other wetlands of high conservation significance and their buffers (as defined in Environmental Protection Authority 2008), or resource enhancement category wetlands and their buffers, unless authorised by the Department of Environment and Conservation or the Environmental Protection Authority. For multiple use category wetlands, stormwater management shall be consistent with *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008). There shall be no new constructed stormwater infrastructure within a waterway foreshore area, unless authorised by the Department of Water or the Environmental Protection Authority or, where applicable, the Swan River Trust.
3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined lakes that require groundwater to maintain water levels in summer), or the modification of wetland type (e.g. converting a dampland into a lake). Where water conservation (e.g. summer water supply) and environmental and health concerns (e.g. hydrology, water quality, mosquitoes, midges, algal blooms, acid sulfate soils and iron monosulfide minerals) can be shown to be addressed adequately through design and maintenance, consideration may be given to the creation of artificial lakes/ponds. Ephemeral detention or infiltration areas, or approved constructed waterways (i.e. ephemeral living streams) are preferred options. For further guidance, refer to the *Interim position statement: constructed lakes* (Department of Water 2007).

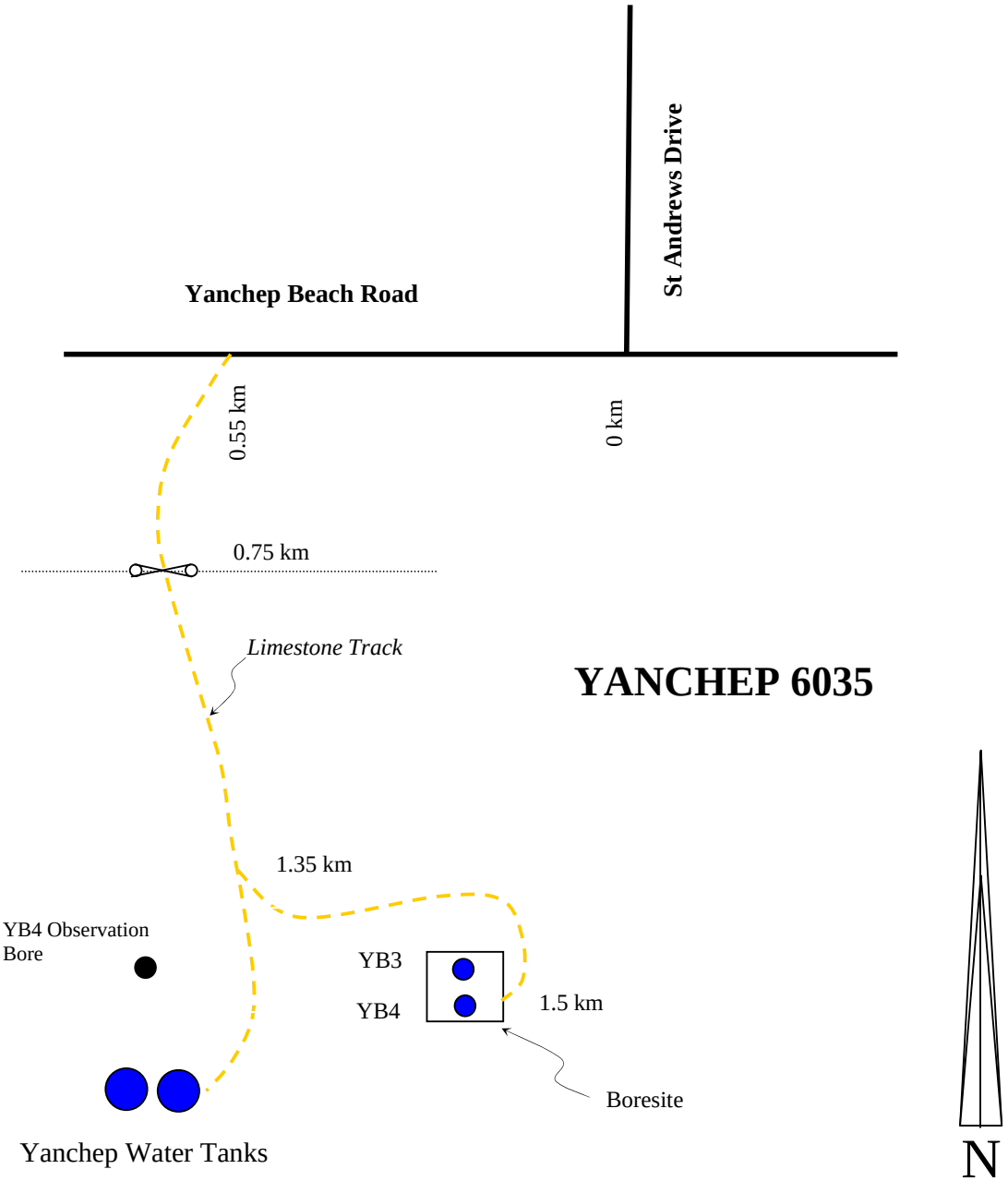
Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through controlled groundwater levels (CGL) shall demonstrate (through adequate field investigation and to the satisfaction of the Department of Water) that local and regional environmental impacts are managed adequately.
2. The CGL is defined as the controlled (i.e. modified) groundwater level (measured in metres Australian height datum) at which the Department of Water will permit drainage inverts to be set. The CGL must be based on local and regional ecological water requirements determined in accordance with the *Environmental water provisions policy for Western Australia* (Water and Rivers Commission 2000) and the *Guidelines for ecological water requirements for urban water management* (Department of Water, in preparation). If groundwater levels are proposed to be controlled using a subsoil drainage system, the proposal to determine and implement a CGL is to be described in a district water management strategy and the estimated CGL level may be proposed at this stage. The CGL calculation will then need to be refined in a local water management strategy and further refined in an urban water management plan. The Department of Water is preparing guidelines on determining groundwater drainage levels.
3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater levels via drainage should not expose ASS to the air, as this may cause groundwater contamination. Refer to the Department of Environment and Conservation ASS guideline series, including *Policy position - acid sulfate soils and the Contaminated Sites Act 2003* (Department of Environment and Conservation 2007) and the Western Australian Planning Commission ASS planning guidelines. If field investigations identify ASS, seek further advice from the Department of Environment and Conservation.

Appendix D
Existing Water Corporation Production Bore Locations

Yanchep City Structure Plan
Local Water Management Strategy

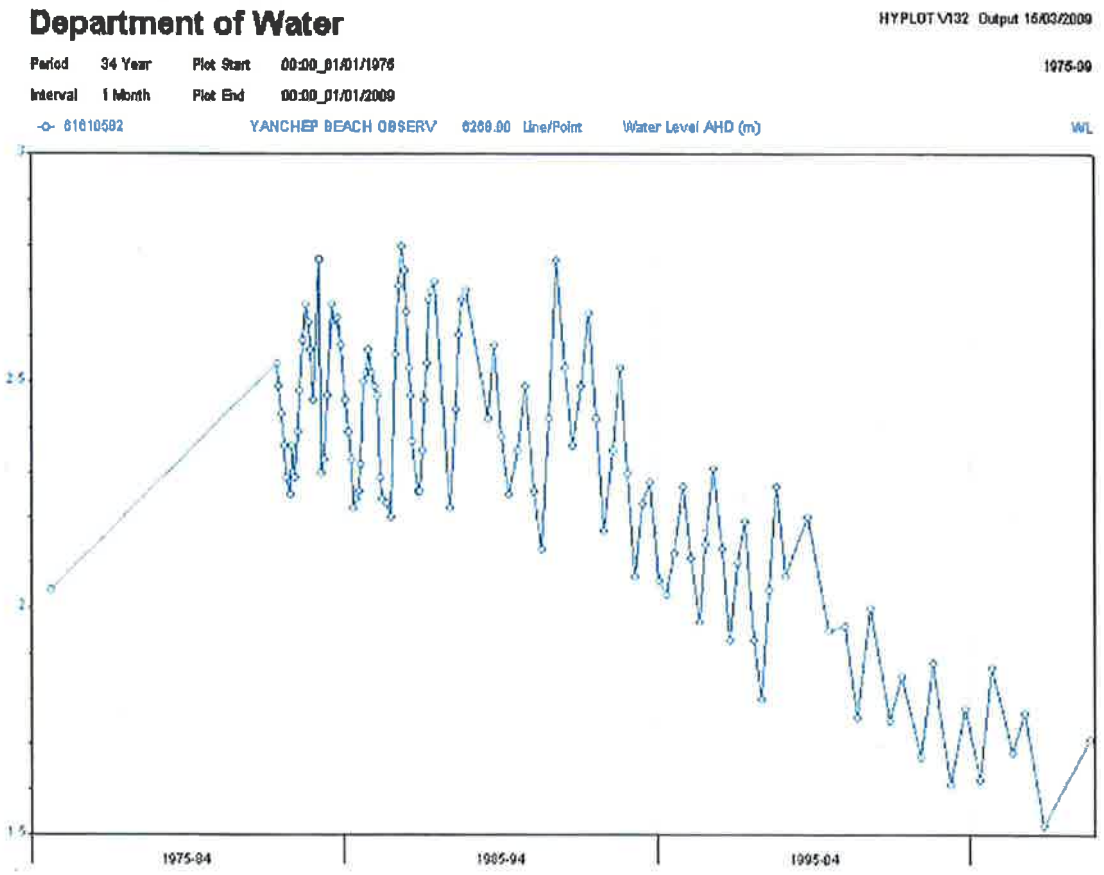
Yanchep Beach Boresite
Location Map



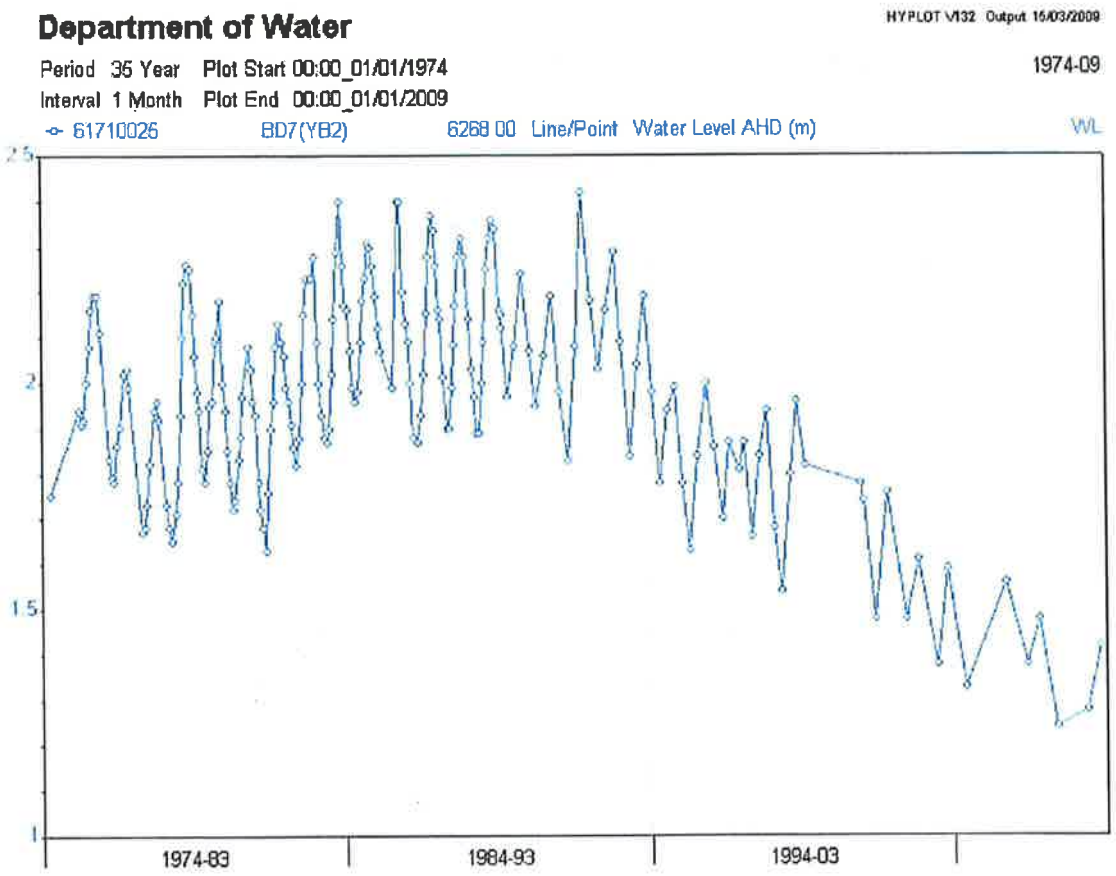
Appendix E
Hydrographs for nearby DoW Bores

Yanchep City Structure Plan
Local Water Management Strategy

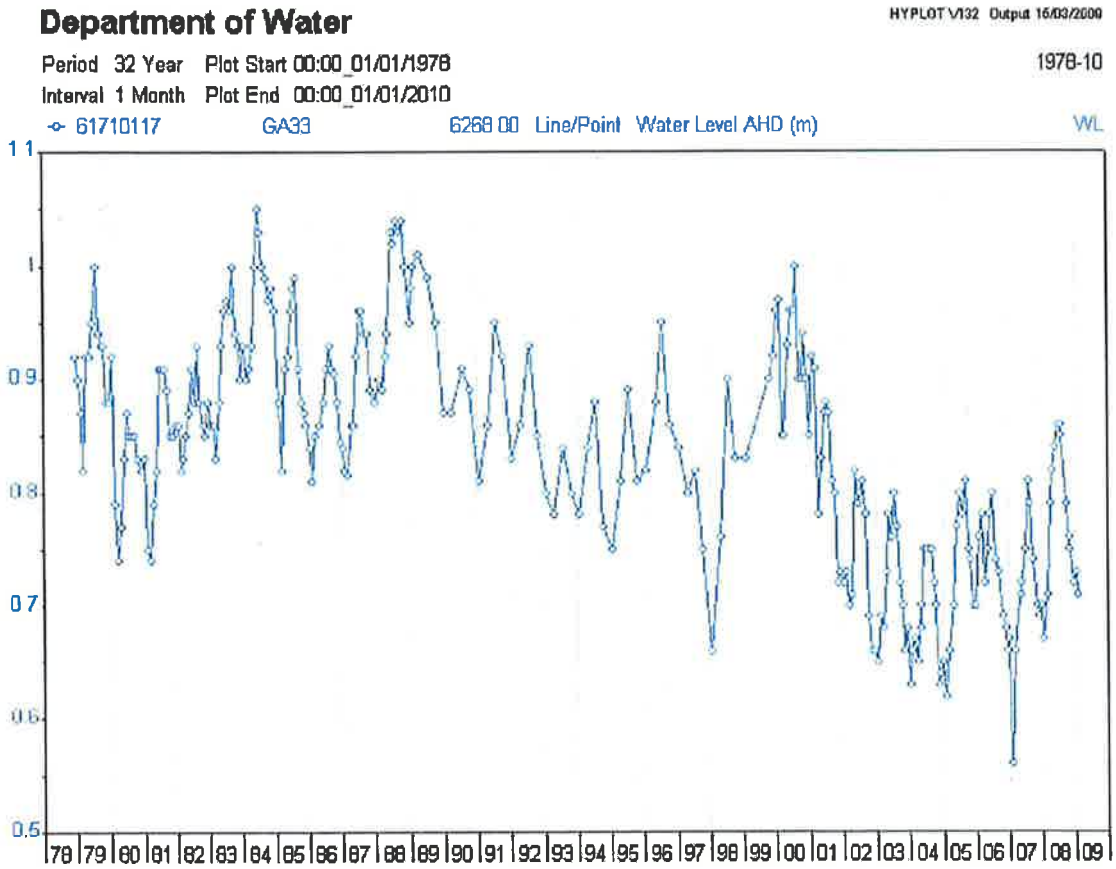
Water Resources Data - Groundwater Sites



Water Resources Data - Groundwater Sites

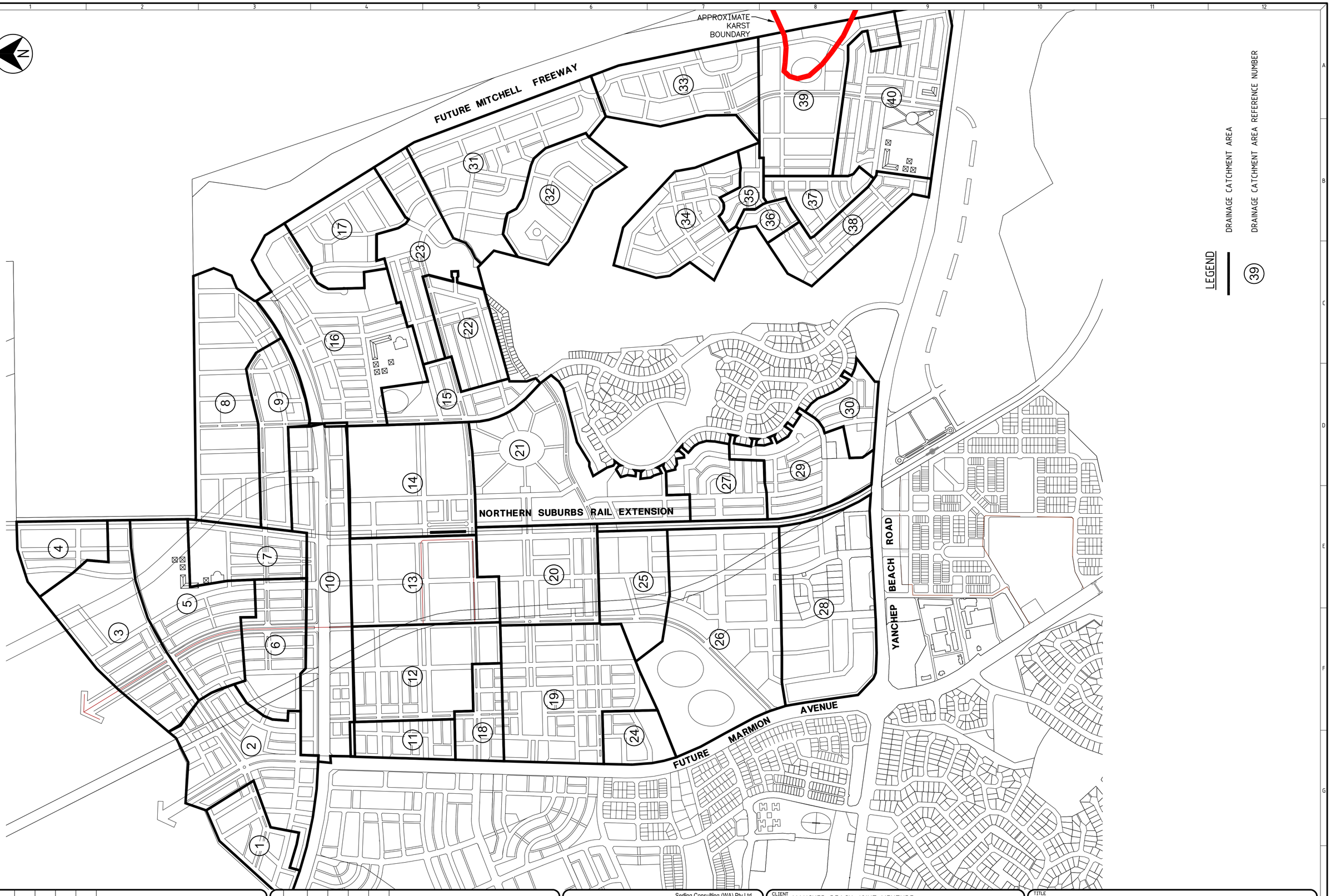


Water Resources Data - Groundwater Sites



Appendix F
Drainage Concept Reference Plan and Calculations

Yanchep City Structure Plan
Local Water Management Strategy



REV No.	DATE	DRAFTING CHECK	DESIGN REVIEW	REV'D P.ENG.	APP'D P.MGR	AMENDMENT
A	07/07/10	*PA	*GGA	*GGA	*GGA	AMENDED AS PER DOW COMMENTS & ISSUED FOR INFORMATION - LSP

REV No.	DATE	DRAFTING CHECK	DESIGN REVIEW	REV'D P.ENG.	APP'D P.MGR	AMENDMENT

SERLING CONSULTING
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CLIENT: YANCHEP BEACH JOINT VENTURE

PROJECT: YANCHEP CITY STRUCTURE PLAN

DRAFTER	DRAFTING CHECK	REVIEWED PROJECT ENGINEER	APPROVED PROJECT MANAGER
P.ALEBAKIS	*P.ALEBAKIS	07/07/2010	07/07/2010
DESIGNED	DESIGN REVIEW	*G.ALEXANDER	*G.ALEXANDER
P.ALEBAKIS	*G.ALEXANDER		

