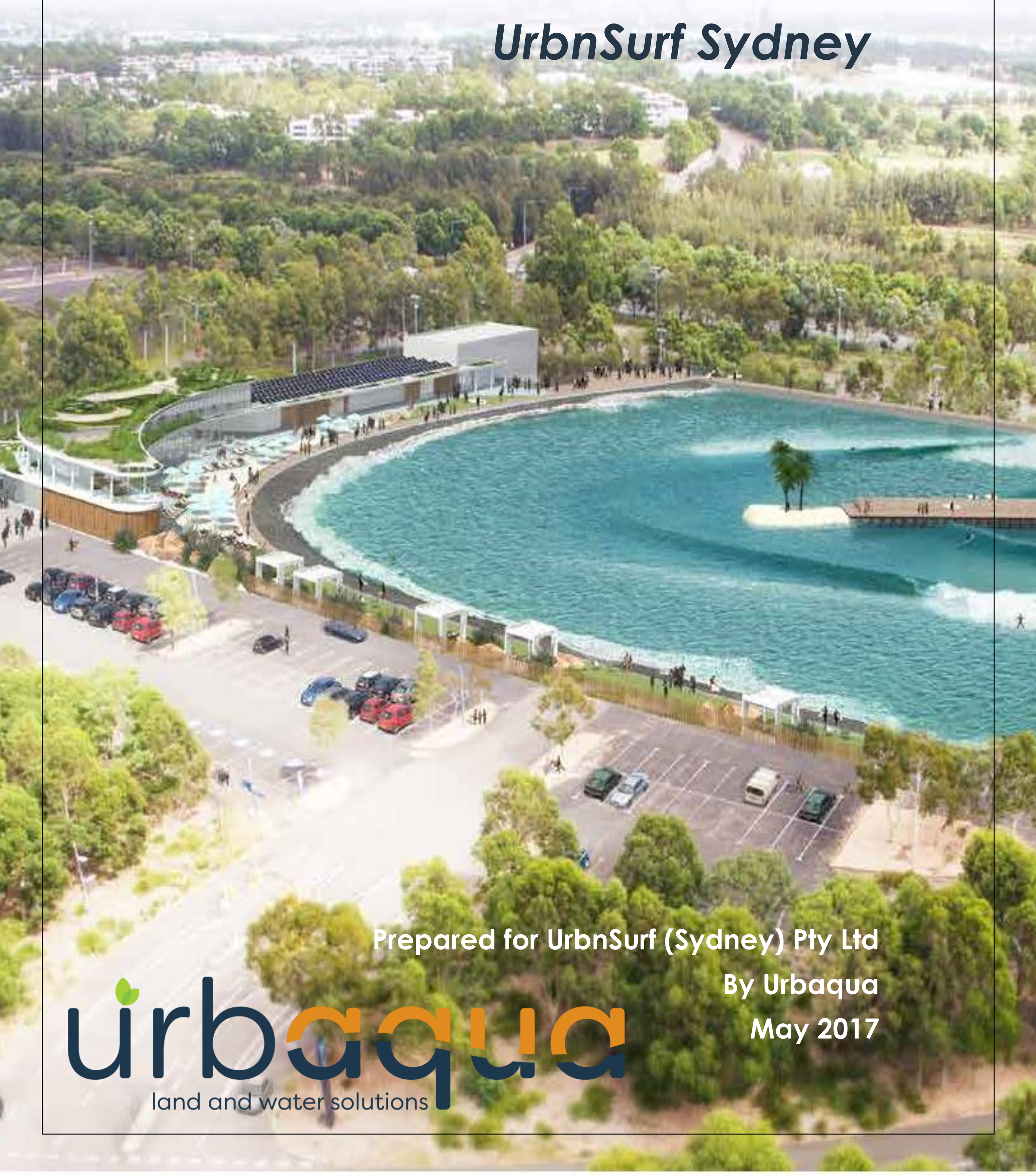
Integrated Water Cycle Management Plan

UrbnSurf Sydney



Prepared for UrbnSurf (Sydney) Pty Ltd

By Urbaqua

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urbaqua

land and water solutions

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1 INTRODUCTION

Urbn Surf (Sydney) Pty Ltd is proposing to construct and operate "URBNSURF Sydney"; a world-class sport, recreation, leisure, tourism and event facility featuring a Wavegarden™ surfing lagoon to be sited at Pod B P5 Carpark, Hill Road, Sydney Olympic Park.

1.1 Purpose

This Integrated Water Cycle Management Plan has been prepared to address elements of the Secretary's Environmental Assessment Requirements (SEAR's) for the UrbnSurf Sydney surfing facility which is proposed to be constructed at the Sydney Olympic Park by UrbnSurf (Sydney) Pty Ltd.

1.2 Site description

The site is located within the Sydney Olympic Park. It is bounded by Hill Road to the north, Holker Busway and bus port to the west, the "Monster Mountain X" mountain biking course and BMX track to the south-east and the Pod C Carpark to the east.

Figure 1 shows the location of the site within the Sydney Olympic Park and identifies key characteristics of the existing site and surrounds. The site is approximately 3.15 ha and currently contains infrequently used event car parking facilities. The closest of the major Sydney Olympic Park facilities is the Sydney Showgrounds, located approximately 600 metres south of the Proposal site.

Haslams Creek is located approximately 200 metres to the south of the site, providing drainage to a large residential and industrial catchment. Approximately 100 metres north of the site is the Narawang wetlands which are a series of natural and constructed wetlands and drainage basins.

1.3 Proposed development

The proposal includes construction of a single lagoon which will be fitted with a mechanical wave generation system to enable surfers of varying ability to participate in year-round surfing. Supporting infrastructure to be constructed includes showering and changing facilities, retail outlets selling swimming and surfing equipment and refreshments, surf hire outlets and a surf school. The layout of the proposed facility is illustrated in Figure 2.

1.4 Report scope and structure

This Integrated Water Cycle Management Plan has been prepared in accordance with the SOPA Stormwater Management and Water Sensitive Urban Design Policy. It outlines the proposed approach to water related issues and identifies ongoing actions that will be required to implement the proposal.

Operational constraints in regards to the design of the lagoon requires that a minimum depth of approximately 3.5m is maintained and the allowable variation in water level is 0.1m. In order to address these operational constraints, it is necessary to consider the seasonal water balance for the lagoon and estimate the volume of water that would be required to top-up the lagoon during summer.

In addition to water requirements for operation of the lagoon, the SOPA Stormwater Management and Water Sensitive Urban Design Policy requires consideration of integrated water cycle management and flood risk.

This plan includes:

- A description of the site characteristics (Section 0);
- The proposed strategy for water quality management (Section 2.5);
- A description of how all stormwater generated on the site will be managed (Section 4);
- A management strategy for flood risk at the site;
- A water balance report incorporating water source strategy (Section 0);
- Justification for why each element of the water sensitive urban design strategy has been selected over alternate approaches (Sections 2.5, 4 and 0);
- Design assumptions including design rainfall events used to size rainwater tanks and water sensitive urban design elements (Section 0 and appendices);
- A site layout plan showing the location of each element of the proposed stormwater treatment train and design details of each element (Figure 2);
- Strategies for management of nuisance insects and landscape (Section 6);
- Construction soil and water management plan, prepared in accordance with Landcom's Blue Book (*Managing Urban Stormwater – Soils and Construction Volume 1 2004*) (Section 7); and
- Monitoring and maintenance plan for all stormwater devices and other water sensitive urban design elements (Section 8).

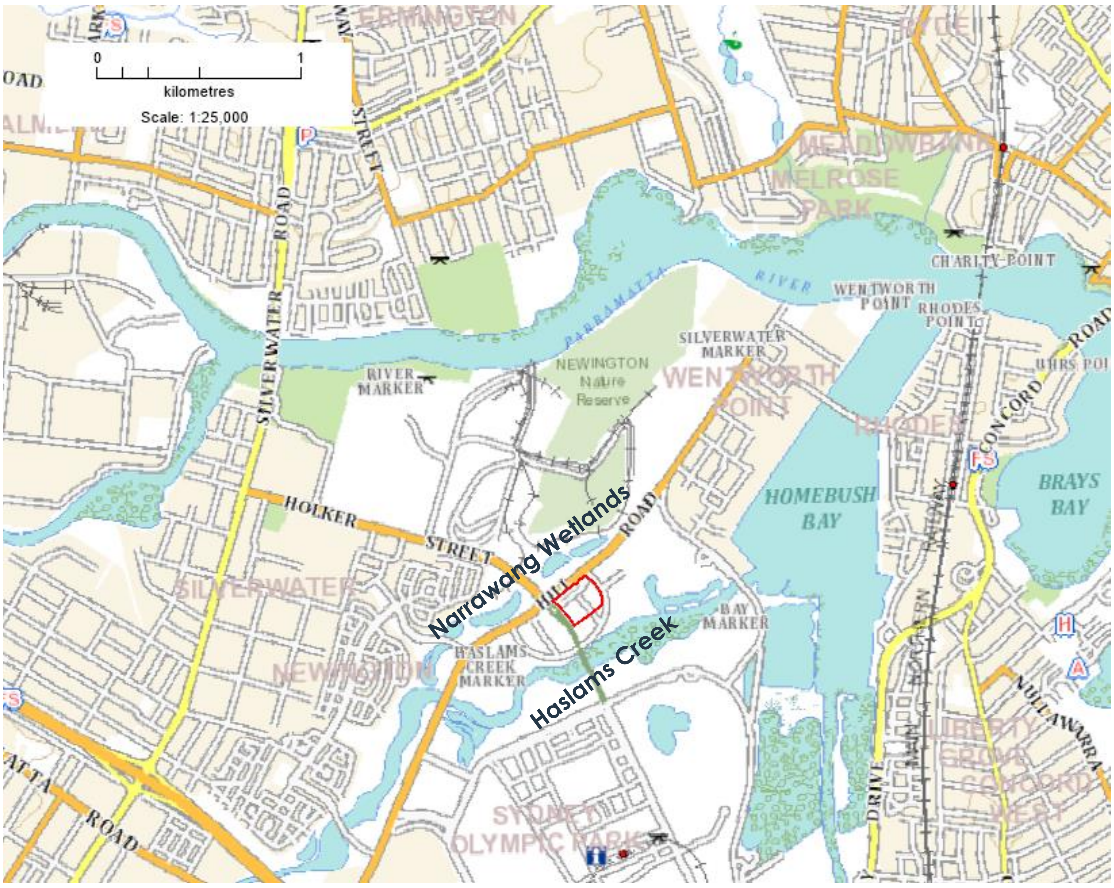

Figure 1: Location plan

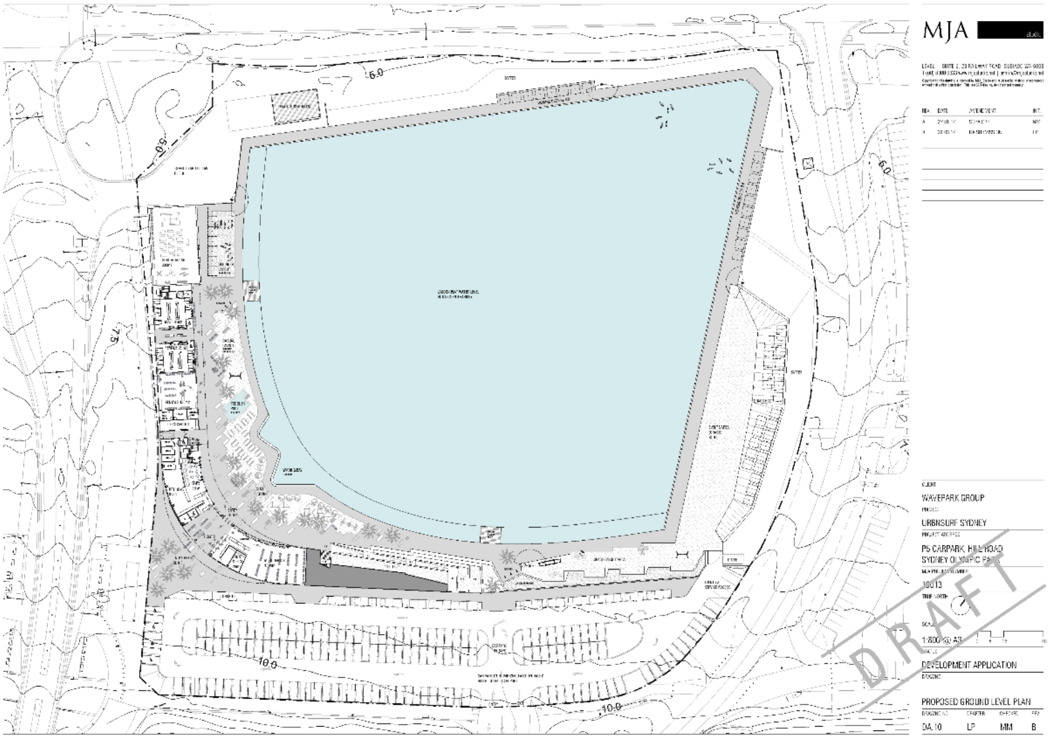

Figure 2: Proposed site layout

1.5 Objectives

The following objectives of this Integrated Water Cycle Management Plan have been adapted from the SOPA *Stormwater Management and Water Sensitive Urban Design Policy* to reflect site specific characteristics and requirements of the site and proposal:

1. Maximise harvest and reuse of roof-water.
    - All non-potable water demand shall be met by non-potable water sources (eg roof water, recycled water) where connection to the Park's recycled water supply (Water Reclamation and Management Scheme - WRAMS) is available.
    - Locally-harvested rainwater shall be the primary source of non-potable water for developments located within a Sydney Olympic Park non-stormwater harvesting catchment. Where practicable, at least 90% of non-potable demand shall be met from this source, which may be supplemented by recycled water as a back-up if harvested rainwater is insufficient to meet demand. Where non-potable demand within a development site is low, alternative uses for roof water such as landscaping, roof gardens, as well as off-site re-use, should be considered so as to minimise the volume of stormwater discharged to local waterways.
2. Minimise volume and frequency of stormwater discharge from hardstand areas such as paving, driveways and car parks, and maximise quality of any stormwater discharged.
    a) All stormwater discharged from the site is to meet:
        - water quality pollutant load reduction targets as outlined in *Stormwater Management and Water Sensitive Urban Design Policy*.
        - water quantity volume reduction targets and peak flow reduction targets as outlined in *Stormwater Management and Water Sensitive Urban Design Policy*.

b) Design of landscaped and paved areas must incorporate water sensitive urban design elements and pollution control devices including but not limited to:
   - Appropriate stormwater management measures as detailed in Master Plan 2030
   - Retaining a minimum of 20% of the site's open space area as deep soil. Areas included as deep soil are to have a minimum dimension of two metres. Consolidate areas of deep soil within sites and between adjacent sites to increase the benefits.
   - Minimising impervious areas that are directly connected to the stormwater system. Runoff from impervious areas such as driveways, paving and rainwater tank overflows should be directed onto landscaped areas designed to accept such flows.
   - Removal of gross pollutants, sediments and nutrients prior to stormwater discharge to the trunk drainage system, through use of devices such as bioswales, sand filters, gross pollutant traps, and litter baskets.
   - Installation of appropriately-designed bioswales or other stormwater harvesting systems within surface carparks that have more than ten spaces, such that water flows meet the relevant water quality and quantity targets for the catchment
   - Installation of oil and grease traps in surface and basement carparks
   - Using wetland plant species native to the Sydney region in water sensitive urban design features and associated landscaping, to avoid spread of weed propagules to downstream wetlands.