TITLE

CONCEPT DRAINAGE STRATEGY PLAN
CATCHMENT REFERENCE PLAN

SHEET	DATUM	WAPC No.	PROJECT No.	DRAWING No.	REVISION
A1	A.H.D.	N/A	SC00101.001	SK018	A

SCALE DIAGRAMMATIC

Q:\Projects\SC00101.001 - Yanchep Beach JV - LSP\Deliverables\dwg\SC00101-001 - SK18 8/07/2010 8:25:42 PM Peter Alebakis

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 1**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1476**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3272**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	8.2	ha
Impervious Factor	1	82000	m2
Impervious Area:	**2.46**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area	**534**	for a max depth of 0.3m				
	0.06	Side Slopes of Sump (ha)				
1 yr	**0.11**	ha	Total Sump Area			
	37.2	Diameter				
10yr Sump Area	**1342**	for a max depth of 1.1m		100yr Sump Area	**2617**	for a max depth of 1.25m
	0.09	Side Slopes of Sump (ha)			**0.12**	Side Slopes of Sump (ha)
10 yr	**0.22**	ha	Total Sump Area	100 yr	**0.38**	ha Total Sump Area
	53.2	Diameter			**70.0**	Diameter

			Stroage Volume Required	
Volume (m3)	**2617**	m3	**359 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**2220.96**	m2	**250 m³ = 100% of 1 in 2**	✓
Min Area Required	*615*	m2	**160 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	28	54.9	135	107	72.5	178	150	95.1	234	206
10	0.1667	0	47	43.9	180	133	57.7	236	190	74.9	307	260
15	0.25	0	70	35.9	221	151	47.0	289	219	60.5	372	302
20	0.3333	0	93	30.8	252	159	40.2	329	236	51.3	421	328
30	0.5	0	140	24.4	300	160	31.7	390	250	40.1	493	354
45	0.75	0	210	19.0	351	142	24.6	455	245	30.8	569	359
	1	0	280	15.9	390	110	20.5	503	224	25.4	625	345
	1.5	0	420	12.3	454	34	15.8	584	164	19.6	722	302
	2	0	560	10.2	503	-	13.1	647	87	16.2	797	238
	3	0	840	7.9	580	-	10.1	744	-	12.4	914	74
	4	0	1119	6.5	640	-	8.3	821	-	10.2	1006	-
	6	0	1679	5.0	738	-	6.4	944	-	7.8	1151	-
	9	0	2519	3.8	850	-	4.9	1086	-	6.0	1319	-
	12	0	3358	3.2	941	-	4.1	1200	-	4.9	1454	-
	15	0	4198	2.8	1022	-	3.5	1306	-	4.3	1585	-
	18	0	5037	2.5	1094	-	3.2	1398	-	3.8	1699	-
	24	0	6716	2.1	1215	-	2.6	1554	-	3.2	1893	-
	30	0	8395	1.8	1314	-	2.3	1683	-	2.8	2054	-
	36	0	10074	1.6	1398	-	2.0	1791	-	2.5	2190	-
	42	0	11753	1.4	1469	-	1.8	1883	-	2.2	2306	-
	48	0	13432	1.3	1530	-	1.7	1963	-	2.0	2407	-
	60	0	16790	1.1	1629	-	1.4	2092	-	1.7	2571	-
	72	0	20149	1.0	1705	-	1.2	2190	-	1.5	2696	-
Storage Required (m3)						**160** ✓			**250** ✓			**359** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 2**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3771**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**8359**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	21.0	ha
Impervious Factor	1	209500	m2
Impervious Area:	**6.29**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1540**	for a max depth of 0.3m				
	0.09	Side Slopes of Sump (ha)				
1 yr	**0.25**	ha	Total Sump Area			
	56.2	Diameter				
10yr Sump Area	**3428**	for a max depth of 1.1m	100yr Sump Area	**6687**	for a max depth of 1.25m	
	0.14	Side Slopes of Sump (ha)		**0.20**	Side Slopes of Sump (ha)	
10 yr	**0.48**	ha	Total Sump Area	100 yr	**0.86**	ha Total Sump Area
	78.4	Diameter			**104.9**	Diameter

Storage Volume Required

Volume (m3)	**6687**	m3	**997**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**4833.4**	m2	**705**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1571.25*	m2	**462**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	61	54.9	345	284	72.5	456	395	95.1	597	537
10	0.1667	0	102	43.9	459	358	57.7	604	502	74.9	784	683
15	0.25	0	152	35.9	564	412	47.0	738	586	60.5	950	798
20	0.3333	0	203	30.8	644	441	40.2	841	638	51.3	1076	873
30	0.5	0	305	24.4	766	462	31.7	996	692	40.1	1261	956
45	0.75	0	457	19.0	898	441	24.6	1162	705	30.8	1454	997
	1	0	609	15.9	997	388	20.5	1286	677	25.4	1596	987
	1.5	0	914	12.3	1159	245	15.8	1492	579	19.6	1845	932
	2	0	1218	10.2	1285	67	13.1	1652	434	16.2	2037	819
	3	0	1827	7.9	1481	-	10.1	1901	74	12.4	2334	507
	4	0	2436	6.5	1636	-	8.3	2098	-	10.2	2569	133
	6	0	3654	5.0	1884	-	6.4	2412	-	7.8	2942	-
	9	0	5481	3.8	2172	-	4.9	2775	-	6.0	3371	-
	12	0	7308	3.2	2403	-	4.1	3067	-	4.9	3714	-
	15	0	9135	2.8	2612	-	3.5	3336	-	4.3	4048	-
	18	0	10962	2.5	2795	-	3.2	3572	-	3.8	4341	-
	24	0	14616	2.1	3103	-	2.6	3970	-	3.2	4838	-
	30	0	18270	1.8	3357	-	2.3	4299	-	2.8	5248	-
	36	0	21924	1.6	3570	-	2.0	4575	-	2.5	5594	-
	42	0	25578	1.4	3753	-	1.8	4811	-	2.2	5892	-
	48	0	29232	1.3	3909	-	1.7	5015	-	2.0	6149	-
	60	0	36540	1.1	4163	-	1.4	5345	-	1.7	6568	-
	72	0	43849	1.0	4355	-	1.2	5596	-	1.5	6889	-
Storage Required (m3)						**462** ✓			**705** ✓			**997** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 3**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3704**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**8211**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area
Drainage Catchment Factor	0.3		20.6 ha
Impervious Factor	1		205800 m2
Impervious Area:	**6.17**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area	**1510**	for a max depth of 0.3m					
	0.09	Side Slopes of Sump (ha)					
1 yr	**0.24**	ha	Total Sump Area				
	55.8	Diameter					
10yr Sump Area	**3368**	for a max depth of 1.1m		100yr Sump Area	**6569**	for a max depth of 1.25m	
	0.14	Side Slopes of Sump (ha)			**0.19**	Side Slopes of Sump (ha)	
10 yr	**0.48**	ha	Total Sump Area	100 yr	**0.85**	ha	Total Sump Area
	77.9	Diameter			**104.1**	Diameter	

			Stroage Volume Required	
Volume (m3)	**6569**	m3	**979 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**4760.39**	m2	**692 m³ = 100% of 1 in 2**	✓
Min Area Required	*1543.5*	m2	**453 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	60	54.9	339	279	72.5	448	388	95.1	587	527
10	0.1667	0	100	43.9	451	351	57.7	593	493	74.9	770	670
15	0.25	0	150	35.9	554	404	47.0	725	575	60.5	933	784
20	0.3333	0	200	30.8	633	433	40.2	827	627	51.3	1057	857
30	0.5	0	300	24.4	753	453	31.7	979	679	40.1	1238	938
45	0.75	0	450	19.0	882	432	24.6	1141	692	30.8	1428	979
	1	0	600	15.9	980	380	20.5	1263	664	25.4	1568	968
	1.5	0	900	12.3	1138	239	15.8	1466	566	19.6	1813	913
	2	0	1200	10.2	1262	62	13.1	1623	423	16.2	2001	801
	3	0	1799	7.9	1455	-	10.1	1867	68	12.4	2293	494
	4	0	2399	6.5	1607	-	8.3	2061	-	10.2	2524	125
	6	0	3599	5.0	1851	-	6.4	2369	-	7.8	2890	-
	9	0	5398	3.8	2133	-	4.9	2726	-	6.0	3311	-
	12	0	7198	3.2	2361	-	4.1	3012	-	4.9	3649	-
	15	0	8997	2.8	2566	-	3.5	3277	-	4.3	3977	-
	18	0	10797	2.5	2745	-	3.2	3509	-	3.8	4264	-
	24	0	14395	2.1	3048	-	2.6	3900	-	3.2	4752	-
	30	0	17994	1.8	3298	-	2.3	4223	-	2.8	5155	-
	36	0	21593	1.6	3507	-	2.0	4494	-	2.5	5496	-
	42	0	25192	1.4	3686	-	1.8	4726	-	2.2	5788	-
	48	0	28791	1.3	3840	-	1.7	4926	-	2.0	6040	-
	60	0	35989	1.1	4089	-	1.4	5251	-	1.7	6452	-
	72	0	43186	1.0	4278	-	1.2	5498	-	1.5	6767	-
Storage Required (m3)						**453** ✓			**692** ✓			**979** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 4**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1350**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2993**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	7.5	ha
Impervious Factor	1	75000	m2
Impervious Area:	**2.25**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area	**480**	for a max depth of 0.3m			
	0.05	Side Slopes of Sump (ha)			
1 yr	**0.10**	ha	Total Sump Area		
	35.8	Diameter			
10yr Sump Area	**1227**	for a max depth of 1.1m	100yr Sump Area	**2394**	for a max depth of 1.25m
	0.08	Side Slopes of Sump (ha)		**0.12**	Side Slopes of Sump (ha)
10 yr	**0.21**	ha Total Sump Area	100 yr	**0.36**	ha Total Sump Area
	51.3	Diameter		**67.4**	Diameter

			Stroage Volume Required	
Volume (m3)	**2394**	m3	**325**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**2068.05**	m2	**226**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*562.5*	m2	**144**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	26	54.9	124	97	72.5	163	137	95.1	214	188
10	0.1667	0	43	43.9	164	121	57.7	216	173	74.9	281	237
15	0.25	0	65	35.9	202	137	47.0	264	199	60.5	340	275
20	0.3333	0	87	30.8	231	144	40.2	301	214	51.3	385	298
30	0.5	0	130	24.4	274	144	31.7	357	226	40.1	451	321
45	0.75	0	195	19.0	321	126	24.6	416	221	30.8	521	325
	1	0	261	15.9	357	96	20.5	460	200	25.4	572	311
	1.5	0	391	12.3	415	24	15.8	534	143	19.6	661	270
	2	0	521	10.2	460	-	13.1	591	70	16.2	729	208
	3	0	782	7.9	530	-	10.1	681	-	12.4	836	54
	4	0	1042	6.5	586	-	8.3	751	-	10.2	920	-
	6	0	1563	5.0	675	-	6.4	863	-	7.8	1053	-
	9	0	2345	3.8	778	-	4.9	993	-	6.0	1207	-
	12	0	3127	3.2	860	-	4.1	1098	-	4.9	1330	-
	15	0	3909	2.8	935	-	3.5	1194	-	4.3	1449	-
	18	0	4690	2.5	1000	-	3.2	1279	-	3.8	1554	-
	24	0	6254	2.1	1111	-	2.6	1421	-	3.2	1732	-
	30	0	7817	1.8	1202	-	2.3	1539	-	2.8	1879	-
	36	0	9381	1.6	1278	-	2.0	1638	-	2.5	2003	-
	42	0	10944	1.4	1343	-	1.8	1722	-	2.2	2109	-
	48	0	12508	1.3	1400	-	1.7	1795	-	2.0	2201	-
	60	0	15634	1.1	1490	-	1.4	1914	-	1.7	2351	-
	72	0	18761	1.0	1559	-	1.2	2003	-	1.5	2466	-
Storage Required (m3)						**144** ✓			**226** ✓			**325** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 5**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3577**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**7928**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area
Drainage Catchment Factor	0.3		19.9 ha
Impervious Factor	1		198700 m2
Impervious Area:	**5.96**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1453**	for a max depth of 0.3m				
	0.09	Side Slopes of Sump (ha)				
1 yr	**0.24**	ha	Total Sump Area			
	54.9	Diameter				
10yr Sump Area	**3251**	for a max depth of 1.1m		100yr Sump Area	**6343**	for a max depth of 1.25m
	0.14	Side Slopes of Sump (ha)			**0.19**	Side Slopes of Sump (ha)
10 yr	**0.46**	ha	Total Sump Area	100 yr	**0.83**	ha Total Sump Area
	76.7	Diameter			**102.5**	Diameter

			Stroage Volume Required	
Volume (m3)	**6343**	m3	**943 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**4619.97**	m2	**665 m³ = 100% of 1 in 2**	✓
Min Area Required	*1490.25*	m2	**436 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	58	54.9	327	269	72.5	432	374	95.1	567	508
10	0.1667	0	97	43.9	436	339	57.7	573	476	74.9	744	647
15	0.25	0	146	35.9	535	389	47.0	700	555	60.5	901	756
20	0.3333	0	194	30.8	611	417	40.2	798	604	51.3	1020	826
30	0.5	0	291	24.4	727	436	31.7	945	654	40.1	1196	905
45	0.75	0	437	19.0	852	415	24.6	1102	665	30.8	1379	943
	1	0	582	15.9	946	364	20.5	1220	638	25.4	1514	932
	1.5	0	873	12.3	1099	226	15.8	1415	542	19.6	1750	877
	2	0	1164	10.2	1218	54	13.1	1567	403	16.2	1932	768
	3	0	1746	7.9	1404	-	10.1	1803	57	12.4	2214	468
	4	0	2328	6.5	1552	-	8.3	1990	-	10.2	2437	108
	6	0	3493	5.0	1787	-	6.4	2287	-	7.8	2790	-
	9	0	5239	3.8	2060	-	4.9	2632	-	6.0	3197	-
	12	0	6985	3.2	2279	-	4.1	2908	-	4.9	3523	-
	15	0	8732	2.8	2477	-	3.5	3164	-	4.3	3840	-
	18	0	10478	2.5	2651	-	3.2	3388	-	3.8	4117	-
	24	0	13971	2.1	2943	-	2.6	3766	-	3.2	4588	-
	30	0	17463	1.8	3184	-	2.3	4077	-	2.8	4977	-
	36	0	20956	1.6	3386	-	2.0	4339	-	2.5	5306	-
	42	0	24449	1.4	3559	-	1.8	4563	-	2.2	5588	-
	48	0	27942	1.3	3708	-	1.7	4757	-	2.0	5832	-
	60	0	34927	1.1	3948	-	1.4	5070	-	1.7	6229	-
	72	0	41912	1.0	4130	-	1.2	5308	-	1.5	6534	-
Storage Required (m3)						**436** ✓			**665** ✓			**943** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 6**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2178**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**4828**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	12.1	ha
Impervious Factor	1	121000	m2
Impervious Area:	**3.63**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**835**	for a max depth of 0.3m				
	0.07	Side Slopes of Sump (ha)				
1 yr	**0.15**	ha	Total Sump Area			
	44.1	Diameter				
10yr Sump Area	**1980**	for a max depth of 1.1m		100yr Sump Area	**3862**	for a max depth of 1.25m
	0.11	Side Slopes of Sump (ha)			**0.15**	Side Slopes of Sump (ha)
10 yr	**0.30**	ha	Total Sump Area	100 yr	**0.54**	ha Total Sump Area
	62.3	Diameter			**82.6**	Diameter

			Stroage Volume Required	
Volume (m3)	**3862**	m3	**552 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**3047.9**	m2	**383 m³ = 100% of 1 in 2**	✓
Min Area Required	*907.5*	m2	**251 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	38	54.9	199	161	72.5	263	225	95.1	345	307
10	0.1667	0	64	43.9	265	201	57.7	349	285	74.9	453	389
15	0.25	0	96	35.9	326	230	47.0	426	330	60.5	549	453
20	0.3333	0	128	30.8	372	244	40.2	486	358	51.3	621	493
30	0.5	0	192	24.4	443	251	31.7	575	383	40.1	728	536
45	0.75	0	288	19.0	519	231	24.6	671	383	30.8	840	552
	1	0	384	15.9	576	192	20.5	743	359	25.4	922	538
	1.5	0	576	12.3	669	93	15.8	862	286	19.6	1066	490
	2	0	768	10.2	742	-	13.1	954	186	16.2	1176	408
	3	0	1152	7.9	855	-	10.1	1098	-	12.4	1348	196
	4	0	1536	6.5	945	-	8.3	1212	-	10.2	1484	-
	6	0	2304	5.0	1088	-	6.4	1393	-	7.8	1699	-
	9	0	3456	3.8	1254	-	4.9	1603	-	6.0	1947	-
	12	0	4608	3.2	1388	-	4.1	1771	-	4.9	2145	-
	15	0	5761	2.8	1509	-	3.5	1927	-	4.3	2338	-
	18	0	6913	2.5	1614	-	3.2	2063	-	3.8	2507	-
	24	0	9217	2.1	1792	-	2.6	2293	-	3.2	2794	-
	30	0	11521	1.8	1939	-	2.3	2483	-	2.8	3031	-
	36	0	13825	1.6	2062	-	2.0	2642	-	2.5	3231	-
	42	0	16130	1.4	2167	-	1.8	2779	-	2.2	3403	-
	48	0	18434	1.3	2258	-	1.7	2897	-	2.0	3551	-
	60	0	23042	1.1	2404	-	1.4	3087	-	1.7	3793	-
	72	0	27651	1.0	2515	-	1.2	3232	-	1.5	3979	-
Storage Required (m3)						**251** ✓			**383** ✓			**552** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 7**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1791**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3970**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	10.0	ha
Impervious Factor	1	99500	m2
Impervious Area:	**2.99**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area	**668**	for a max depth of 0.3m				
	0.06	Side Slopes of Sump (ha)				
1 yr	**0.13**	ha	Total Sump Area			
	40.5	Diameter				
10yr Sump Area	**1628**	for a max depth of 1.1m		100yr Sump Area	**3176**	for a max depth of 1.25m
	0.10	Side Slopes of Sump (ha)			**0.14**	Side Slopes of Sump (ha)
10 yr	**0.26**	ha	Total Sump Area	100 yr	**0.45**	ha Total Sump Area
	57.5	Diameter			**75.9**	Diameter

			Stroage Volume Required	
Volume (m3)	**3176**	m3	**445**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**2596.6**	m2	**310**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*746.25*	m2	**200**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	33	54.9	164	131	72.5	216	184	95.1	284	251
10	0.1667	0	55	43.9	218	164	57.7	287	232	74.9	372	318
15	0.25	0	82	35.9	268	186	47.0	351	269	60.5	451	370
20	0.3333	0	109	30.8	306	197	40.2	400	291	51.3	511	402
30	0.5	0	164	24.4	364	200	31.7	473	310	40.1	599	435
45	0.75	0	245	19.0	426	181	24.6	552	306	30.8	691	445
	1	0	327	15.9	474	146	20.5	611	284	25.4	758	431
	1.5	0	491	12.3	550	60	15.8	709	218	19.6	876	386
	2	0	654	10.2	610	-	13.1	785	130	16.2	967	313
	3	0	982	7.9	703	-	10.1	903	-	12.4	1109	127
	4	0	1309	6.5	777	-	8.3	996	-	10.2	1220	-
	6	0	1963	5.0	895	-	6.4	1145	-	7.8	1397	-
	9	0	2945	3.8	1032	-	4.9	1318	-	6.0	1601	-
	12	0	3926	3.2	1141	-	4.1	1456	-	4.9	1764	-
	15	0	4908	2.8	1241	-	3.5	1584	-	4.3	1923	-
	18	0	5889	2.5	1327	-	3.2	1696	-	3.8	2062	-
	24	0	7852	2.1	1474	-	2.6	1886	-	3.2	2298	-
	30	0	9815	1.8	1594	-	2.3	2042	-	2.8	2492	-
	36	0	11778	1.6	1696	-	2.0	2173	-	2.5	2657	-
	42	0	13741	1.4	1782	-	1.8	2285	-	2.2	2798	-
	48	0	15704	1.3	1857	-	1.7	2382	-	2.0	2920	-
	60	0	19630	1.1	1977	-	1.4	2539	-	1.7	3119	-
	72	0	23556	1.0	2068	-	1.2	2658	-	1.5	3272	-
Storage Required (m3)						**200** ✓			**310** ✓			**445** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 8**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4324**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**9585**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	24.0	ha
Impervious Factor	1	240220	m2

Impervious Area: **7.21** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area **1788** for a max depth of 0.3m
0.10 Side Slopes of Sump (ha)
1 yr **0.28** ha Total Sump Area
59.7 Diameter

10yr Sump Area **3931** for a max depth of 1.1m
0.15 Side Slopes of Sump (ha)
10 yr **0.54** ha Total Sump Area
83.2 Diameter

100yr Sump Area **7668** for a max depth of 1.25m
0.21 Side Slopes of Sump (ha)
100 yr **0.98** ha Total Sump Area
111.5 Diameter

			Stroage Volume Required	
Volume (m3)	**7668**	m3	**1154**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5435.6**	m2	**819**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1801.65*	m2	**536**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	68	54.9	396	327	72.5	522	454	95.1	685	617
10	0.1667	0	114	43.9	527	413	57.7	693	578	74.9	899	785
15	0.25	0	171	35.9	647	475	47.0	847	675	60.5	1090	918
20	0.3333	0	228	30.8	739	511	40.2	965	737	51.3	1233	1005
30	0.5	0	342	24.4	879	536	31.7	1143	800	40.1	1446	1103
45	0.75	0	514	19.0	1030	516	24.6	1332	819	30.8	1667	1154
	1	0	685	15.9	1143	458	20.5	1475	790	25.4	1831	1146
	1.5	0	1027	12.3	1329	302	15.8	1711	684	19.6	2116	1088
	2	0	1370	10.2	1473	103	13.1	1894	524	16.2	2336	966
	3	0	2055	7.9	1698	-	10.1	2180	125	12.4	2677	622
	4	0	2740	6.5	1876	-	8.3	2406	-	10.2	2946	207
	6	0	4109	5.0	2161	-	6.4	2765	-	7.8	3373	-
	9	0	6164	3.8	2490	-	4.9	3182	-	6.0	3865	-
	12	0	8219	3.2	2755	-	4.1	3516	-	4.9	4259	-
	15	0	10273	2.8	2995	-	3.5	3825	-	4.3	4642	-
	18	0	12328	2.5	3204	-	3.2	4095	-	3.8	4978	-
	24	0	16437	2.1	3558	-	2.6	4553	-	3.2	5547	-
	30	0	20547	1.8	3849	-	2.3	4929	-	2.8	6017	-
	36	0	24656	1.6	4094	-	2.0	5246	-	2.5	6415	-
	42	0	28765	1.4	4303	-	1.8	5517	-	2.2	6756	-
	48	0	32874	1.3	4483	-	1.7	5750	-	2.0	7050	-
	60	0	41093	1.1	4773	-	1.4	6129	-	1.7	7531	-
	72	0	49312	1.0	4993	-	1.2	6417	-	1.5	7899	-
Storage Required (m3)						**536** ✓			**819** ✓			**1154** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 9**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1940**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**4300**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	10.8	ha
Impervious Factor	1	107780	m2
Impervious Area:	**3.23**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**732**	for a max depth of 0.3m					
	0.06	Side Slopes of Sump (ha)					
1 yr	**0.14**	ha	Total Sump Area				
	41.9	Diameter					
10yr Sump Area	**1764**	for a max depth of 1.1m		100yr Sump Area	**3440**	for a max depth of 1.25m	
	0.10	Side Slopes of Sump (ha)			**0.14**	Side Slopes of Sump (ha)	
10 yr	**0.28**	ha	Total Sump Area	100 yr	**0.48**	ha	Total Sump Area
	59.4	Diameter			**78.6**	Diameter	

			Stroage Volume Required	
Volume (m3)	**3440**	m3	**486 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**2771.6**	m2	**338 m³ = 100% of 1 in 2**	✓
Min Area Required	*808.35*	m2	**220 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	35	54.9	178	143	72.5	234	199	95.1	307	272
10	0.1667	0	58	43.9	236	178	57.7	311	253	74.9	403	345
15	0.25	0	87	35.9	290	203	47.0	380	293	60.5	489	402
20	0.3333	0	116	30.8	332	215	40.2	433	317	51.3	553	437
30	0.5	0	175	24.4	394	220	31.7	513	338	40.1	649	474
45	0.75	0	262	19.0	462	200	24.6	598	336	30.8	748	486
	1	0	349	15.9	513	164	20.5	662	312	25.4	821	472
	1.5	0	524	12.3	596	72	15.8	768	244	19.6	949	425
	2	0	698	10.2	661	-	13.1	850	151	16.2	1048	349
	3	0	1048	7.9	762	-	10.1	978	-	12.4	1201	153
	4	0	1397	6.5	842	-	8.3	1079	-	10.2	1322	-
	6	0	2095	5.0	969	-	6.4	1241	-	7.8	1513	-
	9	0	3143	3.8	1117	-	4.9	1428	-	6.0	1734	-
	12	0	4191	3.2	1236	-	4.1	1578	-	4.9	1911	-
	15	0	5238	2.8	1344	-	3.5	1716	-	4.3	2083	-
	18	0	6286	2.5	1438	-	3.2	1837	-	3.8	2233	-
	24	0	8381	2.1	1597	-	2.6	2043	-	3.2	2489	-
	30	0	10477	1.8	1727	-	2.3	2211	-	2.8	2700	-
	36	0	12572	1.6	1837	-	2.0	2354	-	2.5	2878	-
	42	0	14667	1.4	1931	-	1.8	2475	-	2.2	3031	-
	48	0	16763	1.3	2011	-	1.7	2580	-	2.0	3163	-
	60	0	20953	1.1	2142	-	1.4	2750	-	1.7	3379	-
	72	0	25144	1.0	2240	-	1.2	2879	-	1.5	3544	-
Storage Required (m3)						**220** ✓			**338** ✓			**486** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 10**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4752**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**10534**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	26.4	ha
Impervious Factor	1	264000	m2
Impervious Area:	**7.92** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area: **1981** for a max depth of 0.3m
0.11 Side Slopes of Sump (ha)
1 yr: **0.30** ha Total Sump Area
62.3 Diameter

10yr Sump Area: **4320** for a max depth of 1.1m
0.16 Side Slopes of Sump (ha)
10 yr: **0.59** ha Total Sump Area
86.7 Diameter

100yr Sump Area: **8427** for a max depth of 1.25m
0.22 Side Slopes of Sump (ha)
100 yr: **1.06** ha Total Sump Area
116.3 Diameter

			Stroage Volume Required	
Volume (m3)	**8427**	m3	**1275**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5897.4**	m2	**907**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1980*	m2	**594**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	74	54.9	435	361	72.5	574	500	95.1	753	679
10	0.1667	0	124	43.9	579	455	57.7	761	637	74.9	988	864
15	0.25	0	186	35.9	711	525	47.0	930	745	60.5	1197	1012
20	0.3333	0	248	30.8	812	564	40.2	1060	813	51.3	1355	1108
30	0.5	0	372	24.4	966	594	31.7	1256	884	40.1	1589	1217
45	0.75	0	557	19.0	1131	574	24.6	1464	907	30.8	1832	1275
	1	0	743	15.9	1257	513	20.5	1621	877	25.4	2012	1269
	1.5	0	1115	12.3	1460	346	15.8	1880	766	19.6	2325	1211
	2	0	1486	10.2	1619	133	13.1	2082	595	16.2	2567	1081
	3	0	2229	7.9	1866	-	10.1	2395	166	12.4	2942	713
	4	0	2972	6.5	2062	-	8.3	2644	-	10.2	3238	265
	6	0	4458	5.0	2375	-	6.4	3039	-	7.8	3707	-
	9	0	6688	3.8	2737	-	4.9	3497	-	6.0	4248	-
	12	0	8917	3.2	3028	-	4.1	3864	-	4.9	4681	-
	15	0	11146	2.8	3291	-	3.5	4204	-	4.3	5101	-
	18	0	13375	2.5	3522	-	3.2	4501	-	3.8	5470	-
	24	0	17834	2.1	3911	-	2.6	5003	-	3.2	6096	-
	30	0	22292	1.8	4230	-	2.3	5417	-	2.8	6613	-
	36	0	26751	1.6	4499	-	2.0	5765	-	2.5	7050	-
	42	0	31209	1.4	4729	-	1.8	6063	-	2.2	7424	-
	48	0	35668	1.3	4926	-	1.7	6320	-	2.0	7748	-
	60	0	44585	1.1	5246	-	1.4	6736	-	1.7	8276	-
	72	0	53502	1.0	5488	-	1.2	7052	-	1.5	8681	-
Storage Required (m3)						**594** ✓			**907** ✓			**1275** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 11**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1089**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2414**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	6.1	ha
Impervious Factor	1	60500	m2
Impervious Area:	**1.82** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**376**	for a max depth of 0.3m				
	0.05	Side Slopes of Sump (ha)				
1 yr	**0.08**	ha	Total Sump Area			
	32.7	Diameter				
10yr Sump Area	**990**	for a max depth of 1.1m		100yr Sump Area	**1931**	for a max depth of 1.25m
	0.08	Side Slopes of Sump (ha)			**0.11**	Side Slopes of Sump (ha)
10 yr	**0.17**	ha	Total Sump Area	100 yr	**0.30**	ha Total Sump Area
	47.1	Diameter			**61.7**	Diameter

			Stroage Volume Required	
Volume (m3)	**1931**	m3	**255**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**1745.1**	m2	**178**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*453.75*	m2	**113**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	22	54.9	100	78	72.5	132	110	95.1	173	151
10	0.1667	0	37	43.9	133	96	57.7	174	138	74.9	226	190
15	0.25	0	55	35.9	163	108	47.0	213	158	60.5	274	219
20	0.3333	0	73	30.8	186	113	40.2	243	170	51.3	311	237
30	0.5	0	110	24.4	221	111	31.7	288	178	40.1	364	254
45	0.75	0	165	19.0	259	94	24.6	336	171	30.8	420	255
	1	0	220	15.9	288	68	20.5	371	151	25.4	461	241
	1.5	0	330	12.3	335	5	15.8	431	101	19.6	533	203
	2	0	440	10.2	371	-	13.1	477	37	16.2	588	148
	3	0	660	7.9	428	-	10.1	549	-	12.4	674	14
	4	0	880	6.5	473	-	8.3	606	-	10.2	742	-
	6	0	1319	5.0	544	-	6.4	696	-	7.8	849	-
	9	0	1979	3.8	627	-	4.9	801	-	6.0	973	-
	12	0	2639	3.2	694	-	4.1	886	-	4.9	1073	-
	15	0	3298	2.8	754	-	3.5	963	-	4.3	1169	-
	18	0	3958	2.5	807	-	3.2	1031	-	3.8	1254	-
	24	0	5277	2.1	896	-	2.6	1147	-	3.2	1397	-
	30	0	6597	1.8	969	-	2.3	1241	-	2.8	1515	-
	36	0	7916	1.6	1031	-	2.0	1321	-	2.5	1616	-
	42	0	9235	1.4	1084	-	1.8	1389	-	2.2	1701	-
	48	0	10555	1.3	1129	-	1.7	1448	-	2.0	1776	-
	60	0	13193	1.1	1202	-	1.4	1544	-	1.7	1897	-
	72	0	15832	1.0	1258	-	1.2	1616	-	1.5	1989	-
Storage Required (m3)						**113** ✓			**178** ✓			**255** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 12**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3424**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**7589**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	19.0	ha
Impervious Factor	1	190200	m2
Impervious Area:	**5.71**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1385**	for a max depth of 0.3m				
	0.09	Side Slopes of Sump (ha)				
1 yr	**0.23**	ha	Total Sump Area			
	53.9	Diameter				
10yr Sump Area	**3112**	for a max depth of 1.1m	100yr Sump Area	**6071**	for a max depth of 1.25m	
	0.13	Side Slopes of Sump (ha)		**0.19**	Side Slopes of Sump (ha)	
10 yr	**0.45**	ha	Total Sump Area	100 yr	**0.79**	ha Total Sump Area
	75.3	Diameter			**100.6**	Diameter

			Stroage Volume Required	
Volume (m3)	**6071**	m3	**899**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**4451.3**	m2	**634**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1426.5*	m2	**415**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	56	54.9	313	257	72.5	414	358	95.1	542	486
10	0.1667	0	93	43.9	417	324	57.7	548	455	74.9	712	618
15	0.25	0	140	35.9	512	372	47.0	670	530	60.5	863	723
20	0.3333	0	187	30.8	585	398	40.2	764	577	51.3	977	790
30	0.5	0	280	24.4	696	415	31.7	905	624	40.1	1145	864
45	0.75	0	421	19.0	815	394	24.6	1055	634	30.8	1320	899
	1	0	561	15.9	905	344	20.5	1168	607	25.4	1449	889
	1.5	0	841	12.3	1052	211	15.8	1355	513	19.6	1675	834
	2	0	1122	10.2	1166	44	13.1	1500	378	16.2	1849	728
	3	0	1683	7.9	1344	-	10.1	1726	43	12.4	2119	437
	4	0	2243	6.5	1486	-	8.3	1905	-	10.2	2333	89
	6	0	3365	5.0	1711	-	6.4	2190	-	7.8	2671	-
	9	0	5048	3.8	1972	-	4.9	2519	-	6.0	3060	-
	12	0	6730	3.2	2182	-	4.1	2784	-	4.9	3372	-
	15	0	8413	2.8	2371	-	3.5	3029	-	4.3	3675	-
	18	0	10096	2.5	2537	-	3.2	3243	-	3.8	3941	-
	24	0	13461	2.1	2817	-	2.6	3605	-	3.2	4392	-
	30	0	16826	1.8	3048	-	2.3	3903	-	2.8	4764	-
	36	0	20191	1.6	3242	-	2.0	4154	-	2.5	5079	-
	42	0	23556	1.4	3407	-	1.8	4368	-	2.2	5349	-
	48	0	26921	1.3	3549	-	1.7	4553	-	2.0	5582	-
	60	0	33652	1.1	3779	-	1.4	4853	-	1.7	5963	-
	72	0	40382	1.0	3954	-	1.2	5081	-	1.5	6254	-
Storage Required (m3)						**415** ✓			**634** ✓			**899** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 13**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3344**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**7413**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	18.6	ha
Impervious Factor	1	185800	m2

Impervious Area: **5.57** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area: **1349** for a max depth of 0.3m
0.09 Side Slopes of Sump (ha)
1 yr: **0.22** ha Total Sump Area
53.3 Diameter

10yr Sump Area: **3040** for a max depth of 1.1m
0.13 Side Slopes of Sump (ha)
10 yr: **0.44** ha Total Sump Area
74.5 Diameter

100yr Sump Area: **5931** for a max depth of 1.25m
0.18 Side Slopes of Sump (ha)
100 yr: **0.78** ha Total Sump Area
99.5 Diameter

Volume (m3)	**5931**	m3
Surface Area Base:	**4363.7**	m2
Min Area Required	*1393.5*	m2

Stroage Volume Required

877	**m³ = 100% of 1 in 5** ✓
618	**m³ = 100% of 1 in 2** ✓
405	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	55	54.9	306	251	72.5	404	349	95.1	530	475
10	0.1667	0	92	43.9	408	316	57.7	536	444	74.9	696	604
15	0.25	0	137	35.9	500	363	47.0	655	517	60.5	843	705
20	0.3333	0	183	30.8	572	388	40.2	746	563	51.3	954	771
30	0.5	0	275	24.4	680	405	31.7	884	609	40.1	1118	843
45	0.75	0	412	19.0	796	384	24.6	1030	618	30.8	1290	877
	1	0	550	15.9	884	335	20.5	1141	591	25.4	1416	866
	1.5	0	825	12.3	1028	203	15.8	1323	499	19.6	1636	812
	2	0	1100	10.2	1139	40	13.1	1465	365	16.2	1806	707
	3	0	1649	7.9	1313	-	10.1	1686	36	12.4	2070	421
	4	0	2199	6.5	1451	-	8.3	1861	-	10.2	2279	79
	6	0	3299	5.0	1671	-	6.4	2139	-	7.8	2609	-
	9	0	4948	3.8	1926	-	4.9	2461	-	6.0	2990	-
	12	0	6598	3.2	2131	-	4.1	2720	-	4.9	3294	-
	15	0	8247	2.8	2316	-	3.5	2959	-	4.3	3590	-
	18	0	9897	2.5	2478	-	3.2	3168	-	3.8	3850	-
	24	0	13196	2.1	2752	-	2.6	3521	-	3.2	4290	-
	30	0	16495	1.8	2977	-	2.3	3812	-	2.8	4654	-
	36	0	19794	1.6	3167	-	2.0	4058	-	2.5	4962	-
	42	0	23093	1.4	3328	-	1.8	4267	-	2.2	5225	-
	48	0	26392	1.3	3467	-	1.7	4448	-	2.0	5453	-
	60	0	32990	1.1	3692	-	1.4	4741	-	1.7	5825	-
	72	0	39588	1.0	3862	-	1.2	4963	-	1.5	6110	-
Storage Required (m3)						**405** ✓			**618** ✓			**877** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 14**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3906**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**8658**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	21.7	ha
Impervious Factor	1	217000	m2
Impervious Area:	**6.51**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1600**	for a max depth of 0.3m				
	0.10	Side Slopes of Sump (ha)				
1 yr	**0.26**	ha	Total Sump Area			
	57.1	Diameter				
10yr Sump Area	**3551**	for a max depth of 1.1m	100yr Sump Area	**6927**	for a max depth of 1.25m	
	0.14	Side Slopes of Sump (ha)		**0.20**	Side Slopes of Sump (ha)	
10 yr	**0.50**	ha	Total Sump Area	100 yr	**0.89**	ha Total Sump Area
	79.6	Diameter			**106.6**	Diameter

			Stroage Volume Required	
Volume (m3)	**6927**	m3	**1035**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**4981.1**	m2	**733**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1627.5*	m2	**480**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	63	54.9	357	295	72.5	472	409	95.1	619	556
10	0.1667	0	105	43.9	476	371	57.7	626	521	74.9	812	708
15	0.25	0	157	35.9	584	427	47.0	765	608	60.5	984	827
20	0.3333	0	209	30.8	668	458	40.2	872	662	51.3	1114	905
30	0.5	0	314	24.4	794	480	31.7	1032	718	40.1	1306	992
45	0.75	0	471	19.0	930	459	24.6	1204	733	30.8	1506	1035
	1	0	628	15.9	1033	405	20.5	1332	704	25.4	1654	1026
	1.5	0	941	12.3	1200	259	15.8	1546	604	19.6	1911	970
	2	0	1255	10.2	1331	75	13.1	1711	456	16.2	2110	855
	3	0	1883	7.9	1534	-	10.1	1969	86	12.4	2418	535
	4	0	2510	6.5	1695	-	8.3	2173	-	10.2	2661	151
	6	0	3766	5.0	1952	-	6.4	2498	-	7.8	3047	-
	9	0	5649	3.8	2250	-	4.9	2874	-	6.0	3492	-
	12	0	7531	3.2	2489	-	4.1	3176	-	4.9	3847	-
	15	0	9414	2.8	2705	-	3.5	3455	-	4.3	4193	-
	18	0	11297	2.5	2895	-	3.2	3700	-	3.8	4496	-
	24	0	15063	2.1	3214	-	2.6	4112	-	3.2	5011	-
	30	0	18828	1.8	3477	-	2.3	4452	-	2.8	5436	-
	36	0	22594	1.6	3698	-	2.0	4739	-	2.5	5795	-
	42	0	26360	1.4	3887	-	1.8	4984	-	2.2	6103	-
	48	0	30125	1.3	4049	-	1.7	5195	-	2.0	6369	-
	60	0	37657	1.1	4312	-	1.4	5537	-	1.7	6803	-
	72	0	45188	1.0	4511	-	1.2	5797	-	1.5	7136	-
Storage Required (m3)						**480** ✓			**733** ✓			**1035** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 15**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1638**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3631**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	9.1	ha
Impervious Factor	1	91000	m2
Impervious Area:	**2.73**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**602**	for a max depth of 0.3m					
	0.06	Side Slopes of Sump (ha)					
1 yr	**0.12**	ha	Total Sump Area				
	39.0	Diameter					
10yr Sump Area	**1489**	for a max depth of 1.1m		100yr Sump Area	**2905**	for a max depth of 1.25m	
	0.09	Side Slopes of Sump (ha)			**0.13**	Side Slopes of Sump (ha)	
10 yr	**0.24**	ha	Total Sump Area	100 yr	**0.42**	ha	Total Sump Area
	55.5	Diameter			**73.1**	Diameter	