3. Water conservation
   - Connect all new development to Sydney Olympic Park's recycled water system for all approved uses of recycled water
   - Mixed use development must comply with the requirements detailed in Master Plan 2030.
4. Riparian protection
   - Development within 40 metres of a creek, river, lake or estuary must have regard for the 'Guidelines for riparian corridors on waterfront land' (dated July 2012, or subsequent revisions) issued by NSW Office of Water. Any necessary approvals required under the *NSW Water Management Act 2000* must be obtained.

- Flood risk
   - Address flood risk and any relevant provisions of the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise, and increase in rainfall intensity.

Note: There are no creeks, rivers, lakes or estuaries within 40 m of the site. However, the site currently drains to the Narawang Wetlands approximately 80m to the north of the site via culverts beneath Hill Road. The environmental importance of the wetlands and strategies for their protection are considered in this plan.

2 EXISTING SITE CHARACTERISTICS

2.1 Climate

The site's temperate climate is typical of western Sydney with warm summers and mild winters. The closest Bureau of Meteorology (BoM) weather station is located at the Sydney Olympic Park (Site reference: 066195) approximately 1 km from the site. The station has been operating continuously since 1996. Daily evaporation is not recorded at the Sydney Olympic Park weather station and the closest active station for this information is Riverview Observatory (Site reference: 066131) which is located approximately 8 km from the site.

Average maximum temperature peaks during the summer in January at 28.4°C falling to a minimum of 17.6°C in July.

Average monthly rainfall remains relatively consistent throughout the year although there is a noted peak during late Summer and Autumn with a maximum of 109.8mm in February and generally drier conditions in late winter with a minimum of 52.7 mm in September.

Average daily evaporation at Riverview Observatory ranges from a maximum of 6mm in January to a minimum of 1.9mm in June.

A daily time series of rainfall data from Sydney Olympic Park and evaporation data from Riverview Observatory was sourced from the BoM and used in the water balances prepared for the site.

A summary of climate data sourced and applied for various elements of this integrated water cycle management plan is provided in Table 1.

Table 1: Summary of climate data use

Data type	Data source	Use	Details
Average daily evaporation	Riverview Observatory (BoM Site No: 066131)	General climate description	
Average monthly temperature and rainfall	Sydney Olympic Park (BoM Site No: 066195)	General climate description	
Daily time series rainfall	Sydney Olympic Park (BoM Site No: 066195)	Water balance modelling scenarios	Modelling period of 01/01/2001 to 31/12/2011
Average daily evaporation	Riverview Observatory (BoM Site No: 066131)	Water balance modelling scenarios	
Monthly mean dew point temperatures 9am and 3pm	Sydney Olympic Park (BoM Site No: 066195)	Estimation of lagoon evaporation for use in lagoon water balance modelling	Monthly means from 1996 to 2010 used in calculation of average daily evaporation rate for disturbed open water body

Data type	Data source	Use	Details
6-minute rainfall data	Sydney Airport AMO (BoM Site No: 066037)	MUSIC modelling scenarios	Modelling period of 1/1/1988 to 31/12/1998
Average monthly potential evapotranspiration	Sydney regional summary data provided with MUSIC V6	MUSIC modelling scenarios Water balance modelling scenarios	Sydney regional summary data provided with MUSIC V6
Design rainfall events (1yARI, 20yARI, 100y ARI)	BoM online IFD data system	InfoWorks hydrologic and hydraulic modelling	Design rainfall events generated based on IFD parameters extracted for the site from AR&R87 IFD's

Average monthly potential evapotranspiration values for the Sydney region, including Sydney Olympic Park have been used for all MUSIC modelling scenarios.

2.2 Topography and geology

The site is situated on an area of gently sloping land that has been previously compacted and prepared as a carpark. The land generally slopes towards Hill Road in the north from approximately 9.0mRL to 4.5mRL.

The site has been previously noted as 'highly disturbed' having been developed in 1996 for overflow car parking for the 2000 Sydney Olympic Games through the filling and engineered compaction of inert material (estimated to be 5-6 metres thick).

A preliminary geotechnical investigation was undertaken by Parsons Brinkerhoff in May-July 2016. The investigations found that the site is capped with a flexible asphalt pavement with the following underlying units:

- **Existing Fill**: Fill ranging from approximately 5m to 9m in thickness covers the site. The variable mixture of fill is interpreted to be derived from dredged estuarine sand and mud, demolition rubble, and miscellaneous soil and rock materials.
- **Estuarine:** A firm clay unit exists beneath the fill in some portions of the site. It is interpreted as estuarine muds derived from a low energy stream or tidal environment. The unit appears to vary in thickness across the site, ranging from not encountered to approximately 5m in thickness.
- **Alluvium:** An underlying layer of alluvium was encountered across the site. It is interpreted to be derived from river sediment (fluvial) deposition. The CPT investigation suggests that this unit is also variable in thickness, ranging from approximately 3m thick up to 5m thick.
- **Residual:** A layer of residual soil or extremely weathered rock exists below the alluvium. The unit is interpreted to be generally 2m to 3m in thickness as CPT refusal was reached below this amount of penetration. However, it may be thicker. Some gravel sized weathered rock fragments exist within the unit.

Soil samples from a selection of bores were subject to laboratory testing and a summary of the results are presented in Table 2.

Table 2: Summary geotechnical laboratory testing results

Borehole	Sample depth (m)	pH	Chloride Cl (mg/kg)	Sulfate SO_4 (mg/kg)	Resistivity (ohm m)	Electical Conductivity EC (µS cm)
BH01	2.5-3.0	8.4	130	730	980	338
BH04	2.5-3.0	6.0	520	620	680	499
BH18	1.0-1.5	8.0	240	360	730	368
BH27	2.5-3.0	8.2	180	1090	660	498

2.2.1 Saline soils

The site is shown on the map: *Department of Infrastructure, Planning and Natural Resources, Salinity Potential in Western Sydney 2002* as having a moderate salinity potential (Figure 3).

Preliminary geotechnical investigations undertaken in 2016 including soil sampling from the site fill material indicate EC is in the range 338-498 µS cm (see Table 2) and is therefore not saline.

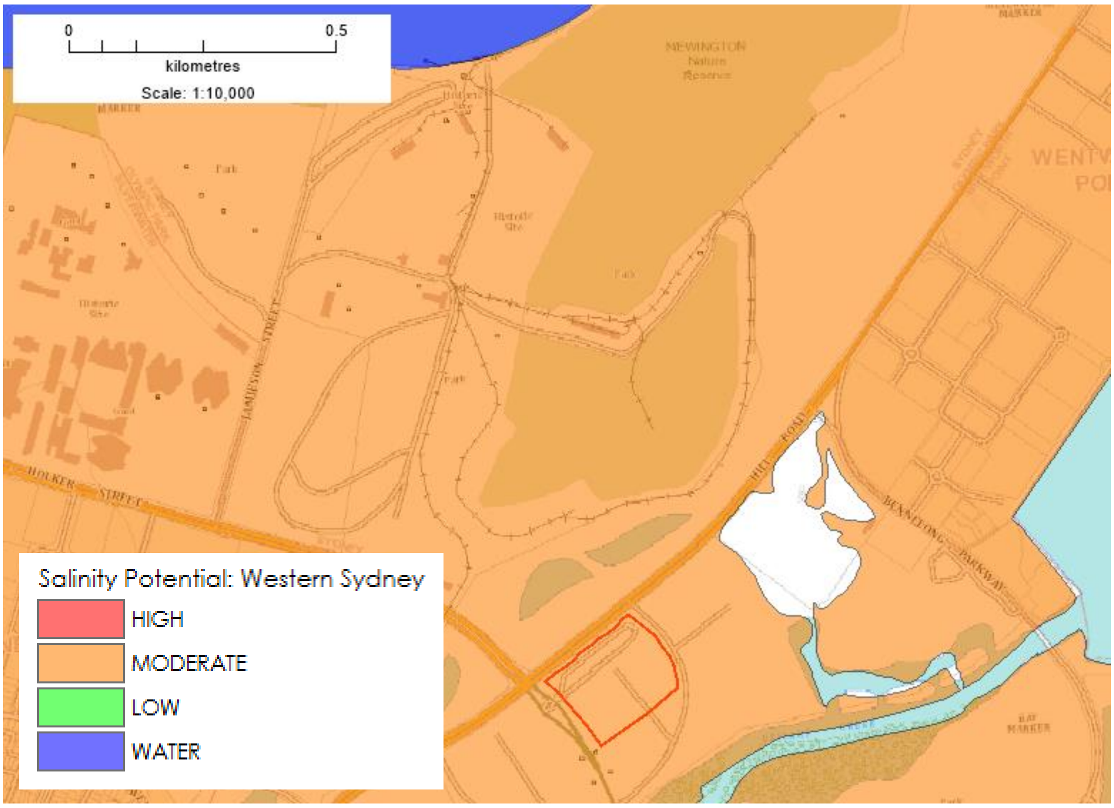

Figure 3: Saline soils

2.2.2 Acid sulfate soils

Acid Sulfate Soils (ASS) are widespread among low lying coastal areas of NSW, in estuarine floodplains and coastal lowlands. These are naturally occurring sediments and soils containing iron sulfides (mostly pyrite). Where these are exposed to the air by drainage of overlying water or excavation, the iron sulfides oxidise and form sulfuric acid.

The probability of the occurrence of ASS within the Parramatta River Estuary catchment has been mapped by DECC, as shown in Figure 4 The site is mapped as 'disturbed terrain' and is located adjacent to areas identified as having a high probability of occurrence for ASS.

However, the site is located on 5-6m of inert semi-engineered material and therefore construction does not require interception of any potential acid sulfate soils.

Preliminary geotechnical investigations undertaken in 2016 including soil sampling from the site fill material indicate field pH is in the range 6.0-8.4 (see Table 2) suggesting low or no risk of acid sulfate soils in this material.

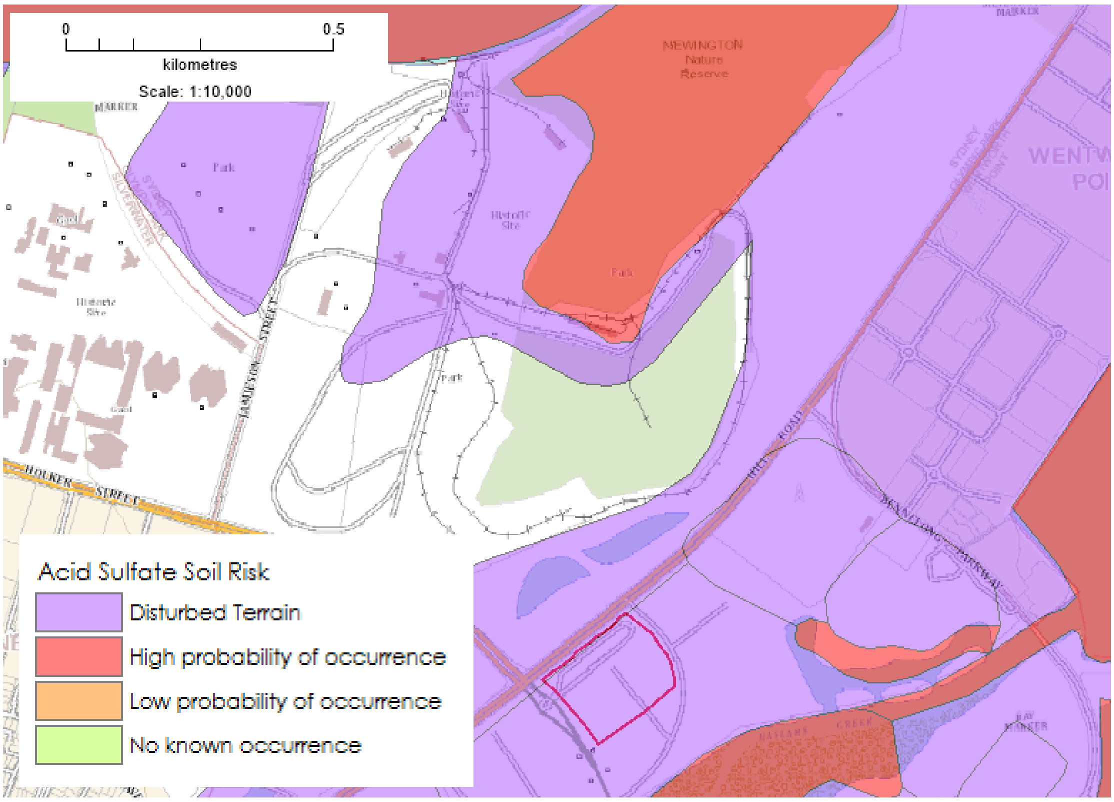

Figure 4: Acid sulfate soil risk

2.3 Environmental assets

The *Plan of Management for the Parklands at Sydney Olympic Park*, referred to as the Parklands Plan, provides a statutory scheme of operations as the basis for managing the Parklands under the *Sydney Olympic Park Authority Act* (2001).