			Stroage Volume Required	
Volume (m3)	**2905**	m3	**403**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**2415.2**	m2	**281**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*682.5*	m2	**181**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	30	54.9	150	119	72.5	198	167	95.1	259	229
10	0.1667	0	51	43.9	200	149	57.7	262	212	74.9	341	290
15	0.25	0	76	35.9	245	169	47.0	321	245	60.5	413	337
20	0.3333	0	101	30.8	280	178	40.2	366	264	51.3	467	366
30	0.5	0	152	24.4	333	181	31.7	433	281	40.1	548	395
45	0.75	0	228	19.0	390	162	24.6	505	276	30.8	632	403
	1	0	304	15.9	433	129	20.5	559	254	25.4	693	389
	1.5	0	456	12.3	503	47	15.8	648	192	19.6	801	345
	2	0	609	10.2	558	-	13.1	718	109	16.2	885	276
	3	0	913	7.9	643	-	10.1	826	-	12.4	1014	101
	4	0	1217	6.5	711	-	8.3	911	-	10.2	1116	-
	6	0	1826	5.0	818	-	6.4	1048	-	7.8	1278	-
	9	0	2739	3.8	943	-	4.9	1205	-	6.0	1464	-
	12	0	3652	3.2	1044	-	4.1	1332	-	4.9	1613	-
	15	0	4565	2.8	1135	-	3.5	1449	-	4.3	1758	-
	18	0	5478	2.5	1214	-	3.2	1551	-	3.8	1886	-
	24	0	7304	2.1	1348	-	2.6	1725	-	3.2	2101	-
	30	0	9130	1.8	1458	-	2.3	1867	-	2.8	2279	-
	36	0	10955	1.6	1551	-	2.0	1987	-	2.5	2430	-
	42	0	12781	1.4	1630	-	1.8	2090	-	2.2	2559	-
	48	0	14607	1.3	1698	-	1.7	2178	-	2.0	2671	-
	60	0	18259	1.1	1808	-	1.4	2322	-	1.7	2853	-
	72	0	21911	1.0	1892	-	1.2	2431	-	1.5	2992	-
Storage Required (m3)						**181** ✓			**281** ✓			**403** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 16**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**5283**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**11711**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	29.4	ha
Impervious Factor	1	293500	m2
Impervious Area:	**8.81**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**2221**	for a max depth of 0.3m				
	0.11	Side Slopes of Sump (ha)				
1 yr	**0.34**	ha	Total Sump Area			
	65.3	Diameter				
10yr Sump Area	**4803**	for a max depth of 1.1m		100yr Sump Area	**9369**	for a max depth of 1.25m
	0.17	Side Slopes of Sump (ha)			**0.23**	Side Slopes of Sump (ha)
10 yr	**0.65**	ha	Total Sump Area	100 yr	**1.17**	ha Total Sump Area
	90.7	Diameter			**122.0**	Diameter

			Stroage Volume Required	
Volume (m3)	**9369**	m3	**1426**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**6466**	m2	**1017**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*2201.25*	m2	**666**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	81	54.9	484	402	72.5	638	557	95.1	837	755
10	0.1667	0	136	43.9	644	508	57.7	846	710	74.9	1099	963
15	0.25	0	204	35.9	790	586	47.0	1034	831	60.5	1331	1128
20	0.3333	0	272	30.8	903	631	40.2	1179	907	51.3	1507	1235
30	0.5	0	407	24.4	1074	666	31.7	1396	989	40.1	1766	1359
45	0.75	0	611	19.0	1258	647	24.6	1628	1017	30.8	2037	1426
	1	0	815	15.9	1397	582	20.5	1802	987	25.4	2237	1422
	1.5	0	1222	12.3	1624	402	15.8	2090	868	19.6	2585	1363
	2	0	1629	10.2	1800	170	13.1	2314	685	16.2	2854	1224
	3	0	2444	7.9	2074	-	10.1	2663	219	12.4	3270	826
	4	0	3259	6.5	2292	-	8.3	2939	-	10.2	3599	341
	6	0	4888	5.0	2640	-	6.4	3379	-	7.8	4121	-
	9	0	7332	3.8	3043	-	4.9	3888	-	6.0	4723	-
	12	0	9777	3.2	3366	-	4.1	4296	-	4.9	5204	-
	15	0	12221	2.8	3659	-	3.5	4673	-	4.3	5672	-
	18	0	14665	2.5	3915	-	3.2	5004	-	3.8	6082	-
	24	0	19553	2.1	4348	-	2.6	5562	-	3.2	6777	-
	30	0	24441	1.8	4703	-	2.3	6022	-	2.8	7352	-
	36	0	29330	1.6	5002	-	2.0	6410	-	2.5	7838	-
	42	0	34218	1.4	5257	-	1.8	6741	-	2.2	8254	-
	48	0	39106	1.3	5477	-	1.7	7026	-	2.0	8614	-
	60	0	48883	1.1	5832	-	1.4	7489	-	1.7	9201	-
	72	0	58659	1.0	6101	-	1.2	7840	-	1.5	9651	-
Storage Required (m3)						**666** ✓			**1017** ✓			**1426** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 17**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2295**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**5087**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	12.8	ha
Impervious Factor	1	127500	m2
Impervious Area:	**3.83**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**886**	for a max depth of 0.3m					
	0.07	Side Slopes of Sump (ha)					
1 yr	**0.16**	ha	Total Sump Area				
	45.1	Diameter					
10yr Sump Area	**2086**	for a max depth of 1.1m		100yr Sump Area	**4070**	for a max depth of 1.25m	
	0.11	Side Slopes of Sump (ha)			**0.15**	Side Slopes of Sump (ha)	
10 yr	**0.32**	ha	Total Sump Area	100 yr	**0.56**	ha	Total Sump Area
	63.7	Diameter			**84.4**	Diameter	

			Stroage Volume Required	
Volume (m3)	**4070**	m3	**584** m³ = 100% of 1 in 5	✓
Surface Area Base:	**3182.6**	m2	**406** m³ = 100% of 1 in 2	✓
Min Area Required	*956.25*	m2	**266** m³ = 100% of 1 in 1	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	40	54.9	210	170	72.5	277	237	95.1	364	323
10	0.1667	0	67	43.9	280	213	57.7	368	301	74.9	477	410
15	0.25	0	100	35.9	343	243	47.0	449	349	60.5	578	478
20	0.3333	0	134	30.8	392	259	40.2	512	378	51.3	655	521
30	0.5	0	201	24.4	466	266	31.7	606	406	40.1	767	567
45	0.75	0	301	19.0	546	246	24.6	707	406	30.8	885	584
	1	0	401	15.9	607	206	20.5	783	382	25.4	972	571
	1.5	0	602	12.3	705	104	15.8	908	307	19.6	1123	521
	2	0	802	10.2	782	-	13.1	1005	203	16.2	1240	438
	3	0	1203	7.9	901	-	10.1	1157	-	12.4	1421	218
	4	0	1604	6.5	996	-	8.3	1277	-	10.2	1564	-
	6	0	2406	5.0	1147	-	6.4	1468	-	7.8	1790	-
	9	0	3609	3.8	1322	-	4.9	1689	-	6.0	2052	-
	12	0	4812	3.2	1462	-	4.1	1866	-	4.9	2261	-
	15	0	6015	2.8	1590	-	3.5	2030	-	4.3	2464	-
	18	0	7218	2.5	1701	-	3.2	2174	-	3.8	2642	-
	24	0	9624	2.1	1889	-	2.6	2416	-	3.2	2944	-
	30	0	12030	1.8	2043	-	2.3	2616	-	2.8	3194	-
	36	0	14436	1.6	2173	-	2.0	2784	-	2.5	3405	-
	42	0	16842	1.4	2284	-	1.8	2928	-	2.2	3586	-
	48	0	19248	1.3	2379	-	1.7	3052	-	2.0	3742	-
	60	0	24060	1.1	2534	-	1.4	3253	-	1.7	3997	-
	72	0	28873	1.0	2650	-	1.2	3406	-	1.5	4193	-
Storage Required (m3)						**266** ✓			**406** ✓			**584** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 18**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1044**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2314**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	5.8	ha
Impervious Factor	1	58000	m2
Impervious Area:	**1.74**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**358**	for a max depth of 0.3m					
	0.05	Side Slopes of Sump (ha)					
1 yr	**0.08**	ha	Total Sump Area				
	32.2	Diameter					
10yr Sump Area	**949**	for a max depth of 1.1m		100yr Sump Area	**1851**	for a max depth of 1.25m	
	0.07	Side Slopes of Sump (ha)			**0.10**	Side Slopes of Sump (ha)	
10 yr	**0.17**	ha	Total Sump Area	100 yr	**0.29**	ha	Total Sump Area
	46.4	Diameter			**60.6**	Diameter	

			Stroage Volume Required	
Volume (m3)	**1851**	m3	**243**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**1688.5**	m2	**169**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*435*	m2	**107**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	21	54.9	96	74	72.5	126	105	95.1	165	144
10	0.1667	0	35	43.9	127	92	57.7	167	132	74.9	217	182
15	0.25	0	53	35.9	156	103	47.0	204	151	60.5	263	210
20	0.3333	0	71	30.8	178	107	40.2	233	162	51.3	298	227
30	0.5	0	106	24.4	212	106	31.7	276	169	40.1	349	243
45	0.75	0	160	19.0	249	89	24.6	322	162	30.8	403	243
	1	0	213	15.9	276	63	20.5	356	143	25.4	442	229
	1.5	0	319	12.3	321	2	15.8	413	94	19.6	511	192
	2	0	425	10.2	356	-	13.1	457	32	16.2	564	138
	3	0	638	7.9	410	-	10.1	526	-	12.4	646	8
	4	0	851	6.5	453	-	8.3	581	-	10.2	711	-
	6	0	1276	5.0	522	-	6.4	668	-	7.8	814	-
	9	0	1915	3.8	601	-	4.9	768	-	6.0	933	-
	12	0	2553	3.2	665	-	4.1	849	-	4.9	1028	-
	15	0	3191	2.8	723	-	3.5	924	-	4.3	1121	-
	18	0	3829	2.5	774	-	3.2	989	-	3.8	1202	-
	24	0	5106	2.1	859	-	2.6	1099	-	3.2	1339	-
	30	0	6382	1.8	929	-	2.3	1190	-	2.8	1453	-
	36	0	7659	1.6	988	-	2.0	1267	-	2.5	1549	-
	42	0	8935	1.4	1039	-	1.8	1332	-	2.2	1631	-
	48	0	10212	1.3	1082	-	1.7	1388	-	2.0	1702	-
	60	0	12765	1.1	1153	-	1.4	1480	-	1.7	1818	-
	72	0	15318	1.0	1206	-	1.2	1549	-	1.5	1907	-
Storage Required (m3)						**107** ✓			**169** ✓			**243** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 19**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4703**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**10424**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	26.1	ha
Impervious Factor	1	261250	m2
Impervious Area:	**7.84** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1958**	for a max depth of 0.3m				
	0.11	Side Slopes of Sump (ha)				
1 yr	**0.30**	ha	Total Sump Area			
	62.0	Diameter				
10yr Sump Area	**4275**	for a max depth of 1.1m		100yr Sump Area	**8339**	for a max depth of 1.25m
	0.16	Side Slopes of Sump (ha)			**0.22**	Side Slopes of Sump (ha)
10 yr	**0.58**	ha	Total Sump Area	100 yr	**1.05**	ha Total Sump Area
	86.3	Diameter			**115.8**	Diameter

			Stroage Volume Required	
Volume (m3)	**8339**	m3	**1261**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5844.2**	m2	**897**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1959.375*	m2	**588**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	74	54.9	430	357	72.5	568	494	95.1	745	671
10	0.1667	0	123	43.9	573	450	57.7	753	630	74.9	978	855
15	0.25	0	184	35.9	703	519	47.0	921	737	60.5	1185	1001
20	0.3333	0	245	30.8	804	558	40.2	1049	804	51.3	1341	1096
30	0.5	0	368	24.4	956	588	31.7	1243	874	40.1	1572	1204
45	0.75	0	552	19.0	1120	567	24.6	1449	897	30.8	1813	1261
	1	0	736	15.9	1243	507	20.5	1604	867	25.4	1991	1254
	1.5	0	1105	12.3	1445	341	15.8	1861	756	19.6	2301	1196
	2	0	1473	10.2	1602	129	13.1	2060	587	16.2	2540	1067
	3	0	2209	7.9	1846	-	10.1	2370	161	12.4	2911	702
	4	0	2945	6.5	2041	-	8.3	2616	-	10.2	3204	258
	6	0	4418	5.0	2350	-	6.4	3008	-	7.8	3668	-
	9	0	6627	3.8	2708	-	4.9	3461	-	6.0	4204	-
	12	0	8836	3.2	2997	-	4.1	3824	-	4.9	4632	-
	15	0	11046	2.8	3257	-	3.5	4160	-	4.3	5048	-
	18	0	13255	2.5	3485	-	3.2	4454	-	3.8	5413	-
	24	0	17673	2.1	3870	-	2.6	4951	-	3.2	6033	-
	30	0	22091	1.8	4186	-	2.3	5360	-	2.8	6544	-
	36	0	26509	1.6	4452	-	2.0	5705	-	2.5	6976	-
	42	0	30928	1.4	4680	-	1.8	6000	-	2.2	7347	-
	48	0	35346	1.3	4875	-	1.7	6254	-	2.0	7668	-
	60	0	44182	1.1	5191	-	1.4	6666	-	1.7	8190	-
	72	0	53019	1.0	5431	-	1.2	6979	-	1.5	8591	-
Storage Required (m3)						**588** ✓			**897** ✓			**1261** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 20**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1364**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3022**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	7.6	ha
Impervious Factor	1	75750	m2
Impervious Area:	**2.27**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**486**	for a max depth of 0.3m					
	0.05	Side Slopes of Sump (ha)					
1 yr	**0.10**	ha	Total Sump Area				
	35.9	Diameter					
10yr Sump Area	**1240**	for a max depth of 1.1m		100yr Sump Area	**2418**	for a max depth of 1.25m	
	0.08	Side Slopes of Sump (ha)			**0.12**	Side Slopes of Sump (ha)	
10 yr	**0.21**	ha	Total Sump Area	100 yr	**0.36**	ha	Total Sump Area
	51.5	Diameter			**67.7**	Diameter	

			Stroage Volume Required	
Volume (m3)	**2418**	m3	**329 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**2084.5**	m2	**229 m³ = 100% of 1 in 2**	✓
Min Area Required	*568.125*	m2	**146 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	26	54.9	125	99	72.5	165	138	95.1	216	190
10	0.1667	0	44	43.9	166	122	57.7	218	175	74.9	284	240
15	0.25	0	66	35.9	204	138	47.0	267	201	60.5	344	278
20	0.3333	0	88	30.8	233	145	40.2	304	217	51.3	389	301
30	0.5	0	131	24.4	277	146	31.7	360	229	40.1	456	325
45	0.75	0	197	19.0	325	128	24.6	420	223	30.8	526	329
	1	0	263	15.9	361	98	20.5	465	202	25.4	577	315
	1.5	0	394	12.3	419	25	15.8	540	146	19.6	667	273
	2	0	525	10.2	464	-	13.1	597	72	16.2	736	211
	3	0	788	7.9	535	-	10.1	687	-	12.4	844	56
	4	0	1051	6.5	592	-	8.3	759	-	10.2	929	-
	6	0	1576	5.0	681	-	6.4	872	-	7.8	1064	-
	9	0	2364	3.8	785	-	4.9	1003	-	6.0	1219	-
	12	0	3152	3.2	869	-	4.1	1109	-	4.9	1343	-
	15	0	3940	2.8	944	-	3.5	1206	-	4.3	1464	-
	18	0	4728	2.5	1010	-	3.2	1291	-	3.8	1570	-
	24	0	6304	2.1	1122	-	2.6	1436	-	3.2	1749	-
	30	0	7879	1.8	1214	-	2.3	1554	-	2.8	1897	-
	36	0	9455	1.6	1291	-	2.0	1654	-	2.5	2023	-
	42	0	11031	1.4	1357	-	1.8	1740	-	2.2	2130	-
	48	0	12607	1.3	1414	-	1.7	1813	-	2.0	2223	-
	60	0	15759	1.1	1505	-	1.4	1933	-	1.7	2375	-
	72	0	18911	1.0	1575	-	1.2	2023	-	1.5	2491	-
Storage Required (m3)						**146** ✓			**229** ✓			**329** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 21**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4820**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**10683**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	26.8	ha
Impervious Factor	1	267750	m2
Impervious Area:	**8.03** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area: **2011** for a max depth of 0.3m
0.11 Side Slopes of Sump (ha)
1 yr: **0.31** ha Total Sump Area
62.7 Diameter

10yr Sump Area: **4381** for a max depth of 1.1m
0.16 Side Slopes of Sump (ha)
10 yr: **0.60** ha Total Sump Area
87.2 Diameter

100yr Sump Area: **8547** for a max depth of 1.25m
0.22 Side Slopes of Sump (ha)
100 yr: **1.08** ha Total Sump Area
117.1 Diameter

			Stroage Volume Required	
Volume (m3)	**8547**	m3	**1294 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**5970**	m2	**921 m³ = 100% of 1 in 2**	✓
Min Area Required	*2008.125*	m2	**603 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	75	54.9	441	366	72.5	582	507	95.1	764	688
10	0.1667	0	125	43.9	587	462	57.7	772	647	74.9	1002	877
15	0.25	0	188	35.9	721	533	47.0	944	756	60.5	1214	1026
20	0.3333	0	251	30.8	824	573	40.2	1075	825	51.3	1375	1124
30	0.5	0	376	24.4	980	603	31.7	1273	897	40.1	1611	1235
45	0.75	0	564	19.0	1147	583	24.6	1485	921	30.8	1858	1294
	1	0	752	15.9	1274	522	20.5	1644	891	25.4	2040	1288
	1.5	0	1128	12.3	1481	353	15.8	1907	779	19.6	2358	1230
	2	0	1504	10.2	1642	137	13.1	2111	607	16.2	2603	1099
	3	0	2257	7.9	1892	-	10.1	2429	173	12.4	2984	727
	4	0	3009	6.5	2091	-	8.3	2681	-	10.2	3284	275
	6	0	4513	5.0	2408	-	6.4	3082	-	7.8	3759	-
	9	0	6770	3.8	2776	-	4.9	3547	-	6.0	4308	-
	12	0	9027	3.2	3071	-	4.1	3919	-	4.9	4747	-
	15	0	11283	2.8	3338	-	3.5	4263	-	4.3	5174	-
	18	0	13540	2.5	3572	-	3.2	4565	-	3.8	5548	-
	24	0	18053	2.1	3966	-	2.6	5074	-	3.2	6183	-
	30	0	22566	1.8	4290	-	2.3	5494	-	2.8	6707	-
	36	0	27080	1.6	4563	-	2.0	5847	-	2.5	7150	-
	42	0	31593	1.4	4796	-	1.8	6149	-	2.2	7530	-
	48	0	36106	1.3	4996	-	1.7	6409	-	2.0	7858	-
	60	0	45133	1.1	5320	-	1.4	6832	-	1.7	8394	-
	72	0	54160	1.0	5566	-	1.2	7152	-	1.5	8804	-
Storage Required (m3)						**603** ✓			**921** ✓			**1294** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 22**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1629**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3611**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	9.1	ha
Impervious Factor	1	90500	m2
Impervious Area:	**2.72**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**599**	for a max depth of 0.3m					
	0.06	Side Slopes of Sump (ha)					
1 yr	**0.12**	ha	Total Sump Area				
	38.9	Diameter					
10yr Sump Area	**1481**	for a max depth of 1.1m		100yr Sump Area	**2889**	for a max depth of 1.25m	
	0.09	Side Slopes of Sump (ha)			**0.13**	Side Slopes of Sump (ha)	
10 yr	**0.24**	ha	Total Sump Area	100 yr	**0.42**	ha	Total Sump Area
	55.3	Diameter			**72.9**	Diameter	

			Stroage Volume Required	
Volume (m3)	**2889**	m3	**401**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**2404.5**	m2	**279**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*678.75*	m2	**180**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	30	54.9	149	119	72.5	197	166	95.1	258	228
10	0.1667	0	50	43.9	198	148	57.7	261	210	74.9	339	288
15	0.25	0	76	35.9	244	168	47.0	319	243	60.5	410	335
20	0.3333	0	101	30.8	278	177	40.2	364	263	51.3	465	364
30	0.5	0	151	24.4	331	180	31.7	430	279	40.1	545	393
45	0.75	0	227	19.0	388	161	24.6	502	275	30.8	628	401
	1	0	303	15.9	431	128	20.5	556	253	25.4	690	387
	1.5	0	454	12.3	501	46	15.8	645	190	19.6	797	343
	2	0	606	10.2	555	-	13.1	714	108	16.2	880	274
	3	0	909	7.9	640	-	10.1	821	-	12.4	1008	100
	4	0	1212	6.5	707	-	8.3	906	-	10.2	1110	-
	6	0	1818	5.0	814	-	6.4	1042	-	7.8	1271	-
	9	0	2727	3.8	938	-	4.9	1199	-	6.0	1456	-
	12	0	3636	3.2	1038	-	4.1	1325	-	4.9	1605	-
	15	0	4544	2.8	1128	-	3.5	1441	-	4.3	1749	-
	18	0	5453	2.5	1207	-	3.2	1543	-	3.8	1875	-
	24	0	7271	2.1	1341	-	2.6	1715	-	3.2	2090	-
	30	0	9089	1.8	1450	-	2.3	1857	-	2.8	2267	-
	36	0	10907	1.6	1542	-	2.0	1976	-	2.5	2417	-
	42	0	12725	1.4	1621	-	1.8	2078	-	2.2	2545	-
	48	0	14542	1.3	1689	-	1.7	2166	-	2.0	2656	-
	60	0	18178	1.1	1798	-	1.4	2309	-	1.7	2837	-
	72	0	21814	1.0	1881	-	1.2	2418	-	1.5	2976	-
Storage Required (m3)						**180** ✓			**279** ✓			**401** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 23**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2673**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**5925**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	14.9	ha
Impervious Factor	1	148500	m2

Impervious Area: **4.46** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area **1052** for a max depth of 0.3m
0.08 Side Slopes of Sump (ha)
1 yr **0.18** ha Total Sump Area
48.3 Diameter

10yr Sump Area **2430** for a max depth of 1.1m
0.12 Side Slopes of Sump (ha)
10 yr **0.36** ha Total Sump Area
67.8 Diameter

100yr Sump Area **4740** for a max depth of 1.25m
0.17 Side Slopes of Sump (ha)
100 yr **0.64** ha Total Sump Area
90.2 Diameter

Volume (m3)	**4740**	m3
Surface Area Base:	**3613.1**	m2
Min Area Required	*1113.75*	m2

Stroage Volume Required

689	**m³ = 100% of 1 in 5** ✓
482	**m³ = 100% of 1 in 2** ✓
316	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	46	54.9	245	199	72.5	323	277	95.1	423	378
10	0.1667	0	76	43.9	326	250	57.7	428	352	74.9	556	480
15	0.25	0	114	35.9	400	286	47.0	523	410	60.5	674	560
20	0.3333	0	152	30.8	457	305	40.2	596	445	51.3	762	611
30	0.5	0	228	24.4	543	316	31.7	706	479	40.1	894	666
45	0.75	0	341	19.0	636	295	24.6	824	482	30.8	1031	689
	1	0	455	15.9	707	252	20.5	912	456	25.4	1132	676
	1.5	0	683	12.3	821	139	15.8	1058	375	19.6	1308	625
	2	0	910	10.2	911	0	13.1	1171	260	16.2	1444	533
	3	0	1366	7.9	1050	-	10.1	1347	-	12.4	1655	289
	4	0	1821	6.5	1160	-	8.3	1487	-	10.2	1821	0
	6	0	2731	5.0	1336	-	6.4	1710	-	7.8	2085	-
	9	0	4097	3.8	1539	-	4.9	1967	-	6.0	2389	-
	12	0	5463	3.2	1703	-	4.1	2174	-	4.9	2633	-
	15	0	6829	2.8	1851	-	3.5	2365	-	4.3	2870	-
	18	0	8194	2.5	1981	-	3.2	2532	-	3.8	3077	-
	24	0	10926	2.1	2200	-	2.6	2814	-	3.2	3429	-
	30	0	13657	1.8	2380	-	2.3	3047	-	2.8	3720	-
	36	0	16389	1.6	2531	-	2.0	3243	-	2.5	3966	-
	42	0	19120	1.4	2660	-	1.8	3410	-	2.2	4176	-
	48	0	21852	1.3	2771	-	1.7	3555	-	2.0	4358	-
	60	0	27315	1.1	2951	-	1.4	3789	-	1.7	4655	-
	72	0	32778	1.0	3087	-	1.2	3967	-	1.5	4883	-
Storage Required (m3)						**316** ✓			**482** ✓			**689** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 24**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**936**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2075**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area	
Drainage Catchment Factor	0.3		5.2	ha
Impervious Factor	1		52000	m2
Impervious Area:	**1.56**	ha		
Pipe Outflow Rate:	**0.000**	m3/sec		
	Base			
Infiltration Rate:	**0.035**	L/sec/m2		
	3.50E-05	m3/sec/m2		
	3.024	m/day		
Rainfall Station used:	**Wanneroo**			

Basin Details

1yr Sump Area	**316**	for a max depth of 0.3m					
	0.04	Side Slopes of Sump (ha)					
1 yr	**0.07**	ha	Total Sump Area				
	30.8	Diameter					
10yr Sump Area	**851**	for a max depth of 1.1m		100yr Sump Area	**1660**	for a max depth of 1.25m	
	0.07	Side Slopes of Sump (ha)			**0.10**	Side Slopes of Sump (ha)	
10 yr	**0.16**	ha	Total Sump Area	100 yr	**0.26**	ha	Total Sump Area
	44.4	Diameter			**58.0**	Diameter	

			Stroage Volume Required	
Volume (m3)	**1660**	m3	**215**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**1551**	m2	**150**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*390*	m2	**95**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	20	54.9	86	66	72.5	113	94	95.1	148	129
10	0.1667	0	33	43.9	114	81	57.7	150	117	74.9	195	162
15	0.25	0	49	35.9	140	91	47.0	183	134	60.5	236	187
20	0.3333	0	65	30.8	160	95	40.2	209	144	51.3	267	202
30	0.5	0	98	24.4	190	93	31.7	247	150	40.1	313	215
45	0.75	0	147	19.0	223	76	24.6	288	142	30.8	361	214
	1	0	195	15.9	248	52	20.5	319	124	25.4	396	201
	1.5	0	293	12.3	288	-	15.8	370	77	19.6	458	165
	2	0	391	10.2	319	-	13.1	410	19	16.2	506	115
	3	0	586	7.9	368	-	10.1	472	-	12.4	579	-
	4	0	782	6.5	406	-	8.3	521	-	10.2	638	-
	6	0	1173	5.0	468	-	6.4	599	-	7.8	730	-
	9	0	1759	3.8	539	-	4.9	689	-	6.0	837	-
	12	0	2345	3.2	596	-	4.1	761	-	4.9	922	-
	15	0	2931	2.8	648	-	3.5	828	-	4.3	1005	-
	18	0	3518	2.5	694	-	3.2	887	-	3.8	1077	-
	24	0	4690	2.1	770	-	2.6	985	-	3.2	1201	-
	30	0	5863	1.8	833	-	2.3	1067	-	2.8	1303	-
	36	0	7035	1.6	886	-	2.0	1136	-	2.5	1389	-
	42	0	8208	1.4	931	-	1.8	1194	-	2.2	1462	-
	48	0	9380	1.3	970	-	1.7	1245	-	2.0	1526	-
	60	0	11726	1.1	1033	-	1.4	1327	-	1.7	1630	-
	72	0	14071	1.0	1081	-	1.2	1389	-	1.5	1710	-
Storage Required (m3)						**95** ✓			**150** ✓			**215** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN
TASK	CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 25

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1787**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3960**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	9.9	ha
Impervious Factor	1	99250	m2
Impervious Area:	**2.98**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**666**	for a max depth of 0.3m				
	0.06	Side Slopes of Sump (ha)				
1 yr	**0.13**	ha	Total Sump Area			
	40.5	Diameter				
10yr Sump Area	**1624**	for a max depth of 1.1m		100yr Sump Area	**3168**	for a max depth of 1.25m
	0.10	Side Slopes of Sump (ha)			**0.14**	Side Slopes of Sump (ha)
10 yr	**0.26**	ha	Total Sump Area	100 yr	**0.45**	ha Total Sump Area
	57.4	Diameter			**75.9**	Diameter

Volume (m3)	**3168**	m3	
Surface Area Base:	**2591.29**	m2	
Min Area Required	*744.375*	m2	

Stroage Volume Required

444	**m³ = 100% of 1 in 5** ✓
309	**m³ = 100% of 1 in 2** ✓
200	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	33	54.9	164	131	72.5	216	183	95.1	283	250
10	0.1667	0	54	43.9	218	163	57.7	286	232	74.9	372	317
15	0.25	0	82	35.9	267	185	47.0	350	268	60.5	450	369
20	0.3333	0	109	30.8	305	196	40.2	399	290	51.3	510	401
30	0.5	0	163	24.4	363	200	31.7	472	309	40.1	597	434
45	0.75	0	245	19.0	425	180	24.6	550	306	30.8	689	444
	1	0	327	15.9	472	146	20.5	609	283	25.4	756	430
	1.5	0	490	12.3	549	59	15.8	707	217	19.6	874	384
	2	0	653	10.2	609	-	13.1	783	130	16.2	965	312
	3	0	980	7.9	701	-	10.1	901	-	12.4	1106	126
	4	0	1306	6.5	775	-	8.3	994	-	10.2	1217	-
	6	0	1959	5.0	893	-	6.4	1143	-	7.8	1394	-
	9	0	2939	3.8	1029	-	4.9	1315	-	6.0	1597	-
	12	0	3918	3.2	1138	-	4.1	1453	-	4.9	1760	-
	15	0	4898	2.8	1237	-	3.5	1580	-	4.3	1918	-
	18	0	5877	2.5	1324	-	3.2	1692	-	3.8	2057	-
	24	0	7836	2.1	1470	-	2.6	1881	-	3.2	2292	-
	30	0	9795	1.8	1590	-	2.3	2036	-	2.8	2486	-
	36	0	11754	1.6	1692	-	2.0	2167	-	2.5	2650	-
	42	0	13713	1.4	1778	-	1.8	2279	-	2.2	2791	-
	48	0	15672	1.3	1852	-	1.7	2376	-	2.0	2913	-
	60	0	19590	1.1	1972	-	1.4	2532	-	1.7	3112	-
	72	0	23508	1.0	2063	-	1.2	2651	-	1.5	3264	-
Storage Required (m3)						**200** ✓			**309** ✓			**444** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN
TASK CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 26

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4465**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**9897**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	24.8	ha
Impervious Factor	1	248050	m2

Impervious Area: **7.44** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area **1851** for a max depth of 0.3m
0.10 Side Slopes of Sump (ha)
1 yr **0.29** ha Total Sump Area
60.6 Diameter

10yr Sump Area **4059** for a max depth of 1.1m
0.15 Side Slopes of Sump (ha)
10 yr **0.56** ha Total Sump Area
84.3 Diameter

100yr Sump Area **7918** for a max depth of 1.25m
0.21 Side Slopes of Sump (ha)
100 yr **1.01** ha Total Sump Area
113.1 Diameter

			Stroage Volume Required	
Volume (m3)	**7918**	m3	**1194**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5588**	m2	**848**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1860.375*	m2	**555**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	70	54.9	409	338	72.5	539	469	95.1	707	637
10	0.1667	0	117	43.9	544	427	57.7	715	598	74.9	929	811
15	0.25	0	176	35.9	668	492	47.0	874	698	60.5	1125	949
20	0.3333	0	235	30.8	763	528	40.2	996	762	51.3	1274	1039
30	0.5	0	352	24.4	907	555	31.7	1180	828	40.1	1493	1141
45	0.75	0	528	19.0	1063	535	24.6	1376	848	30.8	1722	1194
	1	0	704	15.9	1181	477	20.5	1523	819	25.4	1890	1186
	1.5	0	1056	12.3	1372	316	15.8	1767	711	19.6	2185	1129
	2	0	1408	10.2	1521	113	13.1	1956	548	16.2	2412	1004
	3	0	2112	7.9	1753	-	10.1	2251	138	12.4	2764	652
	4	0	2816	6.5	1937	-	8.3	2484	-	10.2	3042	226
	6	0	4225	5.0	2231	-	6.4	2856	-	7.8	3483	-
	9	0	6337	3.8	2571	-	4.9	3286	-	6.0	3991	-
	12	0	8449	3.2	2845	-	4.1	3631	-	4.9	4398	-
	15	0	10561	2.8	3093	-	3.5	3950	-	4.3	4793	-
	18	0	12674	2.5	3309	-	3.2	4229	-	3.8	5140	-
	24	0	16898	2.1	3674	-	2.6	4701	-	3.2	5728	-
	30	0	21123	1.8	3975	-	2.3	5090	-	2.8	6213	-
	36	0	25347	1.6	4227	-	2.0	5417	-	2.5	6624	-
	42	0	29572	1.4	4443	-	1.8	5697	-	2.2	6976	-
	48	0	33797	1.3	4629	-	1.7	5938	-	2.0	7280	-
	60	0	42246	1.1	4929	-	1.4	6329	-	1.7	7776	-
	72	0	50695	1.0	5156	-	1.2	6626	-	1.5	8157	-
Storage Required (m3)						**555** ✓			**848** ✓			**1194** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 27**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1674**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3711**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	9.3	ha
Impervious Factor	1	93000	m2
Impervious Area:	**2.79**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**618**	for a max depth of 0.3m					
	0.06	Side Slopes of Sump (ha)					
1 yr	**0.12**	ha	Total Sump Area				
	39.3	Diameter					
10yr Sump Area	**1522**	for a max depth of 1.1m		100yr Sump Area	**2969**	for a max depth of 1.25m	
	0.09	Side Slopes of Sump (ha)			**0.13**	Side Slopes of Sump (ha)	
10 yr	**0.25**	ha	Total Sump Area	100 yr	**0.43**	ha	Total Sump Area
	55.9	Diameter			**73.8**	Diameter	

			Stroage Volume Required	
Volume (m3)	**2969**	m3	**413 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**2458.1**	m2	**287 m³ = 100% of 1 in 2**	✓
Min Area Required	*697.5*	m2	**185 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	31	54.9	153	122	72.5	202	171	95.1	265	234
10	0.1667	0	52	43.9	204	152	57.7	268	216	74.9	348	297
15	0.25	0	77	35.9	250	173	47.0	328	250	60.5	422	344
20	0.3333	0	103	30.8	286	183	40.2	374	270	51.3	477	374
30	0.5	0	155	24.4	340	185	31.7	442	287	40.1	560	405
45	0.75	0	232	19.0	399	166	24.6	516	284	30.8	645	413
	1	0	310	15.9	443	133	20.5	571	261	25.4	709	399
	1.5	0	465	12.3	514	50	15.8	662	198	19.6	819	355
	2	0	619	10.2	570	-	13.1	733	114	16.2	904	285
	3	0	929	7.9	657	-	10.1	844	-	12.4	1036	107
	4	0	1239	6.5	726	-	8.3	931	-	10.2	1141	-
	6	0	1858	5.0	836	-	6.4	1071	-	7.8	1306	-
	9	0	2787	3.8	964	-	4.9	1232	-	6.0	1496	-
	12	0	3717	3.2	1067	-	4.1	1361	-	4.9	1649	-
	15	0	4646	2.8	1159	-	3.5	1481	-	4.3	1797	-
	18	0	5575	2.5	1241	-	3.2	1586	-	3.8	1927	-
	24	0	7433	2.1	1378	-	2.6	1762	-	3.2	2147	-
	30	0	9292	1.8	1490	-	2.3	1908	-	2.8	2330	-
	36	0	11150	1.6	1585	-	2.0	2031	-	2.5	2483	-
	42	0	13008	1.4	1666	-	1.8	2136	-	2.2	2615	-
	48	0	14866	1.3	1735	-	1.7	2226	-	2.0	2729	-
	60	0	18583	1.1	1848	-	1.4	2373	-	1.7	2916	-
	72	0	22300	1.0	1933	-	1.2	2484	-	1.5	3058	-
Storage Required (m3)						**185** ✓			**287** ✓			**413** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN
TASK CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 28

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4710**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**10441**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	26.2	ha
Impervious Factor	1	261680	m2
Impervious Area:	**7.85** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area **1962** for a max depth of 0.3m
0.11 Side Slopes of Sump (ha)
1 yr **0.30** ha Total Sump Area
62.1 Diameter

10yr Sump Area **4282** for a max depth of 1.1m
0.16 Side Slopes of Sump (ha)
10 yr **0.59** ha Total Sump Area
86.3 Diameter

100yr Sump Area **8353** for a max depth of 1.25m
0.22 Side Slopes of Sump (ha)
100 yr **1.05** ha Total Sump Area
115.9 Diameter

			Stroage Volume Required	
Volume (m3)	**8353**	m3	**1263**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5852.5**	m2	**898**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1962.6*	m2	**589**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	74	54.9	431	357	72.5	569	495	95.1	746	672
10	0.1667	0	123	43.9	574	451	57.7	754	632	74.9	980	857
15	0.25	0	184	35.9	704	520	47.0	922	738	60.5	1187	1003
20	0.3333	0	246	30.8	805	559	40.2	1051	805	51.3	1344	1098
30	0.5	0	369	24.4	957	589	31.7	1245	876	40.1	1575	1206
45	0.75	0	553	19.0	1121	568	24.6	1451	898	30.8	1816	1263
	1	0	737	15.9	1245	508	20.5	1606	869	25.4	1994	1257
	1.5	0	1106	12.3	1448	341	15.8	1864	758	19.6	2305	1199
	2	0	1475	10.2	1604	130	13.1	2063	589	16.2	2544	1069
	3	0	2212	7.9	1850	-	10.1	2374	162	12.4	2916	704
	4	0	2950	6.5	2044	-	8.3	2621	-	10.2	3209	260
	6	0	4425	5.0	2354	-	6.4	3013	-	7.8	3674	-
	9	0	6637	3.8	2713	-	4.9	3466	-	6.0	4211	-
	12	0	8849	3.2	3001	-	4.1	3830	-	4.9	4640	-
	15	0	11061	2.8	3262	-	3.5	4167	-	4.3	5057	-
	18	0	13274	2.5	3491	-	3.2	4461	-	3.8	5422	-
	24	0	17698	2.1	3876	-	2.6	4959	-	3.2	6042	-
	30	0	22123	1.8	4193	-	2.3	5369	-	2.8	6555	-
	36	0	26547	1.6	4460	-	2.0	5715	-	2.5	6988	-
	42	0	30972	1.4	4687	-	1.8	6010	-	2.2	7359	-
	48	0	35396	1.3	4883	-	1.7	6264	-	2.0	7680	-
	60	0	44245	1.1	5200	-	1.4	6677	-	1.7	8204	-
	72	0	53094	1.0	5440	-	1.2	6990	-	1.5	8605	-
Storage Required (m3)						**589** ✓			**898** ✓			**1263** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 29**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2322**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**5147**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	12.9	ha
Impervious Factor	1	129000	m2
Impervious Area:	**3.87**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**898**	for a max depth of 0.3m				
	0.07	Side Slopes of Sump (ha)				
1 yr	**0.16**	ha	Total Sump Area			
	45.4	Diameter				
10yr Sump Area	**2111**	for a max depth of 1.1m	100yr Sump Area	**4118**	for a max depth of 1.25m	
	0.11	Side Slopes of Sump (ha)		**0.15**	Side Slopes of Sump (ha)	
10 yr	**0.32**	ha	Total Sump Area	100 yr	**0.57**	ha Total Sump Area
	64.0	Diameter			**84.9**	Diameter

			Stroage Volume Required	
Volume (m3)	**4118**	m3	**592**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**3213.6**	m2	**412**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*967.5*	m2	**269**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	40	54.9	213	172	72.5	281	240	95.1	368	327
10	0.1667	0	67	43.9	283	215	57.7	372	304	74.9	483	415
15	0.25	0	101	35.9	347	246	47.0	455	353	60.5	585	484
20	0.3333	0	135	30.8	397	262	40.2	518	383	51.3	662	527
30	0.5	0	202	24.4	472	269	31.7	614	411	40.1	776	574
45	0.75	0	304	19.0	553	249	24.6	715	412	30.8	895	592
	1	0	405	15.9	614	209	20.5	792	387	25.4	983	578
	1.5	0	607	12.3	714	106	15.8	919	311	19.6	1136	529
	2	0	810	10.2	791	-	13.1	1017	207	16.2	1254	444
	3	0	1215	7.9	912	-	10.1	1170	-	12.4	1437	223
	4	0	1620	6.5	1008	-	8.3	1292	-	10.2	1582	-
	6	0	2429	5.0	1160	-	6.4	1485	-	7.8	1811	-
	9	0	3644	3.8	1337	-	4.9	1709	-	6.0	2076	-
	12	0	4859	3.2	1480	-	4.1	1888	-	4.9	2287	-
	15	0	6074	2.8	1608	-	3.5	2054	-	4.3	2493	-
	18	0	7288	2.5	1721	-	3.2	2199	-	3.8	2673	-
	24	0	9718	2.1	1911	-	2.6	2445	-	3.2	2979	-
	30	0	12147	1.8	2067	-	2.3	2647	-	2.8	3231	-
	36	0	14577	1.6	2199	-	2.0	2817	-	2.5	3445	-
	42	0	17006	1.4	2311	-	1.8	2963	-	2.2	3628	-
	48	0	19436	1.3	2407	-	1.7	3088	-	2.0	3786	-
	60	0	24295	1.1	2563	-	1.4	3291	-	1.7	4044	-
	72	0	29154	1.0	2682	-	1.2	3446	-	1.5	4242	-
Storage Required (m3)						**269** ✓			**412** ✓			**592** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 30**