The Parklands are an association of many different parks and places brought together as a single entity for management purposes. The majority of the physical landscape of the Parklands is the deliberate result of remediating waste industrial land, acquiring Naval property of heritage significance and conserving disturbed remnant natural areas - since the mid 1990's - to create a series of different places consistent with a planned concept for the Parklands (Millennium Parklands Concept Master Plan [Hassell 1997]).

The site is located within the Parkland Junction Precinct, which is categorised for management purposes as "Sports and Recreation Parks". The established functions of Parkland Junction are as a carpark and a recreational area. It contains the Monster Skate Park and a fenced off-leash dog walking area between the carpark and Haslams Creek.

The precinct also functions as a contained remediated landfill (which requires ongoing management), water harvesting area, and as a visitor connection link. Stormwater runoff on the site is captured in deep swales and drain structures and drains to the Narawang Wetland irrigation storage areas for irrigation use in the Parklands.

The Parklands Plan notes that the "precinct is a highly modified environment and has limited natural heritage significance. Parkland Junction does not contain any documented Aboriginal relics or registered significant Aboriginal sites".

2.3.1 Narawang Wetland

The Narawang Wetland is a series of constructed wetland ponds which contain native vegetation and important habitat including for threatened species, located to the north of the site. It contributes to the continuous wetland corridor extending from Haslams Creek Flats in the south of the Park to Homebush Bay in the east. Narrawang Wetland also serves as an irrigation storage facility and floodway, and incorporates leachate management infrastructure from adjoining areas.

The Parklands Plan notes that the constructed habitat simulates a freshwater wetland on coastal floodplain by receiving floodwaters from Haslams Creek and a floodway under Hill Road linked to the Nuwi Wetland. Stormwater from a 105-hectare catchment comprising Newington, Parkland Junction and Hill Road also feeds into Narawang Wetland for water quality treatment, storage and subsequent irrigation re-use. A water pumping system permits water circulation and level control in the Wetlands. Water is circulated through the ponds to improve water quality and prevent the formation of eutrophic conditions. Water can also be drained to reduce pest and weed species in the ponds.

The Parklands Plan establishes the functions of Narawang Wetland as being for biodiversity conservation and flood mitigation for Haslams Creek. The precinct also functions as a water harvesting and storage area, as a site for environmental education activities, as a leisure area for walking and cycling and as a visitor connection link.

2.3.2 Haslams Creek

Haslams Creek runs to the south of the site, providing flood mitigation for the urbanised creek catchment. Prior to 2000, Haslams Creek was a concrete-lined stormwater channel. It has been reconstructed to mimic more natural, estuarine processes through extensive plantings of mangroves and three rare saltmarsh species.

The creek now provides important habitat for many species of native birds, reptiles, fish and frogs. The landscaped linear system also contains walking and cycling trails and open space for informal recreation.

The Parklands Plan establishes the functions of Haslams Creek being for biodiversity conservation; and as a containment structure for landfill. This includes evaporation ponds which are a component of the leachate management system. Three in-stream islands improve tidal flow to the Nuwi Wetland.

2.3.3 Nuwi Wetland

The Nuwi Wetland is located to the north east of the site. It is an important component of the flood mitigation strategy due to its role in discharging diverted floodwaters from Narawang Wetland back into Haslams Creek. The Nuwi Wetland is fenced on all sides for security reasons.

The Nuwi Wetland provides a habitat linkage between the Narawang Wetland and the northern end of Haslams Creek. It consists of a lagoon fringed with mangroves and patches of saltmarsh and is associated with leachate management infrastructure and a sandstone rock wall are also located along the boundary of the car park.

2.3.4 Newington Nature Reserve

The Newington Nature Reserve is situated to the north of the Narawang Wetland, approximately 200 m from the site. It contains the JAMBA/CAMBA-listed Wanngal Wetland, and Wannagal Forest. The Wanngal Wetland is an intact and diverse estuarine wetland system containing significant areas of remnant saltmarsh and mangroves in excellent condition. The Forest provides a representation of the Sydney Turpentine Ironbark Forest, which is listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* and is listed as vulnerable nationally under the *Environment Protection and Biodiversity Conservation Act 1999*.

The Newington Nature Reserve is part of the Millennium Parklands Heritage Precinct and is managed consistent with the Newington Nature Reserve Plan of Management (2003).

2.3.5 Site flora and fauna investigations

Applied Ecology P/L completed a flora and fauna survey and report for the site. Field surveys were completed on 12th January 2017, and the data from these surveys was considered in the context of flora and fauna records available on databases including NSW Wildlife Atlas (OEH) and the federal Protected Matters Search (DEE). This was further supplemented with fauna records provided by SOPA.

No threatened species, endangered ecological communities, endangered populations, or critical habitat was recorded on the subject site and the report noted the presence of 43 weed species on the site, with 5 species of noxious weeds.

Flora and fauna species identified during the investigations, as well as significant species in the surrounding environmental areas discussed previously, are described in the report and the following potential water cycle related impacts are identified:

- Wastewater discharge to the downstream environment;
- Discharge of stormwater runoff to the downstream environment;
- Potential loss of habitat used by Blue Tongue and other lizards through removal and/or modification of existing vegetated swales; and
- Weed incursion to environmental areas through poor selection of new landscape plantings (particularly in existing and new stormwater management infrastructure).

The management of each of these potential impacts are discussed in sections 3 to 6 of this report and are summarised in Table 3 below:

Table 3: Summary of management strategies for potential environmental impacts

Potential impact	Management strategy	Section
Wastewater discharge	No wastewater discharge to the environment is proposed. Domestic wastewater and wastewater from the Lagoon treatment process will be discharged to sewer.	Section 5.3
Lagoon water discharge	Quantity – The potential discharge of lagoon water to the environment under emergency circumstances will be controlled to prevent physical impacts. Emergency discharge of lagoon water will be via the existing drainage system discharging to the Nuwi wetland. Quality – The treatment system proposed for the lagoon water has been developed to meet ANZECC guidelines for fresh and marine water quality.	Section 5.5
Stormwater runoff	Quantity – stormwater discharge peak flow rates via the existing culverts beneath Hill Road will be significantly reduced as demonstrated using hydrologic and hydraulic modelling of the site. Quality – the quality of stormwater discharged via the existing culverts beneath Hill Road will be treated in accordance with current best practice in water sensitive urban design as demonstrated using MUSIC water quality modelling.	Quantity – Section 4.2 Quality – Section 4.3
Habitat loss	A suitably licenced and experienced ecologist will be on site to ensure that lizards, where possible, are rescued and relocated prior to removal of existing vegetated swales. Weed removal and revegetation of retained swales will apply a methodology developed by a suitably licenced and experienced ecologist to minimise potential impacts.	Section 6.2
Weed incursion	landscaping species, particularly those used in revegetation of existing swales and construction of new stormwater management systems will be selected to support the ecology of the park and avoid inclusion of species that may spread and become weedy	Section 6.2

2.4 Hydrology

The site is located in the catchment of the Narawang wetlands which drain to Haslams Creek just upstream of the Hill Road Bridge. Haslams Creek runs parallel and to the south of the site and drains into the Parramatta River at Homebush Bay.

The Haslams Creek catchment is approximately 17km^2 and is highly urbanised. Upstream of the site, the creek system is a mix of lined open channels and pipes but becomes a natural channel downstream of the Hill Road Bridge. The tidal limit of Haslams Creek is located 350 metres upstream of the Great Western Highway. The mangrove limit is located 100 metres downstream of the freeway (MHL, 2006).

The existing drainage system for the site (Figure 6) discharges to the Narawang wetlands north of the site via culverts beneath Hill Road.

2.4.1 Groundwater

Groundwater observations made during geotechnical site investigations undertaken in May-July 2016 suggest a groundwater level at approximately RL0m to RL2m AHD, this equates to a depth of approximately 4m to 7m below existing ground level across the site. Based on this information, groundwater flow is generally expected to be northward across the site.

Groundwater may be subject to seasonal variations and perched water levels may exist from time to time on parts of the site. Subsoil drainage is therefore recommended for installation beneath the Lagoon liner as a precautionary measure to prevent it from lifting and potentially causing damage and/or leakage. Discharge flows from this subsoil drainage system are expected to be very small. Any subsoil drainage discharges will be directed to the vegetated stormwater management system to receive treatment prior to discharge into the downstream environment.

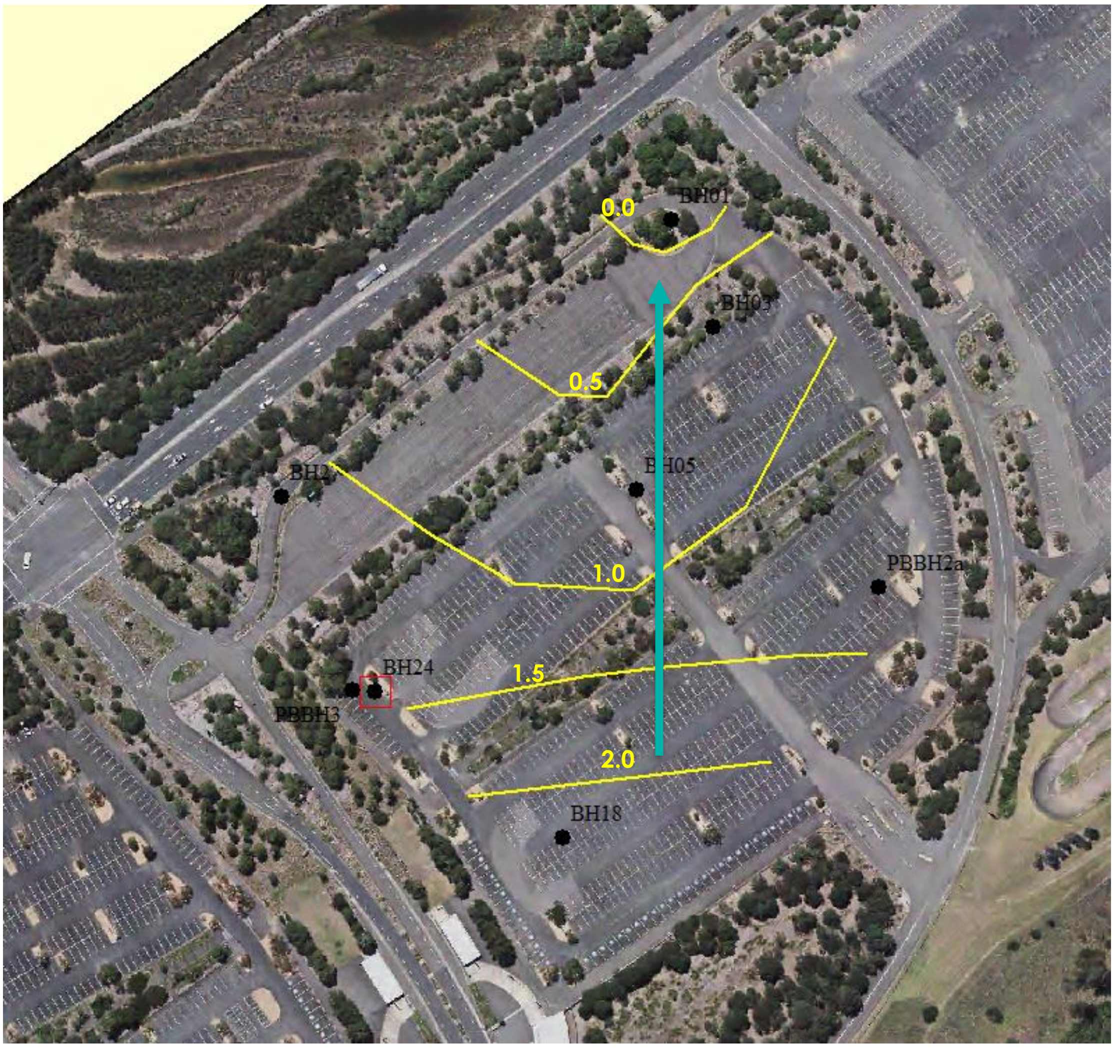

Figure 5: Groundwater levels and direction of flow

2.4.2 Predevelopment water balance

The existing site water balance is dominated by runoff, being largely well-drained hardstand with limited vegetative cover. Based on a simple broadscale water balance model of the site, Table 4 presents the estimated fluxes for Rainfall, Runoff, Evapotranspiration and Recharge.

Table 4: Broadscale predevelopment site water balance

Flux	Estimated volume	% of total
In		
Rainfall	28.55 ML/year	100%
Out		
EVT	2.94 ML/year	10%
Recharge	5.72 ML/year	20%
Runoff	19.89 ML/year	70%
Total	28.55 ML/year	100%

2.4.3 Predevelopment hydrological and hydraulic modelling

Predevelopment hydrological and hydraulic modelling has been undertaken for the site using InfoWorks ICM. A summary of the modelling methodology applied is provided in Appendix 1.

The existing drainage system for the site discharges to the Narawang wetlands north of the site via culverts beneath Hill Road. The system provides capacity for 20 year ARI events within a system of vegetated open swales and culverts. Predevelopment peak discharge flow rates for the critical 1yr, 20yr and 100yr ARI events are presented in Table 5 and the existing drainage layout is shown in Figure 6.

Table 5: Predevelopment peak discharge flow rates

Event	Peak discharge flow rate
1-year ARI	0.33 m^3/s
20-year ARI	0.87 m^3/s
100-year ARI	1.01 m^3/s

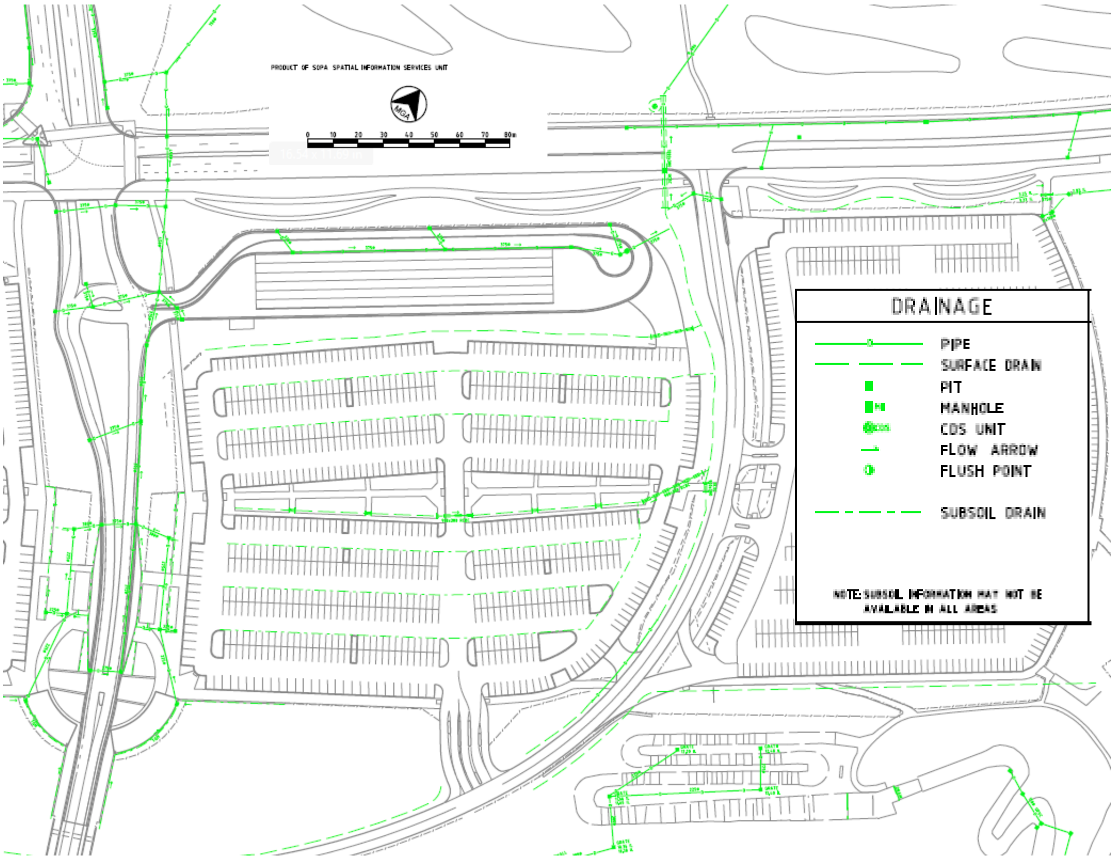

Figure 6: Predevelopment drainage

2.5 Flood risk

Planning Flood levels have been published for Haslams Creek in the *Haslams Creek Floodplain Risk Management Study and Plan* (Auburn City Council, 2003). The 100-year ARI flood level at the Services Bridge immediately downstream of the M4 Motorway Bridge and approximately 1.5 km upstream of the site was predicted to reach 2.8mAHD whilst the probable maximum flood was predicted to reach 7.5mAHD.

Flood levels have also been published for the Parramatta River, including Homebush Bay, in the *Lower Parramatta River Floodplain Risk Management Study* (Parramata City Council, 2005). The 100-year ARI flood level at Homebush Bay, approximately 1km downstream of the site was predicted to reach 0.99 mAHD whilst the probable maximum flood was predicted to reach 2.13mAHD.

The site has a minimum elevation of 4.5mAHD. Assuming that published flood levels up and downstream of the site are representative of flood levels through the Narrawang Wetlands and Haslams Creek adjacent to the site, it may be surmised that the 100-year ARI flood level at the site would be no more than 2mAHD whilst the probable maximum flood would be no more than 4.3mAHD. On this basis, there is considered to be negligible flood risk at the site from the 100-year ARI event, even when considering the potential effects of climate change, sea level rise, and increase in rainfall intensity.

Historical flooding has occurred on the Paramatta River in 1898, 1914, 1956, 1961, 1967, 1969, 1974, 1975, 1986, 1988, 1990 and 1991 (Parramata City Council, 2005). Flood level data for these floods is very limited, but was sourced for a number of sites within the *Lower Parramatta River*

Floodplain Risk Management Study modelling domain and used to validate modelling results. The closest validation point to Homebush Bay at the downstream extent of the model domain had a historical flood record from 1974 of 1.5 m AHD which compares satisfactorily to predicted flooding levels of 1.81 mAHD for the 20 year ARI event and 2.20 mAHD for the 100year ARI event.

2.6 Extreme tidal influences

The *Lower Parramatta River Floodplain Risk Management Study* (Parramata City Council, 2005) included consideration of the influences of extreme tides on flood modelling. The downstream boundary of the model was defined by observed tidal levels and sensitivity testing was carried out to vary the start time/high tide relationship for each modelled flood event. The amplitude of the tide used in this study is about 0.6 m. A higher amplitude tide was not used as it was considered that it would have resulted in a joint probability that would have exceeded the probability of the flood flow being considered (Parramata City Council, 2005). The Parramatta River was found to be tidally influenced during a 100year ARI event as far upstream as the Silverwater Bridge (approximately 3km upstream of Homebush Bay) and these influences were accounted for in modelling.

The *Lower Parramatta River Floodplain Risk Management Study* (Parramata City Council, 2005) did not include consideration of sea level rise. With a high sea-level rise scenario of 1.1m relevant to a 2100 time period, the 100year ARI flood might be expected to rise to 3.1 m AHD which remains 1.4m below the lowest point on the site.

3 WATER QUALITY MANAGEMENT BASIS OF DESIGN

This section summarises the management of water quality in the Lagoon (See Appendix 6 for more detail). For stormwater quality treatment please refer to section 4.3.

3.1 Policy objectives

The Australian Government provides *Guidelines for managing risks in recreational water* (NHMRC, 2008) which are relevant to the proposed facility. The guidelines set out the recommended approach to managing hazards to users.

Hazard groups relevant to this site that are identified by the guidelines are:

1. Physical Hazards; water depth, submerged hazards.
2. Sun, Heat and Cold; including UV radiation, water temperature, air temperature.
3. Microbial quality; waterborne pathogens, bacteria etc.
4. Cyanobacterial quality; cyonbacteria and algae.
5. Chemical quality; natural occurring water quality and pollution.
6. Aesthetic Quality; transparency, colour, oil, litter.

Key risks for water quality in the surf lagoon from the public health perspective are microbial pathogens and algae.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) (ANZECC guidelines) provide authoritative guidance on fresh and marine water quality management issues in both New Zealand and Australia.

The ANZECC Guidelines are a part of Australia's National Water Quality Management Strategy (NWQMS) which provides a national approach for achieving sustainable use of Australia's water resources by protecting and enhancing water quality while maintaining economic and social development.

The ANZECC Guidelines include target ranges for a broad range of water quality parameters including biological indicators, physical and chemical stressors and toxicants.

3.2 Treatment system specification

The proposed treatment system for the lagoon has been designed to maintain required public health criteria in accordance with *Guidelines for managing risks in recreational water* (NHMRC, 2008) as well as to meet *ANZECC Fresh and Marine Water Quality Guidelines* (2000) for freshwater ecosystems. The proposed treatment system includes the following key elements:

- Bulk screening of gross pollutants;
- Filtration for removal of suspended solids;
- Biofiltration for removal of nutrients, pathogens and algae as well as turbidity reductions;
- Electro oxidation for reduction of total organic loading including from sun screen lotions, human perspiration, pathogens and algae; and
- UV Sterilisation to kill remaining pathogens.

Continuous mixing caused by the wave generation system will provide secondary water treatment via permanent oxygenation. It will also provide dispersion which will limit the colonisation or clumping behaviour of algae and some pathogen species.

Specifications are subject to future detailed design by a suitably qualified water treatment engineer in accordance with respective guidelines and policies.

3.3 Monitoring program

The NHMRC Guidelines suggest that water quality of the recreational water should be initially compared against the *Australian drinking water guidelines* to identify the chemicals which are present in concentrations that present sufficient concern to warrant further risk assessment and/or ongoing monitoring. Further, as noted in the NHMRC Guidelines, many of the guideline values for drinking water quality are based on an assumed daily intake (ingestion) of 2L which is not representative of exposure in a recreational environment. It may therefore be acceptable for contaminants to be significantly greater than the concentration that would be acceptable in drinking water sources.

The NHMRC guidelines and ANZECC guidelines have been considered in developing the proposed requirements for water quality monitoring and remedial actions for specific hazards related to lagoon water quality which are summarised in Table 6.

Drinking water is proposed as the primary water source for the lagoon therefore ongoing monitoring of the source water is not considered necessary.

Table 6: Proposed lagoon water quality monitoring program

Issue	Assessment	Remedial actions
Waterborne infection	Laboratory monitoring for enteric viruses and protozoa	Reduce contact time of surfers with the water in proportion to the risk.
Algal toxicoses	Visual monitoring for blue-green Cyanobacteria. Independent laboratory confirmation.	Reduce contact time of surfers with the water in proportion to the risk.
Mosquito	Visual monitoring	Health warning signage. Personal protection for non-surfers. Chemical treatment if infestation is severe.
Turbidity	Field monitoring supported by laboratory calibration.	Review coagulation strategy. Install additional filtration capacity.
Water chemistry	On line analysis supported by laboratory calibration.	Consider addition of chemicals to reduce pH.

4 STORMWATER MANAGEMENT PLAN

4.1 Policy objectives

Policy objectives outlined in section 0 include the following provisions which specifically address storm water quality management:

1. Minimise volume and frequency of stormwater discharge from hardstand areas such as paving, driveways and car parks, and maximise quality of any stormwater discharged.
   c) All stormwater discharged from the site is to meet:
      - water quality pollutant load reduction targets as outlined in *Stormwater Management and Water Sensitive Urban Design Policy*.
      - water quantity volume reduction targets and peak flow reduction targets as outlined in *Stormwater Management and Water Sensitive Urban Design Policy*.
   d) Design of landscaped and paved areas must incorporate water sensitive urban design elements and pollution control devices including but not limited to:
      - Appropriate stormwater management measures as detailed in Master Plan 2030;
      - Retaining a minimum of 20% of the site's open space area as deep soil. Areas included as deep soil are to have a minimum dimension of two metres. Consolidate areas of deep soil within sites and between adjacent sites to increase the benefits.
      - Minimising impervious areas that are directly connected to the stormwater system. Runoff from impervious areas such as driveways, paving and rainwater tank overflows should be directed onto landscaped areas designed to accept such flows
      - Removal of gross pollutants, sediments and nutrients prior to stormwater discharge to the trunk drainage system, through use of devices such as bioswales, sand filters, gross pollutant traps, and litter baskets
      - Installation of appropriately-designed bioswales or other stormwater harvesting systems within surface carparks that have more than ten spaces, such that water flows meet the relevant water quality and quantity targets for the catchment
      - Installation of oil and grease traps in surface and basement carparks o Using wetland plant species native to the Sydney region in water sensitive urban design features and associated landscaping, to avoid spread of weed propagules to downstream wetlands

4.2 Stormwater system design

Post-development hydrological and hydraulic modelling has been undertaken for the site using InfoWorks ICM. A summary of the modelling methodology applied is provided in Appendix 1.

The proposed drainage system for the site maintains existing discharge pathways to the Narawang wetlands north of the site via a vegetated open swale terminating in culverts beneath Hill Road. The proposed system provides capacity for 20 year ARI events within a system of overland flow via biofilters and vegetated buffer strips into vegetated open swales and culverts.

Post-development peak discharge flow rates for the critical 1yr, 20yr and 100yr ARI events are presented in Table 7 and the proposed drainage layout is shown in Figure 7. It is noted that post-development peak flow rates in the all design events including the 1 year ARI are significantly reduced. These peak flow reductions are expected to have a positive effect on the Narrawang wetlands through reduced potential for poor water quality and erosive impacts. The overall annual hydrological cycle of the wetlands as a result of these changes will not be significantly modified.

Typical design cross sections are provided for vegetated swales (Figure 8) and bioretention areas (Figure 9).