Determine Sump Size based on various times and recurrence intervals allowing:

- I total catchment (impervious area)
- I outflow through outlet pipe
- I outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1035**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2294**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area	
Drainage Catchment Factor	0.3		5.8	ha
Impervious Factor	1		57500	m2
Impervious Area:	**1.73**	ha		
Pipe Outflow Rate:	**0.000**	m3/sec		
Base				
Infiltration Rate:	**0.035**	L/sec/m2		
	3.50E-05	m3/sec/m2		
	3.024	m/day		
Rainfall Station used:	**Wanneroo**			

Basin Details

1yr Sump Area	**355**	for a max depth of 0.3m					
	0.05	Side Slopes of Sump (ha)					
1 yr	**0.08**	ha	Total Sump Area				
	32.1	Diameter					
10yr Sump Area	**941**	for a max depth of 1.1m		100yr Sump Area	**1835**	for a max depth of 1.25m	
	0.07	Side Slopes of Sump (ha)			**0.10**	Side Slopes of Sump (ha)	
10 yr	**0.17**	ha	Total Sump Area	100 yr	**0.29**	ha	Total Sump Area
	46.2	Diameter			**60.4**	Diameter	

			Stroage Volume Required	
Volume (m3)	**1835**	m3	**241**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**1677.1**	m2	**168**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*431.25*	m2	**106**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	21	54.9	95	74	72.5	125	104	95.1	164	143
10	0.1667	0	35	43.9	126	91	57.7	166	131	74.9	215	180
15	0.25	0	53	35.9	155	102	47.0	203	150	60.5	261	208
20	0.3333	0	70	30.8	177	106	40.2	231	161	51.3	295	225
30	0.5	0	106	24.4	210	105	31.7	273	168	40.1	346	240
45	0.75	0	158	19.0	246	88	24.6	319	160	30.8	399	241
	1	0	211	15.9	274	62	20.5	353	142	25.4	438	227
	1.5	0	317	12.3	318	1	15.8	410	93	19.6	506	189
	2	0	423	10.2	353	-	13.1	453	31	16.2	559	136
	3	0	634	7.9	406	-	10.1	522	-	12.4	641	7
	4	0	845	6.5	449	-	8.3	576	-	10.2	705	-
	6	0	1268	5.0	517	-	6.4	662	-	7.8	807	-
	9	0	1902	3.8	596	-	4.9	762	-	6.0	925	-
	12	0	2536	3.2	660	-	4.1	842	-	4.9	1019	-
	15	0	3170	2.8	717	-	3.5	916	-	4.3	1111	-
	18	0	3804	2.5	767	-	3.2	980	-	3.8	1191	-
	24	0	5072	2.1	852	-	2.6	1090	-	3.2	1328	-
	30	0	6339	1.8	921	-	2.3	1180	-	2.8	1440	-
	36	0	7607	1.6	980	-	2.0	1256	-	2.5	1535	-
	42	0	8875	1.4	1030	-	1.8	1321	-	2.2	1617	-
	48	0	10143	1.3	1073	-	1.7	1376	-	2.0	1688	-
	60	0	12679	1.1	1143	-	1.4	1467	-	1.7	1803	-
	72	0	15215	1.0	1195	-	1.2	1536	-	1.5	1891	-
Storage Required (m3)						**106** ✓			**168** ✓			**241** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 31**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4414**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**9783**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	24.5	ha
Impervious Factor	1	245200	m2

Impervious Area: **7.36** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area **1828** for a max depth of 0.3m
0.10 Side Slopes of Sump (ha)
1 yr **0.29** ha Total Sump Area
60.3 Diameter

10yr Sump Area **4012** for a max depth of 1.1m
0.15 Side Slopes of Sump (ha)
10 yr **0.55** ha Total Sump Area
83.9 Diameter

100yr Sump Area **7827** for a max depth of 1.25m
0.21 Side Slopes of Sump (ha)
100 yr **1.00** ha Total Sump Area
112.6 Diameter

			Stroage Volume Required	
Volume (m3)	**7827**	m3	**1179 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**5532.6**	m2	**837 m³ = 100% of 1 in 2**	✓
Min Area Required	*1839*	m2	**548 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	70	54.9	404	334	72.5	533	463	95.1	699	630
10	0.1667	0	116	43.9	538	422	57.7	707	591	74.9	918	802
15	0.25	0	174	35.9	660	486	47.0	864	690	60.5	1112	938
20	0.3333	0	232	30.8	754	522	40.2	985	753	51.3	1259	1027
30	0.5	0	349	24.4	897	548	31.7	1166	818	40.1	1475	1127
45	0.75	0	523	19.0	1051	528	24.6	1360	837	30.8	1702	1179
	1	0	697	15.9	1167	470	20.5	1505	808	25.4	1869	1171
	1.5	0	1046	12.3	1356	311	15.8	1746	701	19.6	2160	1114
	2	0	1394	10.2	1503	109	13.1	1933	539	16.2	2384	990
	3	0	2091	7.9	1733	-	10.1	2225	133	12.4	2732	641
	4	0	2788	6.5	1915	-	8.3	2456	-	10.2	3007	219
	6	0	4183	5.0	2205	-	6.4	2823	-	7.8	3443	-
	9	0	6274	3.8	2542	-	4.9	3248	-	6.0	3945	-
	12	0	8365	3.2	2812	-	4.1	3589	-	4.9	4347	-
	15	0	10457	2.8	3057	-	3.5	3904	-	4.3	4738	-
	18	0	12548	2.5	3271	-	3.2	4180	-	3.8	5081	-
	24	0	16731	2.1	3632	-	2.6	4647	-	3.2	5662	-
	30	0	20913	1.8	3929	-	2.3	5031	-	2.8	6142	-
	36	0	25096	1.6	4179	-	2.0	5355	-	2.5	6548	-
	42	0	29279	1.4	4392	-	1.8	5631	-	2.2	6896	-
	48	0	33461	1.3	4576	-	1.7	5870	-	2.0	7196	-
	60	0	41826	1.1	4872	-	1.4	6256	-	1.7	7687	-
	72	0	50192	1.0	5097	-	1.2	6550	-	1.5	8063	-
Storage Required (m3)						**548** ✓			**837** ✓			**1179** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 32**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2277**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**5047**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	12.7	ha
Impervious Factor	1	126500	m2
Impervious Area:	**3.80**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
Base			
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area	**879**	for a max depth of 0.3m				
	0.07	Side Slopes of Sump (ha)				
1 yr	**0.16**	ha	Total Sump Area			
	45.0	Diameter				
10yr Sump Area	**2070**	for a max depth of 1.1m	100yr Sump Area	**4038**	for a max depth of 1.25m	
	0.11	Side Slopes of Sump (ha)		**0.15**	Side Slopes of Sump (ha)	
10 yr	**0.32**	ha	Total Sump Area	100 yr	**0.56**	ha Total Sump Area
	63.4	Diameter			**84.2**	Diameter

			Stroage Volume Required	
Volume (m3)	**4038**	m3	**579 m³ = 100% of 1 in 5**	✓
Surface Area Base:	**3161.9**	m2	**403 m³ = 100% of 1 in 2**	✓
Min Area Required	*948.75*	m2	**264 m³ = 100% of 1 in 1**	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	40	54.9	208	169	72.5	275	235	95.1	361	321
10	0.1667	0	66	43.9	277	211	57.7	365	298	74.9	474	407
15	0.25	0	100	35.9	340	241	47.0	446	346	60.5	574	474
20	0.3333	0	133	30.8	389	256	40.2	508	375	51.3	649	517
30	0.5	0	199	24.4	463	264	31.7	602	402	40.1	761	562
45	0.75	0	299	19.0	542	243	24.6	702	403	30.8	878	579
	1	0	398	15.9	602	204	20.5	777	378	25.4	964	566
	1.5	0	598	12.3	700	102	15.8	901	303	19.6	1114	517
	2	0	797	10.2	776	-	13.1	997	201	16.2	1230	433
	3	0	1195	7.9	894	-	10.1	1148	-	12.4	1410	214
	4	0	1594	6.5	988	-	8.3	1267	-	10.2	1551	-
	6	0	2390	5.0	1138	-	6.4	1456	-	7.8	1776	-
	9	0	3586	3.8	1311	-	4.9	1676	-	6.0	2035	-
	12	0	4781	3.2	1451	-	4.1	1852	-	4.9	2243	-
	15	0	5976	2.8	1577	-	3.5	2014	-	4.3	2444	-
	18	0	7171	2.5	1687	-	3.2	2157	-	3.8	2621	-
	24	0	9562	2.1	1874	-	2.6	2397	-	3.2	2921	-
	30	0	11952	1.8	2027	-	2.3	2596	-	2.8	3169	-
	36	0	14343	1.6	2156	-	2.0	2763	-	2.5	3378	-
	42	0	16733	1.4	2266	-	1.8	2905	-	2.2	3557	-
	48	0	19123	1.3	2361	-	1.7	3028	-	2.0	3713	-
	60	0	23904	1.1	2514	-	1.4	3228	-	1.7	3966	-
	72	0	28685	1.0	2630	-	1.2	3379	-	1.5	4160	-
Storage Required (m3)						**264** ✓			**403** ✓			**579** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 33**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2997**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**6643**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	16.7	ha
Impervious Factor	1	166500	m2
Impervious Area:	**5.00** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1195**	for a max depth of 0.3m				
	0.08	Side Slopes of Sump (ha)				
1 yr	**0.20**	ha	Total Sump Area			
	50.8	Diameter				
10yr Sump Area	**2725**	for a max depth of 1.1m		100yr Sump Area	**5315**	for a max depth of 1.25m
	0.13	Side Slopes of Sump (ha)			**0.17**	Side Slopes of Sump (ha)
10 yr	**0.40**	ha	Total Sump Area	100 yr	**0.71**	ha Total Sump Area
	71.2	Diameter			**94.8**	Diameter

			Stroage Volume Required	
Volume (m3)	**5315**	m3	**780**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**3977.3**	m2	**548**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1248.75*	m2	**359**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	50	54.9	274	224	72.5	362	312	95.1	475	425
10	0.1667	0	84	43.9	365	282	57.7	480	396	74.9	623	540
15	0.25	0	125	35.9	448	323	47.0	587	462	60.5	755	630
20	0.3333	0	167	30.8	512	345	40.2	669	502	51.3	855	688
30	0.5	0	251	24.4	609	359	31.7	792	541	40.1	1002	751
45	0.75	0	376	19.0	714	338	24.6	923	548	30.8	1156	780
	1	0	501	15.9	792	291	20.5	1022	521	25.4	1269	768
	1.5	0	752	12.3	921	169	15.8	1186	434	19.6	1466	715
	2	0	1002	10.2	1021	19	13.1	1313	311	16.2	1619	617
	3	0	1503	7.9	1177	-	10.1	1511	7	12.4	1855	352
	4	0	2005	6.5	1301	-	8.3	1667	-	10.2	2042	37
	6	0	3007	5.0	1498	-	6.4	1917	-	7.8	2338	-
	9	0	4510	3.8	1726	-	4.9	2205	-	6.0	2679	-
	12	0	6014	3.2	1910	-	4.1	2437	-	4.9	2952	-
	15	0	7517	2.8	2076	-	3.5	2651	-	4.3	3217	-
	18	0	9020	2.5	2221	-	3.2	2839	-	3.8	3450	-
	24	0	12027	2.1	2466	-	2.6	3155	-	3.2	3845	-
	30	0	15034	1.8	2668	-	2.3	3416	-	2.8	4171	-
	36	0	18041	1.6	2838	-	2.0	3636	-	2.5	4446	-
	42	0	21048	1.4	2982	-	1.8	3824	-	2.2	4682	-
	48	0	24055	1.3	3107	-	1.7	3986	-	2.0	4887	-
	60	0	30068	1.1	3309	-	1.4	4248	-	1.7	5220	-
	72	0	36082	1.0	3461	-	1.2	4448	-	1.5	5475	-
Storage Required (m3)						**359** ✓			**548** ✓			**780** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN
TASK CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 34

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**2763**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**6125**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area	
Drainage Catchment Factor	0.3		15.4	ha
Impervious Factor	1		153500	m2
Impervious Area:	**4.61**	ha		
Pipe Outflow Rate:	**0.000**	m3/sec		
	Base			
Infiltration Rate:	**0.035**	L/sec/m2		
	3.50E-05	m3/sec/m2		
	3.024	m/day		

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area: **1092** for a max depth of 0.3m
0.08 Side Slopes of Sump (ha)
1 yr: **0.19** ha Total Sump Area
49.0 Diameter

10yr Sump Area: **2512** for a max depth of 1.1m
0.12 Side Slopes of Sump (ha)
10 yr: **0.37** ha Total Sump Area
68.8 Diameter

100yr Sump Area: **4900** for a max depth of 1.25m
0.17 Side Slopes of Sump (ha)
100 yr: **0.66** ha Total Sump Area
91.5 Diameter

			Stroage Volume Required	
Volume (m3)	**4900**	m3	**714**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**3714.7**	m2	**500**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1151.25*	m2	**328**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	47	54.9	253	206	72.5	334	287	95.1	438	391
10	0.1667	0	78	43.9	337	259	57.7	443	365	74.9	575	497
15	0.25	0	117	35.9	413	296	47.0	541	424	60.5	696	579
20	0.3333	0	156	30.8	472	316	40.2	617	461	51.3	788	632
30	0.5	0	234	24.4	562	328	31.7	730	496	40.1	924	690
45	0.75	0	351	19.0	658	307	24.6	851	500	30.8	1065	714
	1	0	468	15.9	731	263	20.5	942	474	25.4	1170	702
	1.5	0	702	12.3	849	147	15.8	1093	391	19.6	1352	650
	2	0	936	10.2	941	5	13.1	1210	274	16.2	1492	556
	3	0	1404	7.9	1085	-	10.1	1393	-	12.4	1710	306
	4	0	1872	6.5	1199	-	8.3	1537	-	10.2	1883	10
	6	0	2808	5.0	1381	-	6.4	1767	-	7.8	2155	-
	9	0	4212	3.8	1591	-	4.9	2033	-	6.0	2470	-
	12	0	5617	3.2	1761	-	4.1	2247	-	4.9	2722	-
	15	0	7021	2.8	1914	-	3.5	2444	-	4.3	2966	-
	18	0	8425	2.5	2048	-	3.2	2617	-	3.8	3181	-
	24	0	11233	2.1	2274	-	2.6	2909	-	3.2	3544	-
	30	0	14041	1.8	2460	-	2.3	3150	-	2.8	3845	-
	36	0	16850	1.6	2616	-	2.0	3352	-	2.5	4099	-
	42	0	19658	1.4	2750	-	1.8	3525	-	2.2	4317	-
	48	0	22466	1.3	2864	-	1.7	3675	-	2.0	4505	-
	60	0	28083	1.1	3050	-	1.4	3917	-	1.7	4812	-
	72	0	33699	1.0	3191	-	1.2	4100	-	1.5	5047	-
Storage Required (m3)						**328** ✓			**500** ✓			**714** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 35**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**576**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**1277**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

Drainage Catchment Factor	0.3	**Catchment Area**	
Impervious Factor	1	3.2	ha
		32000	m2
Impervious Area:	**0.96**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**178**	for a max depth of 0.3m				
	0.03	Side Slopes of Sump (ha)				
1 yr	**0.05**	ha	Total Sump Area			
	25.2	Diameter				
10yr Sump Area	**524**	for a max depth of 1.1m	100yr Sump Area	**1021**	for a max depth of 1.25m	
	0.05	Side Slopes of Sump (ha)		**0.08**	Side Slopes of Sump (ha)	
10 yr	**0.11**	ha	Total Sump Area	100 yr	**0.18**	ha Total Sump Area
	37.0	Diameter			**47.7**	Diameter

		Stroage Volume Required	
Volume (m3)	**1021** m3	**125** m³ = 100% of 1 in 5	✓
Surface Area Base:	**1072.8** m2	**85** m³ = 100% of 1 in 2	✓
Min Area Required	*240* m2	**53** m³ = 100% of 1 in 1	✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	14	54.9	53	39	72.5	70	56	95.1	91	78
10	0.1667	0	23	43.9	70	48	57.7	92	70	74.9	120	97
15	0.25	0	34	35.9	86	52	47.0	113	79	60.5	145	111
20	0.3333	0	45	30.8	98	53	40.2	129	83	51.3	164	119
30	0.5	0	68	24.4	117	49	31.7	152	85	40.1	193	125
45	0.75	0	101	19.0	137	36	24.6	177	76	30.8	222	121
	1	0	135	15.9	152	17	20.5	196	61	25.4	244	109
	1.5	0	203	12.3	177	-	15.8	228	25	19.6	282	79
	2	0	270	10.2	196	-	13.1	252	-	16.2	311	41
	3	0	406	7.9	226	-	10.1	290	-	12.4	357	-
	4	0	541	6.5	250	-	8.3	320	-	10.2	392	-
	6	0	811	5.0	288	-	6.4	368	-	7.8	449	-
	9	0	1217	3.8	332	-	4.9	424	-	6.0	515	-
	12	0	1622	3.2	367	-	4.1	468	-	4.9	567	-
	15	0	2028	2.8	399	-	3.5	510	-	4.3	618	-
	18	0	2433	2.5	427	-	3.2	546	-	3.8	663	-
	24	0	3244	2.1	474	-	2.6	606	-	3.2	739	-
	30	0	4055	1.8	513	-	2.3	657	-	2.8	802	-
	36	0	4866	1.6	545	-	2.0	699	-	2.5	855	-
	42	0	5677	1.4	573	-	1.8	735	-	2.2	900	-
	48	0	6488	1.3	597	-	1.7	766	-	2.0	939	-
	60	0	8111	1.1	636	-	1.4	816	-	1.7	1003	-
	72	0	9733	1.0	665	-	1.2	855	-	1.5	1052	-
Storage Required (m3)						**53** ✓			**85** ✓			**125** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 36**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**423**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**938**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	2.4	ha
Impervious Factor	1	23500	m2
Impervious Area:	**0.71**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**121**	for a max depth of 0.3m				
	0.03	Side Slopes of Sump (ha)				
1 yr	**0.04**	ha	Total Sump Area			
	22.2	Diameter				
10yr Sump Area	**385**	for a max depth of 1.1m		100yr Sump Area	**750**	for a max depth of 1.25m
	0.05	Side Slopes of Sump (ha)			**0.07**	Side Slopes of Sump (ha)
10 yr	**0.09**	ha	Total Sump Area	100 yr	**0.14**	ha Total Sump Area
	33.0	Diameter			**42.3**	Diameter

			Stroage Volume Required	
Volume (m3)	**750**	m3	**88**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**855.18**	m2	**58**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*176.25*	m2	**36**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	11	54.9	39	28	72.5	51	40	95.1	67	56
10	0.1667	0	18	43.9	52	34	57.7	68	50	74.9	88	70
15	0.25	0	27	35.9	63	36	47.0	83	56	60.5	107	80
20	0.3333	0	36	30.8	72	36	40.2	94	58	51.3	121	85
30	0.5	0	54	24.4	86	32	31.7	112	58	40.1	141	88
45	0.75	0	81	19.0	101	20	24.6	130	50	30.8	163	82
	1	0	108	15.9	112	4	20.5	144	37	25.4	179	71
	1.5	0	162	12.3	130	-	15.8	167	6	19.6	207	45
	2	0	216	10.2	144	-	13.1	185	-	16.2	228	13
	3	0	323	7.9	166	-	10.1	213	-	12.4	262	-
	4	0	431	6.5	184	-	8.3	235	-	10.2	288	-
	6	0	647	5.0	211	-	6.4	271	-	7.8	330	-
	9	0	970	3.8	244	-	4.9	311	-	6.0	378	-
	12	0	1293	3.2	270	-	4.1	344	-	4.9	417	-
	15	0	1616	2.8	293	-	3.5	374	-	4.3	454	-
	18	0	1940	2.5	313	-	3.2	401	-	3.8	487	-
	24	0	2586	2.1	348	-	2.6	445	-	3.2	543	-
	30	0	3233	1.8	377	-	2.3	482	-	2.8	589	-
	36	0	3879	1.6	401	-	2.0	513	-	2.5	628	-
	42	0	4526	1.4	421	-	1.8	540	-	2.2	661	-
	48	0	5172	1.3	439	-	1.7	563	-	2.0	690	-
	60	0	6465	1.1	467	-	1.4	600	-	1.7	737	-
	72	0	7758	1.0	488	-	1.2	628	-	1.5	773	-
Storage Required (m3)						**36** ✓			**58** ✓			**88** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 37**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1071**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**2374**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	6.0	ha
Impervious Factor	1	59500	m2
Impervious Area:	**1.79** ha		
Pipe Outflow Rate:	**0.000** m3/sec		
	Base		
Infiltration Rate:	**0.035** L/sec/m2		
	3.50E-05 m3/sec/m2		
	3.024 m/day		
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**369**	for a max depth of 0.3m				
	0.05	Side Slopes of Sump (ha)				
1 yr	**0.08**	ha	Total Sump Area			
	32.5	Diameter				
10yr Sump Area	**974**	for a max depth of 1.1m		100yr Sump Area	**1899**	for a max depth of 1.25m
	0.07	Side Slopes of Sump (ha)			**0.10**	Side Slopes of Sump (ha)
10 yr	**0.17**	ha	Total Sump Area	100 yr	**0.29**	ha Total Sump Area
	46.8	Diameter			**61.2**	Diameter