Table 7: Comparison of pre- and post-development peak discharge flow rates

Event	Predevelopment	Post-development
1-year ARI	0.33 m^3/s	0.20 m^3/s
20-year ARI	0.87 m^3/s	0.46 m^3/s
100-year ARI	1.01 m^3/s	0.54 m^3/s

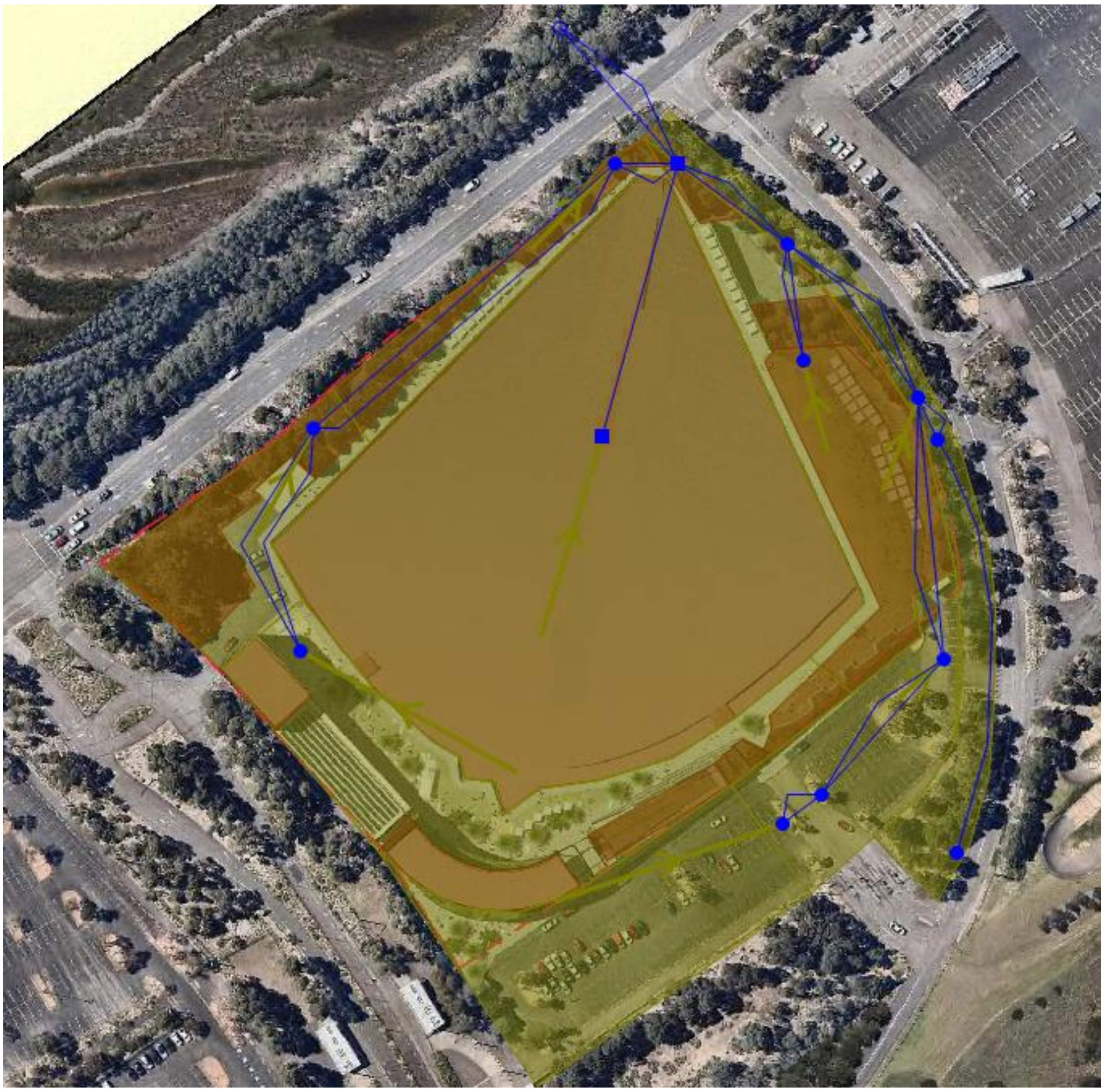

Figure 7: Modelled post-development drainage system

Figure 8: Typical existing vegetated swale

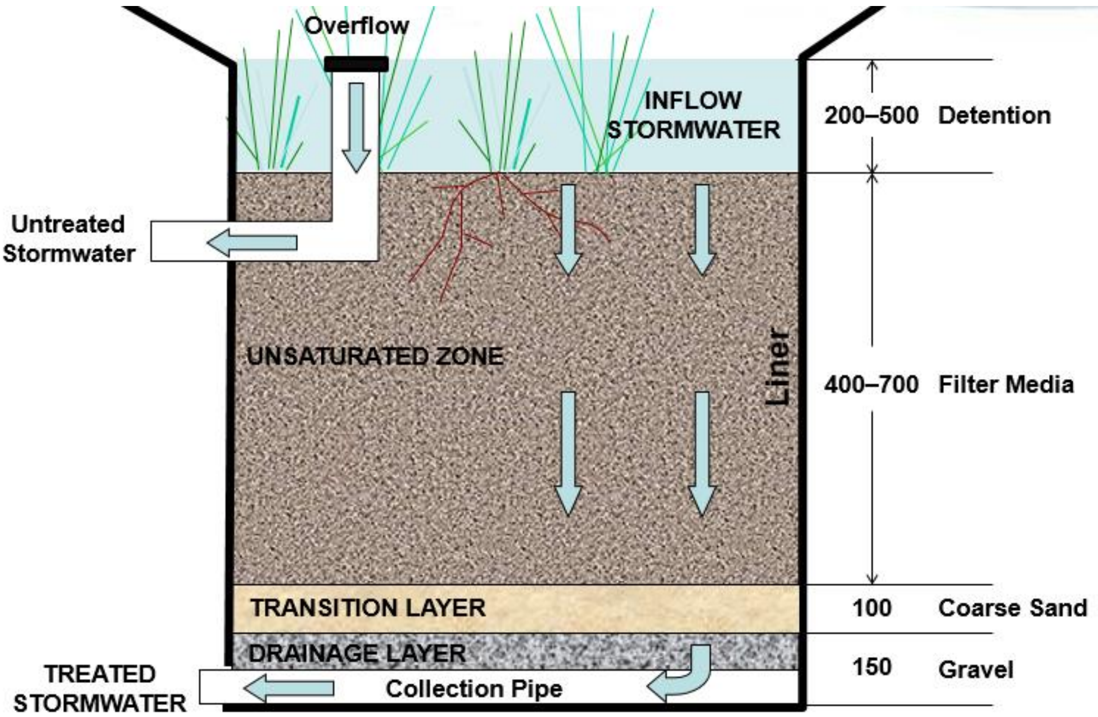

Figure 9: Typical bioretention area

4.3 Stormwater quality management system design

A treatment train for the site has been developed using MUSIC and applying the Sydney Olympic Park MUSIC Modelling Guideline. A summary of the modelling methodology applied is provided in Appendix 2.

The proposed treatment train presented in Figure 10 includes the following major components:

- Connection of all roofed areas to rainwater tanks for harvesting and reuse of stormwater to supply toilet facilities;
- All runoff from lagoon edge areas will pass through vegetated buffers prior to discharge into vegetated swales that will convey flows from the site at flow rates not exceeding pre-development rates;
- All runoff from car-park areas will be treated in bioretention areas prior to discharge into vegetated swales that will convey flows from the site at flow rates not exceeding pre-development rates; and
- Existing road reserves and battered slopes will be revegetated as required and runoff will be directed to vegetated swales that will convey flows from the site at flow rates not exceeding pre-development rates.

An example of the existing vegetated swales is shown in Figure 8 and an indicative bioretention area arrangement is shown in Figure 9. MUSIC modelling results are provided in Table 8 and demonstrate compliance with relevant percentage reduction targets.

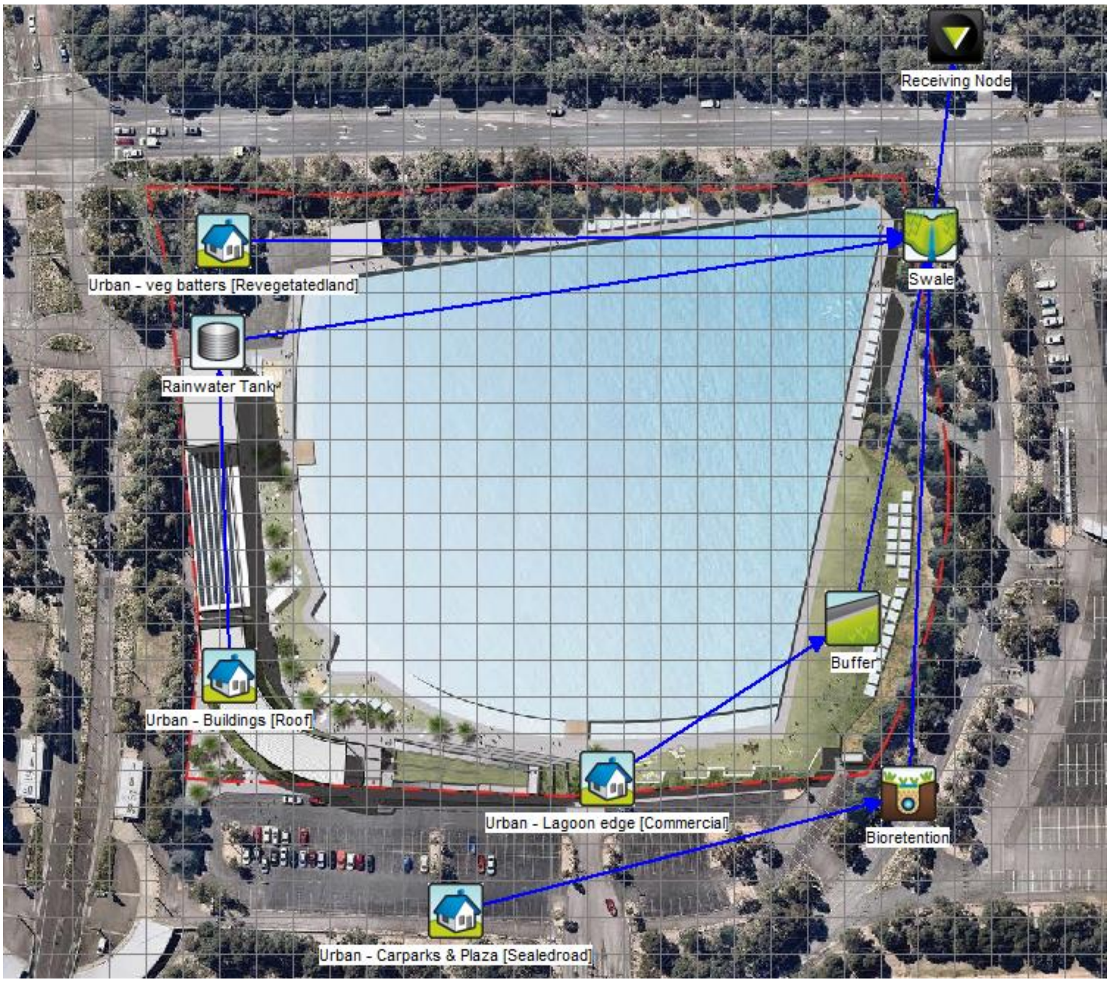

Figure 10: Modelled water quality management system

Table 8: Music modelling results – treatment train effectiveness

	Sources	Residual load	% reduction	Target reduction
Flow (ML/yr)	17.6	16.3	7.4	
Total Suspended Solids (kg/yr)	4640	342	92.6%	85%
Total Phosphorus (kg/yr)	7.87	2.26	71.3%	65%
Total Nitrogen (kg/yr)	38.8	21.3	45.1%	45%
Gross Pollutants (kg/yr)	415	0.00	100.0%	95%

5 WATER BALANCE

Water balance modelling has been undertaken for the site with three major components:

- Water demands assessment for the Lagoon accounting for top-up requirements to replace evaporative and other water losses including back-flushing of the water treatment plant;
- Water demands assessment for other facilities including toilets, showers, wetsuit washing facilities, hospitalities and irrigation; and
- Rainwater tank assessment to appropriately size the tanks for the potential harvesting area and provide an assessment of supply reliability.

5.1 Water demands assessment

5.1.1 Lagoon

Water demand modelling for the lagoon has been developed on a daily timestep over a 10-year duration including rainfall inputs, evaporative losses, leakage and flushing requirements. The modelling duration selected was 2001 to 2011 which represents a close to average decade with an average annual total rainfall for the decade of 1116.9 mm as compares to 1085.8mm which is the long-term average (1929-2017). The Lagoon is approximately 2 ha in size and 3.5m deep at its deepest points. The model incorporates as-designed stage areas and has been set with a tolerance for depth variation of 100mm consistent with the design requirements for the Wavegarden technology. Other modelling assumptions include:

- Base and walls of the lagoon are finished with a 7mm thick bentonite liner with an effective hydraulic conductivity of 10^{-10} m/s (approx. 8.6 x 10^{-6} m/day).
- Surrounding soils are assumed to be saturated.
- Evaporation has been modelled applying a derivation of the mass transfer equation that applies an expression for the mass transfer coefficient that is a function of wind-speed, water body surface area and includes consideration of the level of disturbance from patronage and wave generation.

A summary of the lagoon modelling results is provided in Table 9 and a more detailed output from the model is provided in Appendix 3.

Table 9: Lagoon water balance modelling results

Flux	Average annual volume	%	10-year peak
In			
Rainfall	15.15 ML/year	38.2%	23.19 ML/year
Top-up	22.72 ML/year	57.2%	27.09 ML/year
Flushing	1.83 ML/year	4.6%	
Out			
Evaporation	36.63 ML/year	92.2%	36.71 ML/year
Leakage	0.07 ML/year	0.2%	0.16 ML/year
Overflow	1.18 ML/year	3.0%	3.96 ML/year
Flushing	1.83 ML/year	4.6%	
Total	40.74 ML/year	100%	

5.1.2 Facilities and irrigation

Water demand modelling for other facilities and landscape irrigation has been undertaken based on predicted visitor numbers and including the following assumptions:

- 70% of visitors will use shower facilities
- 90% of female visitors will use toilet and hand washing facilities
- 40% of male visitors will use toilet and hand washing facilities
- 90% of male visitors will use urinal and hand washing facilities
- 70% of visitors will use wetsuit washing facilities
- 0.21 hectares of the site will consist of irrigated turf
- 0.02 hectares of the site will consist of irrigated native planting
- 0.38 hectares of the site will consist of un-irrigated native planting
- 2 buildings will be provided with evaporative cooling
- A small allowance for leaks has been included

A summary of the modelling results is provided in Table 10 and a more detailed output from the model is provided in Appendix 4.

Table 10: Facility and irrigation water demand modelling results (excludes lagoon)

Flux	Drinking water	NDW (WRAMS)	NDW (Rainwater)
In			
Rainfall			20.04
Scheme	8.95		
NDW (WRAMS)		3.16	
Use on site			
Internal facilities (excl. toilets) & external taps	8.34		
Irrigation		3.16	
Internal facilities (toilets only)	0.61		0.45
Out			
Wastewater	8.95		0.45
Runoff (to drains)			13.81
Evapotranspiration		3.16	2.09
Recharge			3.69
Total	8.95	3.16	20.04

5.2 Water source strategy

5.2.1 Water source options

The following water source options were reviewed to determine an optimal water source strategy for the site:

- Scheme water;
- Surface water from:
    - Haslams Creek; and
    - Narrawong Wetlands
- Groundwater;
- Stormwater harvesting from:
    - roofed areas of the site; and
    - carpark areas
- Treated Wastewater from SOPA's Wastewater Reclamation and Management Scheme (WRAMS).

Consideration was given to the quality of the source, the available volumes and sustainability of the source as well as other considerations such as approvals required. A summary of the outcomes of this assessment is presented in Table 11 below.

Table 11: Summary of potential water sources

Source	Quality	Quantity	Further Actions
Scheme Water	Likely to meet requirements (potable)	No issue (just sustainability)	None. Satisfactory quality and yield.
Surface water	Haslams Creek sediment highly contaminated and variable. Parramatta River (estuarine) is located 700m away but is also known for contamination (inc dioxins).	Parramatta River unlimited.	Regulatory approvals required for access and install of infrastructure. The Parramatta River is known for contaminated sediments (inc dioxins). Costs for treatment of contaminants make it prohibitive.
Narrang Wetlands	Unknown	Unknown	SOPA providing information on quality/quantity. Abstraction would require significant modelling and approval process (highly sensitive habitat).
Groundwater	Unknown. Deeper aquifer reportedly contaminated. Shallow aquifer requires further testing.	Unknown.	Site specific testing would be required. Unlikely to be suitable or provide sufficient yield.
WRAMS reclaimed water	Reportedly not suitable for human exposure. Likely to be expensive to treat to suitable standard.	Reportedly fully allocated.	Further discussions with SOPA to obtain supply for non-potable requirements.
Stormwater harvesting from carparks	Easy to remove hydrocarbons and sediment	TBC. It would require a storage reservoir.	Cost of redirecting pipe and storage reservoir make it unlikely.
Stormwater harvesting from roofs	Likely to meet requirements for non-potable use without treatment	Roof areas not extensive so yield may not be large.	Sizing of rainwater tanks to confirm yield.

5.2.2 Selected water sources

The water sources selected for use on the site are described below and have no volumetric licensing requirements.

Scheme water

Scheme water will be used for all drinking water demands at the facility and for the Lagoon to ensure suitable water quality for human contact is maintained at all times.

Sydney Water have advised that the site is able to be connected to the existing 300 mm diameter water main located in Holker Street. Preliminary advice provided indicates that the existing available water pressure will be suitable for the site.

Stormwater – harvested from roof areas

Rainwater is proposed to be harvested from all significant roofed areas within the facility. Water balance modelling has considered a system of four (4)10kL rainwater tanks collectively harvesting from approximately 1,000 m^2 of roof area. Because of the limited roof area of the facility, the harvested water will be prioritised for use in toilet flushing only.

Harvested rainwater falling direct to the lagoon and immediate surrounds is an important component of the lagoon water balance offsetting evaporative and other losses.

Treated wastewater

Treated wastewater will be sourced from the SOPA Wastewater Reclamation and Management Scheme (WRAMS) to supply water for landscape irrigation. The water is not of sufficient quality for any other uses on the site. Figure 11 shows the layout of WRAMS near the site indicating that it will be possible to connect to the system.

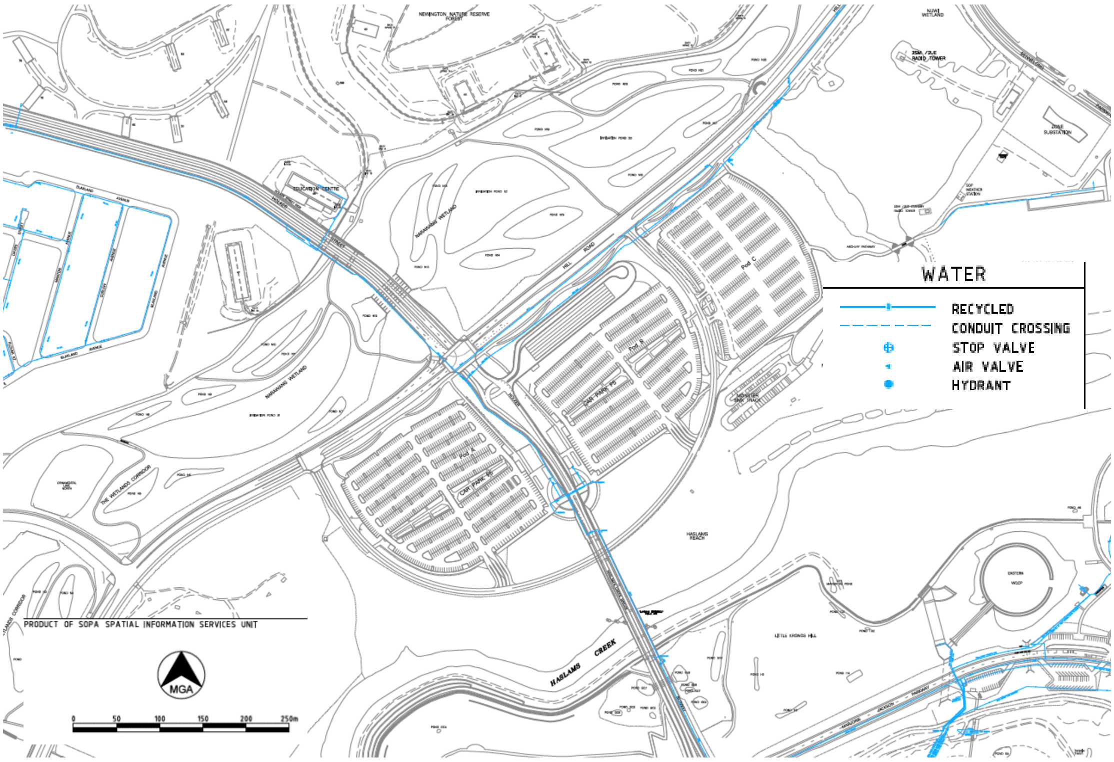

Figure 11: WRAMS Layout (extraction)

5.3 Water conservation measures

The site has been designed to maximise the efficiency of water use and reuse through the specification of water efficient fixtures and fittings and landscaping using low or zero irrigation demand species wherever possible.

Additionally, the site maximises the use of rainwater and treated wastewater to minimise scheme water demand.

Rainwater is proposed to be harvested from all significant roofed areas within the facility as well as the lagoon itself. Harvested rainwater accounts for over 30% of the total site water demand.

Treated wastewater sourced from the SOPA Wastewater Reclamation and Management Scheme (WRAMS) accounts for approximately 6% of the total site water demand.

5.4 Wastewater treatment and disposal

The facility will be connected to mains sewerage for disposal of all domestically generated wastewater.

Wastewater from the Lagoon treatment system will also be disposed of via sewer. Estimated volumes for disposal to sewer are provided in Table 12.

5.5 Water balance

Table 12 presents a consolidated water balance for the site including the lagoon and providing a direct comparison to the pre-development site water balance. A more detailed output from each element of the model is provided in Appendix 5.

Table 12: Broadscale comparison of pre- & post-development site water balance (incl. Lagoon)

Flux	Predevelopment	Post-development	change
In			
Rainfall	35.19 ML/year	35.19 ML/year	-
Scheme		33.50 ML/year	-
WRAMS		3.16 ML/year	-
Out			
EVT	3.92 ML/year	5.25 ML/year	+34%
Evaporation (lagoon)		36.63 ML/year	-
Recharge	6.65 ML/year	3.76 ML/year	-45%
Runoff	24.56 ML/year	14.98 ML/year	-39%
Wastewater		11.23 ML/year	-
Total	35.19 ML/year	71.85 ML/year	

5.6 Circumstantial discharge from the lagoon

It is necessary to have the ability to discharge from the lagoon in the event that significant repairs are required. However, it should be noted that there are no circumstances when an uncontrolled discharge will occur. The flow rate for discharge will be controlled to prevent downstream issues and the discharge can be terminated immediately in the event of significant rainfall or other unforeseen issue.

A number of options for discharge pathways were considered, including direct discharge to Haslams Creek via a new constructed drain. This option was excluded in favour of using existing drainage pathways as a result of the cost and complexity of construction and the need to avoid disturbance of the southern containment cell. Additionally, the use of existing drainage discharge pathways and restriction of flow rates to appropriate design rates will prevent any impact to aquatic and riparian ecosystems, bed and bank stability from construction or increased flow.

It is anticipated that the discharge strategy will be to pump the lagoon water via the existing engineered stormwater drainage to Nuwi wetland (connecting to Haslams Creek and ultimately the Parramatta River) as indicated in Figure 12. The discharge will be managed at less than 130 L/s so that it is comparable to a 1 year ARI rainfall event and will not exceed the capacity of the existing drainage system.

The strategy is highly unlikely to result in adverse water quality impacts to the receiving receptors, given the lagoon water quality will be required to meet the Australian Government National Health and Medical Research Council (NHMRC) *Guidelines for Managing Risks in Recreational Water* (2008), which are generally more prescriptive and sensitive than the applicable Australian and New Zealand *Guidelines for Fresh and Marine Water Quality* (Department of Agriculture and Water Resources, 2000).

It is noted that discharge events will be subject to an Operational Management Plan that will be endorsed by SOPA.

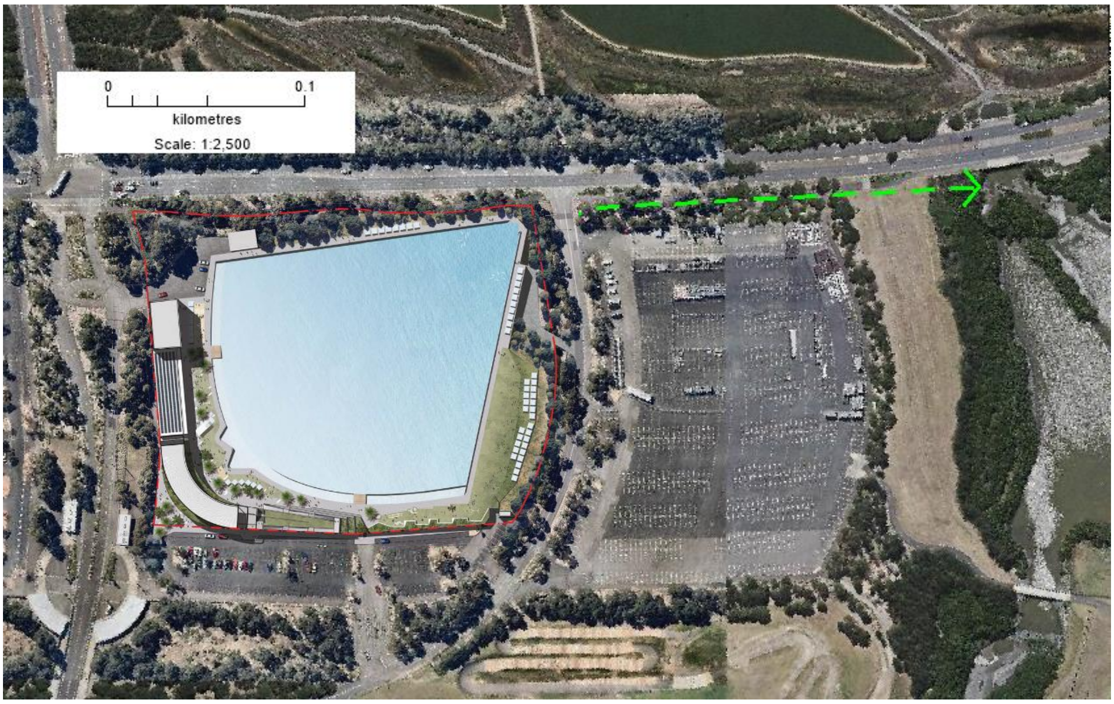

Figure 12: Proposed circumstantial discharge route

6 ENVIRONMENTAL MANAGEMENT PLAN

6.1 Management of nuisance insects

Construction of artificial waterbodies can provide new chironomid midge and mosquito habitats. The risk of nuisance insects can be minimised through good design and is expected to be minimised by the following design specifications:

- Minimal water level fluctuation (<100 mm)
- Regular shape with steep even sides
- Regular aeration (created by wave action)
- No aquatic vegetation
- Water quality treatment for recirculated inflows (insects and insect larvae will be filtered if they enter the Lagoon treatment process)

The site management plan may include, in regards to nuisance insect management, an ongoing program of midge and mosquito control including treatment options.

6.2 Landscape design and management

Landscape designs for the site have been developed with consideration of species selection to minimise water demand and includes the preferential use of locally endemic species in stormwater management systems and other vegetated areas. Specific arrangements for management of each of these areas are outlined below.

6.2.1 Stormwater management systems

Some existing vegetated swales will be removed for construction of the lagoon and other facilities. It has been previously noted that these swales are used by Blue Tongue and other lizards. To avoid harm to these animals, a suitably licenced and experienced ecologist will be on site to ensure that, where possible, they are rescued and relocated prior to removal of existing vegetated swales.

Existing vegetated swales that are to be retained will require weed removal and revegetation. A suitable weed removal and revegetation methodology will be developed by a suitably licenced and experienced ecologist to minimise potential impacts.

6.2.2 Other vegetated areas

The use of turf is minimised and limited to specific functional areas of the site. Verge areas and batters will be vegetated with locally endemic species selected for minimal water demand, to provide suitable visual buffering for the site and to provide habitat for and facilitate the movement of local fauna.