			Stroage Volume Required	
Volume (m3)	**1899**	m3	**250**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**1722.5**	m2	**174**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*446.25*	m2	**111**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	22	54.9	98	76	72.5	129	108	95.1	170	148
10	0.1667	0	36	43.9	131	94	57.7	172	135	74.9	223	187
15	0.25	0	54	35.9	160	106	47.0	210	155	60.5	270	216
20	0.3333	0	72	30.8	183	111	40.2	239	167	51.3	305	233
30	0.5	0	109	24.4	218	109	31.7	283	174	40.1	358	250
45	0.75	0	163	19.0	255	92	24.6	330	167	30.8	413	250
	1	0	217	15.9	283	66	20.5	365	148	25.4	453	236
	1.5	0	326	12.3	329	4	15.8	424	98	19.6	524	198
	2	0	434	10.2	365	-	13.1	469	35	16.2	579	144
	3	0	651	7.9	421	-	10.1	540	-	12.4	663	12
	4	0	868	6.5	465	-	8.3	596	-	10.2	730	-
	6	0	1302	5.0	535	-	6.4	685	-	7.8	835	-
	9	0	1953	3.8	617	-	4.9	788	-	6.0	957	-
	12	0	2604	3.2	682	-	4.1	871	-	4.9	1055	-
	15	0	3256	2.8	742	-	3.5	947	-	4.3	1150	-
	18	0	3907	2.5	794	-	3.2	1014	-	3.8	1233	-
	24	0	5209	2.1	881	-	2.6	1128	-	3.2	1374	-
	30	0	6511	1.8	953	-	2.3	1221	-	2.8	1490	-
	36	0	7813	1.6	1014	-	2.0	1299	-	2.5	1589	-
	42	0	9116	1.4	1066	-	1.8	1366	-	2.2	1673	-
	48	0	10418	1.3	1110	-	1.7	1424	-	2.0	1746	-
	60	0	13022	1.1	1182	-	1.4	1518	-	1.7	1865	-
	72	0	15627	1.0	1237	-	1.2	1589	-	1.5	1957	-
Storage Required (m3)						**111** ✓			**174** ✓			**250** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 38**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**1782**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**3950**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

			Catchment Area	
Drainage Catchment Factor	0.3		9.9	ha
Impervious Factor	1		99000	m2
Impervious Area:	**2.97**	ha		
Pipe Outflow Rate:	**0.000**	m3/sec		
	Base			
Infiltration Rate:	**0.035**	L/sec/m2		
	3.50E-05	m3/sec/m2		
	3.024	m/day		
Rainfall Station used:	**Wanneroo**			

Basin Details

1yr Sump Area	**664**	for a max depth of 0.3m					
	0.06	Side Slopes of Sump (ha)					
1 yr	**0.13**	ha	Total Sump Area				
	40.4	Diameter					
10yr Sump Area	**1620**	for a max depth of 1.1m		100yr Sump Area	**3160**	for a max depth of 1.25m	
	0.10	Side Slopes of Sump (ha)			**0.13**	Side Slopes of Sump (ha)	
10 yr	**0.26**	ha	Total Sump Area	100 yr	**0.45**	ha	Total Sump Area
	57.4	Diameter			**75.8**	Diameter	

			Stroage Volume Required	
Volume (m3)	**3160**	m3	**443**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**2586**	m2	**308**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*742.5*	m2	**199**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	33	54.9	163	131	72.5	215	183	95.1	282	250
10	0.1667	0	54	43.9	217	163	57.7	285	231	74.9	371	316
15	0.25	0	81	35.9	266	185	47.0	349	267	60.5	449	368
20	0.3333	0	109	30.8	305	196	40.2	398	289	51.3	508	400
30	0.5	0	163	24.4	362	199	31.7	471	308	40.1	596	433
45	0.75	0	244	19.0	424	180	24.6	549	305	30.8	687	443
	1	0	326	15.9	471	145	20.5	608	282	25.4	754	429
	1.5	0	489	12.3	548	59	15.8	705	216	19.6	872	383
	2	0	652	10.2	607	-	13.1	781	129	16.2	963	311
	3	0	978	7.9	700	-	10.1	898	-	12.4	1103	126
	4	0	1303	6.5	773	-	8.3	991	-	10.2	1214	-
	6	0	1955	5.0	890	-	6.4	1140	-	7.8	1390	-
	9	0	2933	3.8	1026	-	4.9	1311	-	6.0	1593	-
	12	0	3910	3.2	1136	-	4.1	1449	-	4.9	1755	-
	15	0	4888	2.8	1234	-	3.5	1576	-	4.3	1913	-
	18	0	5865	2.5	1321	-	3.2	1688	-	3.8	2051	-
	24	0	7820	2.1	1466	-	2.6	1876	-	3.2	2286	-
	30	0	9775	1.8	1586	-	2.3	2031	-	2.8	2480	-
	36	0	11730	1.6	1687	-	2.0	2162	-	2.5	2644	-
	42	0	13685	1.4	1773	-	1.8	2274	-	2.2	2784	-
	48	0	15640	1.3	1847	-	1.7	2370	-	2.0	2906	-
	60	0	19550	1.1	1967	-	1.4	2526	-	1.7	3104	-
	72	0	23460	1.0	2058	-	1.2	2645	-	1.5	3255	-
Storage Required (m3)						**199** ✓			**308** ✓			**443** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 39**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**3753**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**8319**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	20.9	ha
Impervious Factor	1	208500	m2

Impervious Area: **6.26** ha

Pipe Outflow Rate: **0.000** m3/sec

Base

Infiltration Rate: **0.035** L/sec/m2
3.50E-05 m3/sec/m2
3.024 m/day

Rainfall Station used: **Wanneroo**

Basin Details

1yr Sump Area **1532** for a max depth of 0.3m
0.09 Side Slopes of Sump (ha)
1 yr **0.25** ha Total Sump Area
56.1 Diameter

10yr Sump Area **3412** for a max depth of 1.1m
0.14 Side Slopes of Sump (ha)
10 yr **0.48** ha Total Sump Area
78.3 Diameter

100yr Sump Area **6655** for a max depth of 1.25m
0.20 Side Slopes of Sump (ha)
100 yr **0.86** ha Total Sump Area
104.7 Diameter

			Stroage Volume Required	
Volume (m3)	**6655**	m3	**992**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**4813.7**	m2	**701**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1563.75*	m2	**459**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	61	54.9	343	283	72.5	453	393	95.1	595	534
10	0.1667	0	101	43.9	457	356	57.7	601	500	74.9	780	679
15	0.25	0	152	35.9	561	410	47.0	735	583	60.5	946	794
20	0.3333	0	202	30.8	641	439	40.2	837	635	51.3	1070	868
30	0.5	0	303	24.4	763	459	31.7	992	688	40.1	1255	951
45	0.75	0	455	19.0	894	439	24.6	1156	701	30.8	1447	992
	1	0	607	15.9	992	386	20.5	1280	673	25.4	1589	982
	1.5	0	910	12.3	1153	244	15.8	1485	575	19.6	1836	927
	2	0	1213	10.2	1278	65	13.1	1644	431	16.2	2027	814
	3	0	1820	7.9	1474	-	10.1	1892	72	12.4	2323	504
	4	0	2426	6.5	1629	-	8.3	2088	-	10.2	2557	131
	6	0	3639	5.0	1875	-	6.4	2400	-	7.8	2928	-
	9	0	5459	3.8	2161	-	4.9	2762	-	6.0	3355	-
	12	0	7278	3.2	2391	-	4.1	3052	-	4.9	3697	-
	15	0	9098	2.8	2599	-	3.5	3320	-	4.3	4029	-
	18	0	10917	2.5	2781	-	3.2	3555	-	3.8	4320	-
	24	0	14557	2.1	3088	-	2.6	3951	-	3.2	4814	-
	30	0	18196	1.8	3341	-	2.3	4278	-	2.8	5223	-
	36	0	21835	1.6	3553	-	2.0	4553	-	2.5	5568	-
	42	0	25474	1.4	3735	-	1.8	4788	-	2.2	5863	-
	48	0	29113	1.3	3891	-	1.7	4991	-	2.0	6119	-
	60	0	36391	1.1	4143	-	1.4	5320	-	1.7	6537	-
	72	0	43670	1.0	4334	-	1.2	5570	-	1.5	6856	-
Storage Required (m3)						**459** ✓			**701** ✓			**992** ✓

Serling Consulting (WA) Pty Ltd

Calculation Record

Job Number: SC00101.001
Prepared by: Peter Alebakis
Date: 8/07/2010

JOB	**ST ANDREWS CITY CENTRE LOCAL STRUCTURE PLAN**
TASK	**CONCEPT DRAINAGE STRATEGY CALCULATIONS - AREA 40**

Determine Sump Size based on various times and recurrence intervals allowing:

- l total catchment (impervious area)
- l outflow through outlet pipe
- l outflow from infiltration

Calculations As per City of Wanneroo Requirments

10 yr Storage Required	**4140**	600	per Imp Ha (10yr Event 10hr storm)
100 yr Storage Required	**9177**	1330	per Imp Ha (100yr Event 10hr storm)

Note: Refer attached sheet for IFD data and calculation notes.

Catchment Details

		Catchment Area	
Drainage Catchment Factor	0.3	23.0	ha
Impervious Factor	1	230000	m2
Impervious Area:	**6.90**	ha	
Pipe Outflow Rate:	**0.000**	m3/sec	
	Base		
Infiltration Rate:	**0.035**	L/sec/m2	
	3.50E-05	m3/sec/m2	
	3.024	m/day	
Rainfall Station used:	**Wanneroo**		

Basin Details

1yr Sump Area	**1705**	for a max depth of 0.3m				
	0.10	Side Slopes of Sump (ha)				
1 yr	**0.27**	ha	Total Sump Area			
	58.6	Diameter				
10yr Sump Area	**3764**	for a max depth of 1.1m	100yr Sump Area	**7342**	for a max depth of 1.25m	
	0.15	Side Slopes of Sump (ha)		**0.21**	Side Slopes of Sump (ha)	
10 yr	**0.52**	ha	Total Sump Area	100 yr	**0.94**	ha Total Sump Area
	81.6	Diameter			**109.4**	Diameter

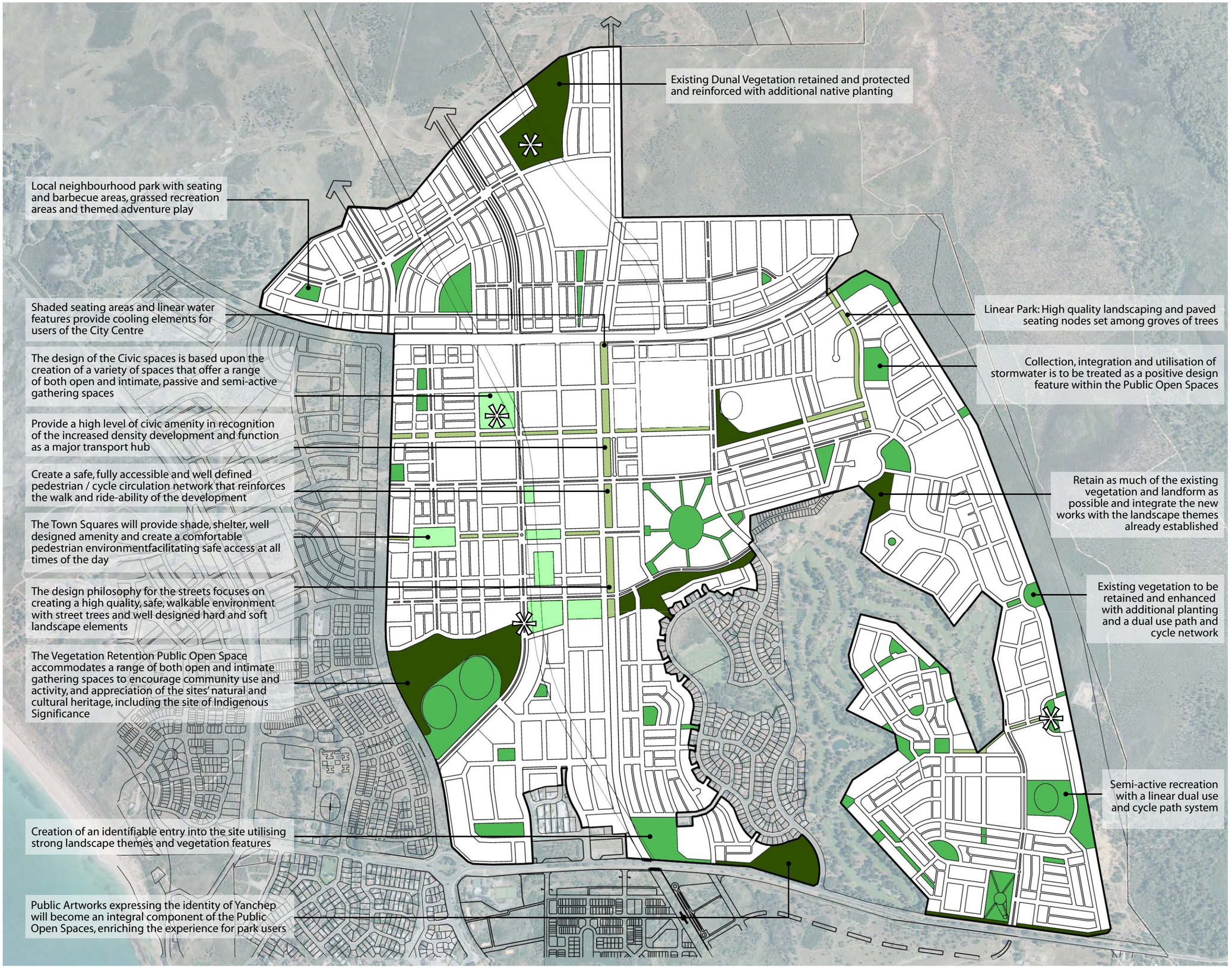
			Stroage Volume Required	
Volume (m3)	**7342**	m3	**1102**	**m³ = 100% of 1 in 5** ✓
Surface Area Base:	**5236**	m2	**781**	**m³ = 100% of 1 in 2** ✓
Min Area Required	*1725*	m2	**512**	**m³ = 100% of 1 in 1** ✓

Calculation Table

TIME		OUTFLOW		1 in 1			1 in 2			1 in 5		
min	hr	Piped	Soak	I	Vol	Net	I	Vol	Net	I	Vol	Net
6	0.1	0	66	54.9	379	313	72.5	500	434	95.1	656	590
10	0.1667	0	110	43.9	504	394	57.7	663	553	74.9	861	751
15	0.25	0	165	35.9	619	454	47.0	811	646	60.5	1043	878
20	0.3333	0	220	30.8	708	488	40.2	924	704	51.3	1181	961
30	0.5	0	330	24.4	841	512	31.7	1094	764	40.1	1384	1054
45	0.75	0	495	19.0	986	491	24.6	1276	781	30.8	1596	1102
	1	0	660	15.9	1095	435	20.5	1412	752	25.4	1753	1093
	1.5	0	990	12.3	1272	283	15.8	1638	649	19.6	2026	1036
	2	0	1319	10.2	1410	91	13.1	1814	494	16.2	2236	917
	3	0	1979	7.9	1626	-	10.1	2087	108	12.4	2563	584
	4	0	2639	6.5	1796	-	8.3	2303	-	10.2	2821	182
	6	0	3958	5.0	2069	-	6.4	2648	-	7.8	3229	-
	9	0	5938	3.8	2384	-	4.9	3047	-	6.0	3701	-
	12	0	7917	3.2	2638	-	4.1	3367	-	4.9	4078	-
	15	0	9896	2.8	2867	-	3.5	3662	-	4.3	4444	-
	18	0	11875	2.5	3068	-	3.2	3921	-	3.8	4766	-
	24	0	15834	2.1	3407	-	2.6	4359	-	3.2	5311	-
	30	0	19792	1.8	3686	-	2.3	4719	-	2.8	5761	-
	36	0	23750	1.6	3920	-	2.0	5023	-	2.5	6142	-
	42	0	27709	1.4	4120	-	1.8	5282	-	2.2	6468	-
	48	0	31667	1.3	4292	-	1.7	5506	-	2.0	6750	-
	60	0	39584	1.1	4570	-	1.4	5868	-	1.7	7211	-
	72	0	47501	1.0	4781	-	1.2	6144	-	1.5	7563	-
Storage Required (m3)						**512** ✓			**781** ✓			**1102** ✓

Appendix G
Landscape Master Plan Concept

Yanchep City Structure Plan
Local Water Management Strategy



LEGEND
PUBLIC OPEN SPACE TYPES

LANDFORM AND VEGETATION RETENTION - 20.29ha
Passive and semi-active recreation facilities
Duel use and cycle path network
Existing vegetation retained and enhanced with additional native planting
Interpretation and information signs
Integrated public artwork

NEIGHBOURHOOD AND TOWN PARKS - 35.61ha
Passive and semi-active recreation facilities
Barbecue/picnic/play facilities (themed adventure playground)
Duel use and cycle path networks
Shelters/pavilions/shade structures
Naturalistic drainage systems
Combination of formal and informal tree and shrub planting

LINEAR PARKS AND BOULEVARDS - 3.39ha
Formal landscaping, combination of hard and soft landscape elements
Avenues/grids of tree planting
High quality visual landscape
Built forms – seating, seating walls, steps
Lighting, water features

TOWN SQUARES AND CIVIC SPACES - 5.40ha
High quality hard landscape and urban forms
Broad range of hard landscape elements, paving and material types
Creation of flexible spaces to accommodate performances, gatherings and community events
Lighting, water features, seating
Sculptural and integrated public artworks

Total POS - 64.66ha

SEE CONCEPT DESIGN (Figs 26 - 29)

YANCHEP CITY STUCTURE PLAN
LANDSCAPING CONCEPT PLAN

figure **25**

client - Yanchep Beach Joint Venture
date - July 2009
source - Plan E

Yanchep beach joint venture

Timber viewing deck and boardwalk structure provides access across the ridge-line, with the viewing deck situated at the highest point providing panoramic views of the site and ocean, and a focal element within the landscape.

The Site of Indigenous Significance is the focal element of the linear 'green spine' open space and contains existing avenues of mature Tuart trees and significant indigenous vegetation. Significant Site to be revegetated with indigenous plant species and protected with dog-proof fencing.

A central pavilion structure sits within the formal park space framed by arbors and avenues of trees, providing a variety of semi-private seating areas for passive recreation.

Central lawn area protected from prevailing winds and framed by avenues of trees, provides a flexible gathering and community space adjacent the Tafe education facility.

Grassed areas for semi-active and passive recreation located along dual use path cycle network.

Informal grass and seating areas adjacent dual use path provide areas for respite and use by workers and residents of the City Centre.

Retained dunal vegetation and site character.

AQUATIC CENTRE

TAFE

Open lawn area with meandering dual use path connects the Primary School with the 'Ridge-top' linear park.

Adventure Play and picnic facilities in close proximity to Primary School, set within an open lawn area and avenues of shade trees.

PRIMARY SCHOOL

Grassed amphitheatre / viewing facility adjacent Aquatic Centre.

Informal turf recreation areas with Adventure play, shade and picnic facilities in close proximity to parking and visible from the road.

Existing site vegetation and landform retained and enhanced with additional native planting and controlled public access.

Meandering dual use cycle paths and interpretive signs provide enjoyment and education to the site.

Recreation precinct containing clubrooms, tennis courts, viewing pavilions, picnic and barbecue facilities and ample parking, highly visible from the main road for passive surveillance to encourage high levels of recreation and activity.

Shelters set among groves of native trees provide picnic and recreation facilities in close proximity to active recreation areas.

Avenues of native trees line the boulevards and identify the main roads leading into the City Centre.

YANCHEP CITY STUCTURE PLAN

LINEAR GREEN SPINE PUBLIC OPEN SPACE - LANDSCAPE MASTERPLAN CONCEPT

client - Yanchep Beach Joint Venture

date - July 2009

source - Plan 9

Yanchep beach joint venture

Very good quality Banksia - covered hillock retained, with ramp and stair infastructure located on the eastern side of the hill to minimise disruption to the existing Banksia vegetation.

Good quality Banksia woodland retained and enhanced with additional native planting to the perimeter

Open lawn area for passive and semi-active recreation, stormwater drainage fronting onto adjacent residential and commercial

Central informal play space and picnic nodes located beneath grove of feature trees

Dual use and cycle path located to the perimeter of the POS site to minimise impact on good quality landform and Banksksia vegetation

Significant high point retained with a lookout located at the highest point of the POS - views north and west towards ocean, east towards the Bush Forever site and south over the Yanchep Beach development

Informal play space, shelter, picnic facilities and feature trees at termination of view corridor

Extensive dual use and cycle path network to perimeter of Public Open Space

Information and interpretation signs to existing retained vegetation

Informal crushed limestone walk trails through Banksia woodland with protective fencing and interpretive signs

Good quality Banksia attenuata woodland retained (protective and dog - proof fence to perimeter)

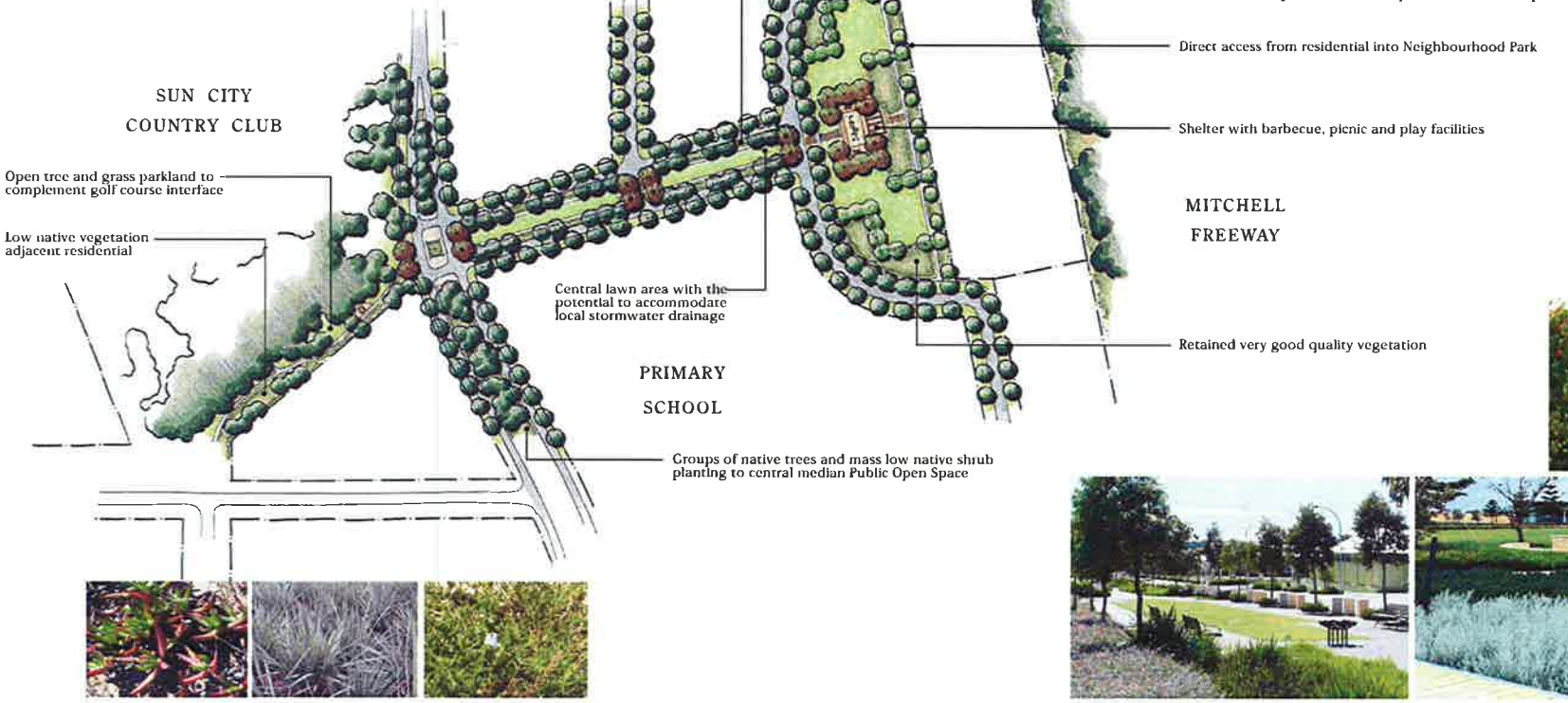
High level of connectivity to south east corner between the Public Open Space and the adjacent High School facility

YANCHEP CITY STRUCTURE PLAN

LANDFORM RETENTION AND CONSERVATION POS

client - Yanchep Beach Joint Venture
date - July 2009
source - Plan 9

Yanchep beach joint venture


Dual use and cycle path access to perimeter of Neighbourhood Park
Formal native planting to perimeter of linear Public Open Space
Revegetated Mitchell Freeway reserve
Small pocket park with seating node revegetated with Dryandra and Banksia species
Small pockets of good quality Dryandra / Calothamnus vegetation retained where possible and incorporated into formal park design
Direct access from residential into Neighbourhood Park
Shelter with barbecue, picnic and play facilities
SUN CITY COUNTRY CLUB
Open tree and grass parkland to complement golf course interface
Low native vegetation adjacent residential
MITCHELL FREEWAY
Central lawn area with the potential to accommodate local stormwater drainage
Retained very good quality vegetation
PRIMARY SCHOOL
Groups of native trees and mass low native shrub planting to central median Public Open Space

Adventure Play with picnic and barbecue facilities. Good visibility into this space will be maintained.

Retention of existing Tuart and Indigenous trees supplemented by groves of additional native tree planting.

Defined entry points into Central Park with arbors, structures and directional feature paving creating a highly legible pedestrian network.

Retention of indigenous vegetation to frame active Adventure Play and Picnic facilities, with Artwork and interpretive signs integrated into the Play and path network to explain the site history.

Toddler play area nestled among existing dunal vegetation, in close proximity to amenities. Good visibility into this space will be maintained.

Informal walking trail with interpretive signs and Artwork.

Transit stop for light rail.

Informal grass area with seating and picnic facilities adjacent light rail transit stop.

Central lawn area protected from prevailing winds, highly accessible with pavilion structures for community events, performances and seating.

Central lawn area framed by avenues of feature trees - flexible open space suitable for informal active recreation, shaded seating and picnic areas accessible by an extensive path network.

Semi-private seating and gathering areas for socialising, community interaction and use at lunchtime for workers and visitors to the City Centre.

Central Park located at the heart of the City Centre, providing a strong recreational and visual focus.

Highly legible path network to City Centre.

Seating nodes located in linear parks adjacent light rail and bus routes.

Linear structured water features, decks and decorative paving provide a focus to the Park and areas for respite and passive recreation.

Large expanses of paving and grids of trees create a highly permeable 'urban park' landscape able to accommodate high levels of pedestrian use.

Avenues of native trees provide ample shade to paved verges and roadside parking facilities.

YANCHEP CITY STUCTURE PLAN

CITY CENTRE CENTRAL PARK - LANDSCAPE MASTERPLAN CONCEPT

client - Yanchep Beach Joint Venture
date - July 2009
source - Plan 9

Yanchep beach joint venture

Appendix H

Public Open Space Irrigation Plan and Indicative Staging

Yanchep City Structure Plan
Local Water Management Strategy

LEGEND
PUBLIC OPEN SPACE BY TYPE

- LANDFORM AND VEGETATION RETENTION (LVR)
- NEIGHBOURHOOD AND TOWN PARKS (NTP)
- LINEAR PARKS AND BOULEVARDS (LPB)
- TOWN SQUARES AND CIVIC SPACES (TSQ)
- 1 POS AREA
- STAGING BOUNDARY (INDICATIVE ONLY)

IRRIGATION SCHEDULE - YANCHEP CITY LSP AREA
ANTICIPATED WATER USE : Based on Department of Water Allocation Rates

STAGE 1 (0-5 YEARS)

POS No.	Total Area m²	% Irrigated	Area Irrigated m²	KL/ annum	POS Type
7	13715	50%	6857.5	5143.13	TSQ
8	1107	80%	885.6	664.20	LPB
9A	91916	10%	9191.6	6893.70	LVR
9B	84264	90%	75837.6	56878.20	OVAL
10	3500	40%	1400	1050.00	NTP
11	17319	50%	8659.5	6494.63	TSQ
12	11321	50%	5660.5	4245.38	TSQ
13	2310	80%	1848	1386.00	LPB
14	4751	50%	2375.5	1781.63	TSQ
15	27453	10%	2745.3	2058.98	LVR
21	2081.79	40%	832.716	624.54	NTP
22	528	80%	422.4	316.80	LPB
23	350	80%	280	210.00	LPB
24	369	80%	295.2	221.40	LPB
25	382	80%	305.6	229.20	LPB
26	350	80%	280	210.00	LPB
27	520	80%	416	312.00	LPB
28	442	80%	353.6	265.20	LPB
29	1274.98	80%	1019.984	764.99	LPB
30	350	80%	280	210.00	LPB
31	3275	80%	2620	1965.00	LPB
32	1024	80%	819.2	614.40	LPB
33	1702.82	80%	1362.256	1021.69	LPB
34	2804.66	40%	1121.864	841.40	NTP
35	300	80%	240	180.00	LPB
36	336	80%	268.8	201.60	LPB
37	428	80%	342.4	256.80	LPB
38	2911	40%	1164.4	873.30	NTP
39	3237	40%	1294.8	971.10	NTP
78	645	80%	516	387.00	LPB
79	1399	80%	1119.2	839.40	LPB
80	1721	80%	1376.8	1032.60	LPB
STAGE 1 TOTAL				**99144.24**	

STAGE 2 (5-7YEARS)

POS No.	Total Area m²	% Irrigated	Area Irrigated m²	KL/ annum	POS Type
16	4211	40%	1684.4	1263.30	NTP
17	1455	40%	582	436.50	NTP
18	29628	40%	11851.2	8888.40	NTP
19	1730	50%	865	648.75	NTP
20	37361	10%	3736.1	2802.08	LVR
STAGE 2 TOTAL				**14039.03**	

STAGE 3 (7-10 YEARS)

POS No.	Total Area m²	% Irrigated	Area Irrigated m²	KL/ annum	POS Type
55	6800.89	40%	2720.356	2040.27	NTP
56	1220.62	40%	488.248	366.19	NTP
57	348	80%	278.4	208.80	LPB
58	531	80%	424.8	318.60	LPB
59	820	80%	656	492.00	LPB
60	275	80%	220	165.00	LPB
61	351	80%	280.8	210.60	LPB
62	283	80%	226.4	169.80	LPB
63	624	80%	499.2	374.40	LPB
64	610	80%	488	366.00	LPB
65	149	80%	119.2	89.40	LPB
66	426	80%	340.8	255.60	LPB
67	403	80%	322.4	241.80	LPB
68	239	80%	191.2	143.40	LPB
69	4888	80%	3910.4	2932.80	LPB
70	640	80%	512	384.00	LPB
71	639	80%	511.2	383.40	LPB
72	12981	80%	10384.8	7788.60	NTP
73	5889	80%	4711.2	3533.40	LPB
74	1368	80%	1094.4	820.80	LPB
75	1376	80%	1100.8	825.60	LPB
76	15021	40%	6008.4	4506.30	NTP
77	16251	10%	1625.1	1218.83	LVR
PR PS	55692	50%	27846	20884.50	School
PS 1	44153	50%	22076.5	16557.38	School
STAGE 3 TOTAL				**65277.45**	

STAGE 4 (10-15 YEARS)

POS No.	Total Area m²	% Irrigated	Area Irrigated m²	KL/ annum	POS Type
1	73566	10%	7356.6	5517.45	LVR
2	3644	40%	1457.6	1093.20	NTP
3	1965	40%	786	589.50	NTP
4	20368	40%	8147.2	6110.40	NTP
5	11430	40%	4572	3429.00	NTP
6	4977	40%	1990.8	1493.10	NTP
40	909	80%	727.2	545.40	LPB
41	1273	80%	1018.4	763.80	LPB
42	198	80%	158.4	118.80	LPB
43	257	80%	205.6	154.20	LPB
44	221	80%	176.8	132.60	LPB
45	719	80%	575.2	431.40	LPB
46	250	80%	200	150.00	LPB
47	197	80%	157.6	118.20	LPB
48	185	80%	148	111.00	LPB
49	185	80%	148	111.00	LPB
50	200	80%	160	120.00	LPB
51	200	80%	160	120.00	LPB
52	350	80%	280	210.00	LPB
53	330	80%	264	198.00	LPB
54	375	80%	300	225.00	LPB
81	79	80%	63.2	47.40	LPB
HS	100612	50%	50306	37729.50	School
STAGE 4 TOTAL				59518.95	

OVERALL TOTAL	237979.67

IRRIGATION REQUIREMENTS BY POS TYPE

Schools - 50% Total area irrigated
Irrigation Requirements - 70% Turf
Irrigation Requirements - 30% Garden Bed
Irrigation Requirements - 750Litres /m2/ annum
Landform and Vegetation Retention (LVR) - 10% Total area irrigated
Irrigation Requirements - 750Litres /m2/ annum
Ovals / Active Open Space (OVAL) - 90% Total area irrigated
Irrigation Requirements - 70% Turf
Irrigation Requirements - 30% Garden Bed
Irrigation Requirements - 750Litres /m2/ annum
Town Squares / Civic spaces (TSQ)- 50% Total area irrigated
Irrigation Requirements -80% Turf
Irrigation Requirements - 20% Garden Bed
Irrigation Requirements - 750Litres /m2/ annum
Neighbourhood Parks and Town Parks (NPT) (excluding Ovals) - 40% Total area irrigated
Irrigation Requirements -60% Turf
Irrigation Requirements - 40% Garden Bed
Irrigation Requirements - 750Litres /m2/ annum
Linear Parks and boulevards (LPB) - 80% Total area irrigated
Irrigation Requirements -20% Turf
Irrigation Requirements - 80% Garden Bed
Irrigation Requirements - 750Litres /m2/ annum

YANCHEP CITY STUCTURE PLAN

PUBLIC OPEN SPACE IRRIGATION PLAN AND INDICATIVE STAGING

client: Yanchep Beach Joint Venture
plan: 07/004/G021
date: March 2011

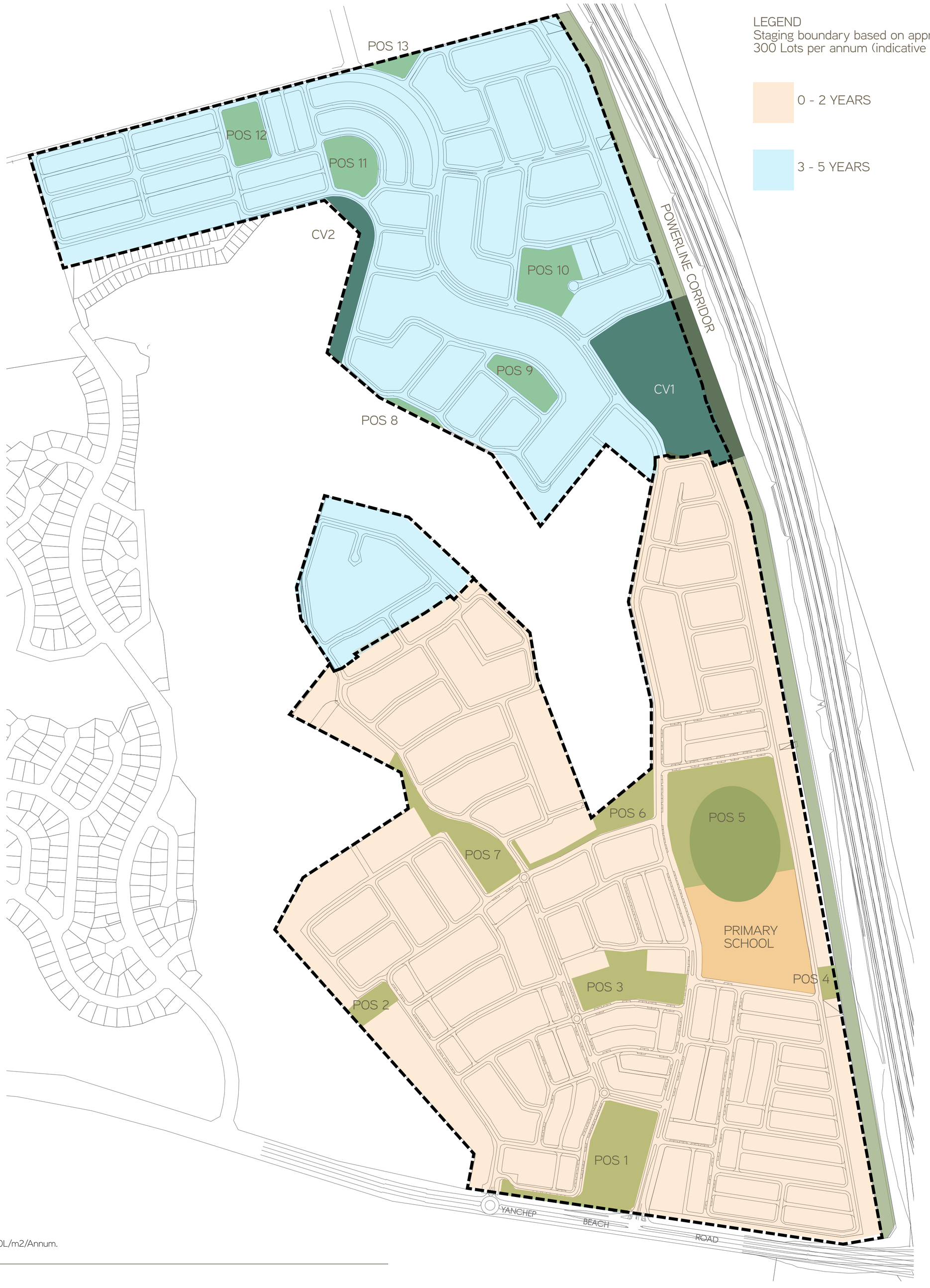
source: Plan E

Yanchep beach joint venture

Appendix I

Plan 1 Irrigation Schedule (Peet Syndicate landholding)

Yanchep City Structure Plan
Local Water Management Strategy



IRRIGATION SCHEDULE

Anticipated water use

Water Volumes have been calculated using 750L/m2/Annum.

IRRIGATION SCHEDULE - Anticipated water use

POS No.	Total Area m2	% Irrigated	Area Irrigated m2	KL/annum	POS Type
1	21,457	40%	8,583	6,437	NTP
2	3,733	40%	1,493	1,120	NTP
3	14,106	40%	5,642	4,232	NTP
4	1,824	40%	730	547	NTP
5	42,279	100%	42,279	34,880	Oval
6	8,588	40%	3,435	2,576	NTP
7	12,526	40%	5,010	3,758	NTP
8	1,441	40%	576	432	NTP
9	5,938	40%	2,375	1,781	NTP
10	10,201	40%	4,080	3,060	NTP
11	7,922	40%	3,169	2,377	NTP
12	6,778	40%	2,711	2,033	NTP
13	2,020	40%	808	606	NTP
CVR 1	43,309	10%	4,331	3,248	LVR
CVR 2	9,941	10%	994	746	LVR
Primary School	37,314	50%	18,657	13,993	School
Streetscape	51,000	80%	40,800	30,600	LPB
				112,427	

NOTE:
BASED ON CURRENT INFORMATION ON HAND
SUBJECT TO DETAILED DESIGN
SUBJECT TO CHANGE AS NO LANDSCAPE DESIGN
HAS TAKEN PLACE

PLAN 1
IRRIGATION SCHEDULE

PLACE LABORATORY

Revision	Date	Scale	Client	Project	Drawing
C	March 2011	NOT TO SCALE	PEET	LOT 609 YANCHEP BEACH RD YANCHEP	CP001