7 CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN

A *Site-Specific Construction Environmental Management Plan* (InSite Remediation Services, 2017) has been prepared for the site. Elements of the plan, relevant to water and soil management, are reproduced below.

7.1 Erosion and Sediment Control Plan (ESCP)

Objective: To ensure that the design, operation and management of all site erosion, sedimentation and water quality controls are integrated during construction or remediation activities and that operational impacts on the environment are minimised

Urban runoff is a source of pollutants in NSW waterways and such pollution is caused by point sources. Contaminants are mainly transported by wind, rainfall or overland flow.

The aim of this ESCP is for the control of surface water and the prevention of erosion and sediment deposition specifically into the stormwater systems adjacent to the site and to prevent surface runoff from the site. It will do this by ensuring the following measures are put in place during all site works:

Entry to the site will be confined to the designated location in the traffic management plan and all vehicles must follow the designated transport routes that will be marked by pickets, tape, ground paint or a combination of these. This is to prevent unnecessary site disturbance. These corridors will have to be moved depending upon where works on site are being carried out. All vehicles will operate in accordance with the Traffic Management Plan. Likewise the exit point will be through the designated exit with all trucks passing through the truck wash / rumble grid prior going onto any roads.

The ESCP will meet the requirements of the "*Managing Urban Stormwater Soils and Construction" NSW Landcom 2004 4PthP Edition* (March 2004). Other elements of the ESCP are:

- Trenches containing contaminated water will not be lined as they will not contain water for an extended period of time.
- Any asbestos contaminated material will be stockpiled on a level sealed surface and be covered at night as the material has the potential to erode during a rain event or has the potential to create a dust hazard;
- Stockpiles will only be placed on sealed areas, or on top of a waterproof layer in unsealed areas;
- Stockpiles shall only be set up within the areas designated as free from items of Heritage significance;
- Silt fences will be constructed around any excavation and stockpile area from geotextile fabric to minimise potential migration of sediment anywhere else on site or to neighbouring properties;
- Any stormwater drains, pits and sumps located within the remediation works area will be protected by a combination of gravel "sausage" and sediment fences comprising of straw bales encased in geotextile fabric;
- If in areas where the anticipated level of sediment may be excessive then the silt fence will also be complemented with straw bales encased in geotextile fabric;
- All stockpiles will be placed at least 2 metres from all areas of concentrated water flow that may exist on site;
- Where possible stockpiles will have a maximum size of 1,000 cubic metres in dimensions but be restricted in height to 3 metres (not anticipated during these works).

- Progressive revegetation or the use of binding agents with grass seed sprays will be considered if necessary to further minimise dust propagation.
- All stockpiles will be placed away from drainage lines, gutters, stormwater pits or inlets;
- Validated backfill material will be reintroduced and suitably compacted in 0.3m lifts to minimise potential for differential erosion;
- All erosion and sediment controls will be checked by the Project Supervisor twice weekly or immediately after rain to ensure they are maintained in a fully functional condition. If in the event of accumulation of sediment around any controls that may reduce their effectiveness, the sediment will be removed by hand with shovel in such a manner as to not disturb or damage the control (i.e. geotextile containment sock or hay) in any way. If it is damaged then it will be replaced immediately. As a further preventative measure, other ways will be considered and implemented to prevent any future sediment runoff in the area.
- Stockpiles will have no slopes greater than 30 degrees to minimise possible erosion and sediment migration to the base of the stockpile during rain activity events.

Other management strategies to control site erosion and the water quality of runoff as determined by the following factors could be implemented in addition to the above:

- material type;
- slope of site;
- site erosion hazard rating;
- surface rock;
- extent and duration of site disturbance;
- Proximity of watercourses and drainage lines and sensitivity of receiving waters.

The proposed erosion and sediment controls and soil and water controls are illustrated in Figure 13 (reproduced from Appendix C of InSite Remediation Services: *Site Specific Construction Environmental Management Plan*, 2017).

Figure 13: Sediment and Erosion Control Plan (Source: InSite Remediation Services)

7.2 Soil and Water Management Plan (SWMP)

Objective: To ensure that the design, operation and management of all site erosion, sedimentation and water quality controls are integrated during construction or remediation activities and that operational impacts on the environment are minimised

The aim of the SWMP is for the control of surface water and the prevention of erosion and sediment deposition specifically into the stormwater systems adjacent to the site and to prevent surface runoff from the site. It will do this by ensuring that the measures as detailed in the ESCP will be put in place during site works in addition to the following:

- Minimise on site vehicle activity during periods of wet weather or when the site is muddy and remove soil on wheels or undercarriage prior to site departure; work will cease during heavy rainfall, and not be recommenced until the site dries out sufficiently to minimize disturbance of soils/fill;
- The project will be managed to prevent erosion at source rather than relying on sediment capture at discharge;
- The project will be staged to ensure vegetation clearing maintains as much natural vegetation wherever possible in accordance with project objectives;
- Disturbed areas will be stabilised as soon as practicable following completion, or temporary cessation, of earthworks. Additional slope stabilisation measures will be provided where required;
- Energy dissipaters or other scour prevention measures will be installed, downstream of culverts or other structures, as required to minimise erosion;
- Any fuel relating to the proposed work is to be contained in sealed vessels of appropriate volumes and stored within bunded areas. The work area bund shall be designed to collect and prevent down slope movement of 110% of the volume of all liquids and fuels stored or used on the site.
- Any spillage of fuels or wastes would be contained and collected in an appropriate manner (such as with the use of sand or sawdust) and the resultant contaminated material would be disposed of at an approved waste depot.
- The project will be designed to minimise runoff volume, velocity and peak flow rates, retain eroded sediment within the construction area and control loss of soil off site;
- Design specifications will include inspection, maintenance and follow-up programs for all water treatment devices and structures. All water treatment structures will be designed to be accessible for structural and vegetation maintenance and for removal of sediments. Control structures will be designed to be stable in the predicted peak flow from the appropriate design storm event.
- The area of disturbed soil and vegetation will be minimised. Where possible, work will be undertaken in a staged manner to minimise the area of exposed soil at any one time.
- Stockpiles will be located on stable surfaces and away from potentially sensitive areas, particularly areas of concentrated water flows. Erosion control measures will be implemented as appropriate.
- Erosion and sedimentation controls are to be regularly inspected to ensure performance to the design criteria and maintained to design specifications. Controls are to be upgraded or altered if these objectives are found not to be satisfied.
- Existing drainage lines are to be identified in design and construction drawings and protected by using appropriate measures such as sedimentation barriers, timber windrows and grassed areas or by directing the site drainage water to a sediment control structure.
- Clean water that may run onto the site shall be diverted around the site to minimise the quantity of water that may require treatment prior to disposal or release. Water should

be diverted along stable diversion drains, banks or bunds around or away from exposed areas of soil or loose material.

The proposed water / sediment controls are illustrated in Figure 13 (reproduced from Appendix C of InSite Remediation Services: *Site Specific Construction Environmental Management Plan*, 2017).

7.2.1 *Stockpiling of Materials*

Only one type of material shall be stored in any given stockpile. The range of different materials that may be required to be separately stockpiled include, but are not limited to:

- Concrete/Bitumen Hardstand;
- Steel (if concrete re-enforcement is encountered);
- VENM; or
- Asbestos impacted soils.

7.2.2 *Stockpile Locations*

Stockpiles will be located in accordance with the following requirements;

- Placement of stockpiles adjacent to areas where capping of "fill areas" is to occur in volumes no larger than can be compacted into those fill areas without exceeding the capping volume.
- Secondary preference will be given to areas where soils can be easily loaded with asbestos impacted soil/fill directly into trucks for transport to asbestos licenced landfill.
- Stockpiles will only be placed at locations that have been first approved by the Project Manager.
- Stockpiles will be located in designated stockpile areas.
- No stockpiles of soils or other materials will be placed on footpaths or nature strips.
- All stockpiles shall be placed away from drainage lines, gutters, stormwater pits or inlets.
- All stockpiles will be laid out on sealed surfaces where possible, and are to be covered and stored progressively to minimise dust and dour emissions and wash-off during rainfall.

7.2.3 *Stockpile Area Preparation*

All stockpiles will be constructed in areas of the site that have been located and prepared in accordance with the requirements of the site WMP. All preparatory works will be undertaken prior to the placement of material in the stockpile. InSite will initially clear the area of rubbish, rubble and vegetation. The area will then be trimmed and graded, so that any local depressions or mounds are removed. The final surface of the stockpile area will be made smooth and even. Buffer zones and access routes will be established around each stockpile area to prevent cross contamination and enable access to haul routes.

7.2.4 *Construction and Maintenance*

All stockpiles will be maintained in an orderly and safe condition. Batters will be formed with slope angles that are appropriate to prevent collapse or sliding of the stockpiled material. Provision for the management of both dust and surface water runoff from the stockpiles will be made so as to minimise the potential for environmental impact from these areas. These measures may include, but will not be limited to, progressive covering with geo-fab, the construction of temporary bunds around the handling areas and dust suppression by use of appropriate water spraying equipment depending on actual site conditions. Covering of stockpiles will be undertaken if required by the nature of the material (i.e. asbestos impacted) or meteorological conditions.

7.3 Construction environmental monitoring program

Monitoring of environmental performance and compliance auditing of InSite's Environmental Management Systems will be conducted throughout the works. This will enable the overall effectiveness of established environmental controls and compliance procedures to be assessed, and allow areas of non-conformance to be identified so corrective actions can to be taken to improve Environmental outcomes.

The environmental monitoring and audit program should consist of daily, weekly and event based inspections and associated reports.

8 MONITORING AND MAINTENANCE PLAN

The following monitoring program, as discussed in section 3.3, will be followed for the lagoon.

Table 13: Proposed lagoon water quality monitoring program

Issue	Assessment	Remedial actions
Waterborne infection	Laboratory monitoring for enteric viruses and protozoa	Reduce contact time of surfers with the water in proportion to the risk.
Algal toxicoses	Visual monitoring for blue-green Cyanobacteria. Independent laboratory confirmation.	Reduce contact time of surfers with the water in proportion to the risk.
Mosquito	Visual monitoring	Health warning signage. Personal protection for non-surfers. Chemical treatment if infestation is severe.
Turbidity	Field monitoring supported by laboratory calibration.	Review coagulation strategy. Install additional filtration capacity.
Water chemistry	On line analysis supported by laboratory calibration.	Consider addition of chemicals to reduce pH.

In addition to monitoring of the lagoon water quality treatment system discussed in section 3.3, there is a need for ongoing monitoring and management of stormwater management systems proposed for the site including regular inspection and remedial actions where necessary. The following preliminary monitoring and maintenance plan is proposed for the site:

Table 14: Proposed stormwater system monitoring program

Element	Inspection frequency	Remedial actions
Stormwater harvesting system	Annual	Clear obstructions and dirt from gutters and rainwater tank inlets
Vegetated swales and biofilters	Twice per year in Spring and Autumn	Sediment and dead plant removal Structural repairs Weed removal Replanting
Mosquito	Twice per year in Spring and Autumn	Health warning signage. Chemical treatment if infestation is severe.
Water quality	Quarterly sampling for first 12 months Frequency may be reduced thereafter following review of data.	Samples will be compared to ANZECC guidelines and typical stormwater discharge quality. Consider system modifications where performance is found to be inadequate

The full scope of onsite monitoring and reporting will be developed once more details including specification and design are completed and available for review.

9 REFERENCES AND RESOURCES

ANZECC & ARMCANZ 2000, *Australian and New Zealand guidelines for fresh and marine water quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

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Sydney Olympic Park Authority, 2016, Stormwater Management and Water Sensitive Urban Design Policy

Sydney Olympic Park Authority, 2016, Sydney Olympic Park MUSIC Modelling Guideline

Sydney Olympic Park Authority, 2016, Water Sensitive Urban Design Guideline

Sydney Olympic Park Authority, 2016, Rainwater Tank Guideline

APPENDIX 1: HYDROLOGICAL AND HYDRAULIC MODELLING METHODOLOGY

InfoWorks is a hydraulic modelling package used to simulate stormwater drainage systems. The software package is capable of hydrological modelling of the complete urban water cycle, including stormwater drainage master planning or studies, assessments of flooding in urban drainage systems and hydraulic response of the stormwater network infrastructure to the changes in the land use. The hydraulic software component can resolve open channel and closed conduit flows, model the effect of backwater effect and reverse flow. The model is used predominantly for calculations of event-based simulations; therefore, the initial conditions are usually set.

Time-varying surface runoff generated by the runoff routing model discharges into the hydraulic network. The hydraulic network consists of interconnected nodes (manholes, outfalls and storage basins) and links (weirs, pipes, culverts and open channels).

The numerical model is run for pre-development land use to determine maximum discharge from each subcatchment for critical 1-, 20- and 100-year average recurrence interval rainfall events. The peak pre-development discharge flow rates of the subcatchments are to be maintained in the post-development scenario.

Design rainfall events based on Australian Rainfall and Runoff 1987 (ARR87) were generated at 1-, 20- and 100-year average recurrence intervals and event durations of 15m, 30m, 1h, 3h, 6h and 12h. ARR87 design rainfall parameters provided by the Bureau of Meteorology are presented in Figure 14.

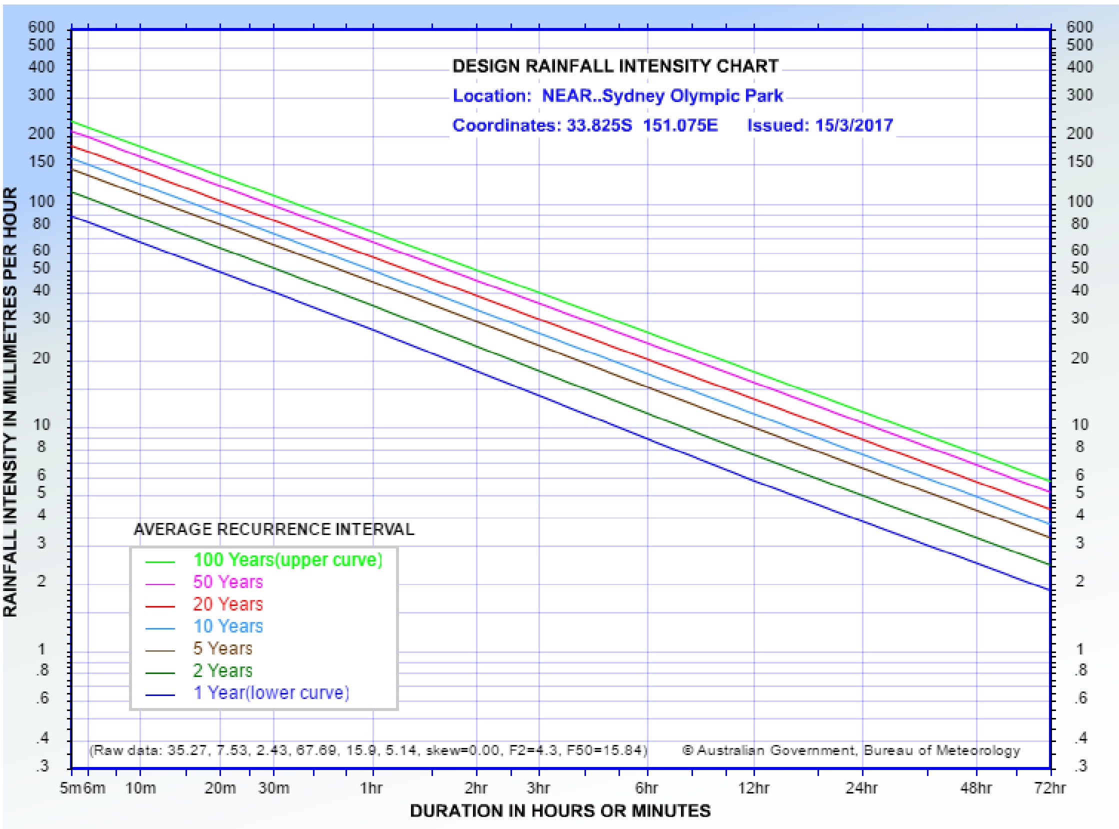


Figure 14: Intensity frequency duration chart and statistics for the site (Source BoM, 2017)

Modelling assumptions

Land use for the existing and development scenarios (Table 15 and Table 16) was developed based on cadastral information and aerial imagery. The land use categories relate to hydrologic responses and do not necessarily relate directly to planning or zoning categories.

Table 15: InfoWorks model catchment properties for pre-development scenarios

		Land use areas (ha)		
Subcatchment ID	Total area (ha)	Hardstand	Landscape	Lagoon
S001	0.7524229	0.640	0.112	n/a
S002a	0.572	0.481	0.091	n/a
S002b	0.550	0.316	0.234	n/a
S003a	0.840	0.726	0.114	n/a
S003b	0.286	0.001	0.285	n/a
S004a	0.752	0.596	0.156	n/a
S004b	0.336	0.183	0.153	n/a

Table 16: InfoWorks model catchment properties for post-development scenarios

		Land use areas (ha)		
Subcatchment ID	Total area (ha)	Hardstand	Landscape	Lagoon
Lagoon	1.754	n/a	n/a	1.754
S001	0.280	0.000	0.280	n/a
S002a	0.267	0.267	0.000	n/a
S002b	0.424	0.424	0.000	n/a
S003a	0.425	0.112	0.313	n/a
S003b	0.532	0.459	0.072	n/a
S004a	0.146	0.058	0.087	n/a
S004b	0.241	0.088	0.153	n/a

Manning's roughness coefficients applied to conduits are summarised in Table 17.

Table 17: Manning's roughness coefficients

Drain type	Mannings N
Open drainage	0.040
Culverts	0.015
Overland flowpaths	0.015

Based on the discussion of extreme flood modelling and recorded events presented in section 2.5 a downstream 100 year ARI flood level of 2.0 m AHD is considered reasonable and has been applied as a downstream boundary condition in hydraulic modelling of the 100 year ARI event.

Surface runoff parameters

The InfoWorks model of the site uses a fixed proportional runoff model to generate rainfall runoff from impervious surfaces and a constant infiltration model to generate rainfall runoff from pervious surfaces. The SWMM single nonlinear reservoir routing model is applied to provide inflows to the Hydraulic component of the model.

Modelled predevelopment catchments were derived based on analysis of LiDAR data and drainage design information provided. Catchments were modified for post-development scenarios based on the current proposed site layout. Pre- and Post-development modelled catchments are presented in Figure 15 and Figure 16.

Catchment parameters are presented in Table 18 and have been developed with consideration of Sydney Olympic Park Authority policies and guidelines as well as other studies carried out in the Haslams Creek and broader Lower Paramatta River catchments (Parramatta City Council, 2005 and Auburn City Council, 2003).

Table 18: Catchment parameters

Land use category	Initial loss (mm)	Runoff parameter	Infiltration rate
Hardstand/paved areas	1.5mm	0.9	-
Landscape areas (pervious)	10mm	-	1.5 mm/hr
Lagoon	10mm	0.9	-

Sensitivity testing – climate change effects

Modelling with rainfall intensities increased by 20% has been completed as a simple consideration of potential climate change effects. Pre- and post-development peak discharge flow rates for the critical 1yr, 20yr and 100yr ARI events are presented in Table 19 compared with post -development peak flows with increased rainfall intensity. It is noted that post-development peak flow rates in the all design events remain lower than pre-development peak flows.

Table 19: Comparison of pre- and post-development peak discharge flow rates

Event	Predevelopment	Post-development	Rainfall intensity +20%
1-year ARI	0.33 m^3/s	0.20 m^3/s	0.27 m^3/s
20-year ARI	0.87 m^3/s	0.46 m^3/s	0.51 m^3/s
100-year ARI	1.01 m^3/s	0.54 m^3/s	0.78 m^3/s

Figure 15: Modelled predevelopment catchments

Figure 16: Modelled post-development catchments

APPENDIX 2: MUSIC MODELLING METHODOLOGY

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) has been used to undertake conceptual design of stormwater treatment systems for the proposed UrbnSurf Sydney facility at Sydney Olympic Park applying methods and parameters recommended by the *Sydney Olympic Park Music Modelling Guidelines*.

Rainfall and Evaporation

Sydney Airport AMO 6-minute rainfall data with a modelling period of 1/1/1988 to 31/12/1998 has been used for all MUSIC modelling scenarios.

Average monthly potential evapotranspiration values for the Sydney region, including Sydney Olympic Park have been used for all MUSIC modelling scenarios.

Source nodes

Four source nodes have been defined for the site and are presented in Table 20.

Table 20: MUSIC model source nodes

Source node id	Area	Surface type	
Carparks & plaza	1.26 ha	Sealed road	100% impervious
Buildings	0.10 ha	Roof	100% impervious
Lagoon Edge	0.70 ha	Commercial	50% impervious
Landscape batters & verges	0.39 ha	Revegetated land	100% pervious
Total	***2.31 ha***		

Soil properties

All source nodes for the site apply 'Urban' soil characteristics outlined in the *Sydney Olympic Park Music Modelling Guidelines* and are presented in Table 21.

Table 21: MUSIC model source node soil properties

Source node id	Units	Urban
Impervious areas		
Rainfall threshold	mm	1.4
Pervious areas		
Soil capacity	mm	93
Initial storage	%	30
Field capacity	mm	68
Infiltration capacity coefficient a		135

Source node id	Units	Urban
Infiltration capacity coefficient b		4.0
Groundwater		
Initial depth	mm	10
Daily recharge rate	%	10
Daily baseflow rate	%	10
Deep seepage	%	0

Pollutant generation

Stormwater quality parameters have been adopted for use from the *Sydney Olympic Park Music Modelling Guidelines* and are presented in Table 22.

Table 22: MUSIC model stormwater quality parameters

Land use category		Log_{10} TSS (mg/L)		Log_{10} TP (mg/L)		Log_{10} TN (mg/L)	
		Storm	Base	Storm	Base	Storm	Base
Roof areas	mean	1.30		-0.89		0.30	
	std. dev.	0.32		0.25		0.19	
Road areas	mean	2.43		-0.30		0.34	
	std. dev.	0.32		0.25		0.19	
Other impervious areas	mean	2.15		-0.60		0.30	
	std. dev.	0.32		0.25		0.19	
Urban pervious areas	mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	std. dev.	0.32	0.17	0.25	0.19	0.19	0.12
Forest/natural areas	mean	1.60	0.78	-1.10	-1.52	-0.05	-0.52
	std. dev.	0.2	0.17	0.22	0.13	0.19	0.13

Link routing

No routing has been applied to all links in MUSIC modelling.

Treatment measures

Swales, Rainwater Tanks, Bioretention and Buffers have been modelled as elements of the proposed stormwater quality treatment train for the UrbnSurf facility at Sydney Olympic Park. Input parameters applied in modelling are consistent with those specified in the *Sydney Olympic Park Music Modelling Guidelines* and are presented in Table 23.

Table 23: MUSIC model treatment system input parameters

Parameter	Units	Value
Swales		
Low flow bypass	m^3/s	0
Length	m	185
Bed Slope	%	2.0
Base width	m	1.5
Top width	m	1.5
Depth	m	0.5
Vegetation height	m	0.25
Exfiltration	mm/hr	0
Rainwater tanks		
Low flow bypass	m^3/s	0
High flow bypass	m^3/s	100
Number of tanks		4
Volume below overflow pipe	kL	40
Depth above overflow	m	0.2
Surface area	m^2	20
Initial volume	kL	40
Overflow pipe diameter	mm	100
Bioretention		
Low flow bypass	m^3/s	0
High flow bypass	m^3/s	100
Extended detention depth	m	0.3
Surface area	m^2	275
Filter area	m^2	275
Unlined filter media perimeter	m	0.0
Saturated hydraulic conductivity	mm/hr	100
Filter depth	m	0.5
TN content of filter media	mg/kg	500
Orthophosphate content of filter media	mg/kg	50
Exfiltration rate	mm/hr	0.0
Is base lined?		yes
Vegetation properties		effective
Overflow weir width	m	2.0
Underdrain present?		yes

Parameter	Units	Value
Submerged zone with carbon present?		no
Buffers		
Percentage of upstream area buffered	%	100
Buffer area (% of upstream imperv. area)	%	50
Exfiltration rate	mm/hr	0

APPENDIX 3: LAGOON WATER BALANCE MODELLING OUTPUT

WATER BALANCE CALCULATIONS
Lagoon Water Balance - Options Analysis

Calculation Sheet 1

Scenario	Geosynthetic Clay Liner
Inf Model	Liner
Rainfall Data	
Source	Sydney Olympic Park
Reference	66195

Date	Rainfall mm
1/01/2001	0
2/01/2001	0
3/01/2001	0
4/01/2001	0
5/01/2001	0
6/01/2001	0.6
7/01/2001	0
8/01/2001	0
9/01/2001	0
10/01/2001	0
11/01/2001	0
12/01/2001	0
13/01/2001	0
14/01/2001	0
15/01/2001	0
16/01/2001	0
17/01/2001	0
18/01/2001	0
19/01/2001	0
20/01/2001	0.2
21/01/2001	0
22/01/2001	0
23/01/2001	0
24/01/2001	0
25/01/2001	0
26/01/2001	0.4
27/01/2001	1
28/01/2001	27
29/01/2001	0.4
12/02/2001	0
24/02/2001	0

Climate Data

Month	Evap mm/month	mm/day	Surr GWL m AHD
Jan	229	7.4	7.5
Feb	173	6.0	7.5
Mar	166	5.3	7.5
Apr	147	4.9	7.5
May	118	3.8	7.5
Jun	99	3.3	7.5
Jul	111	3.6	7.5
Aug	158	5.1	7.5
Sep	202	6.7	7.5
Oct	235	7.6	7.5
Nov	214	7.1	7.5
Dec	242	7.8	7.5
Jan	228.684031	7.4	7.5

Model Inputs

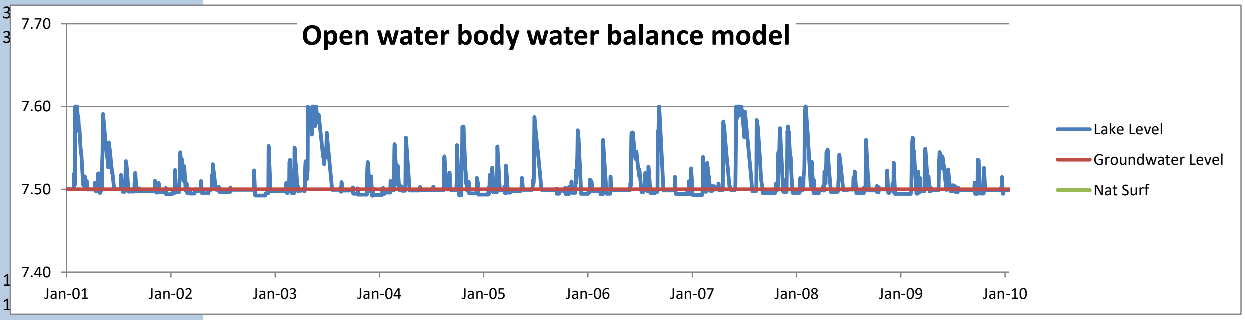
initial water level	7.50	mAD
pan evaporation factor	1.00	El/Ep
liner conductivity - 10^	-10	m/s
liner conductivity	0.00000864	m/day
liner thickness	0.007	m
seepage through base	Y	(Y/N)
base of lake	4.5	m AD
depression storage	2	mm
natural surface level	9	mAD
site area draining to lake	1.754	ha
overflow level	7.6	m
max volume	44226.7735	m3
maintained lake level	7.5	m

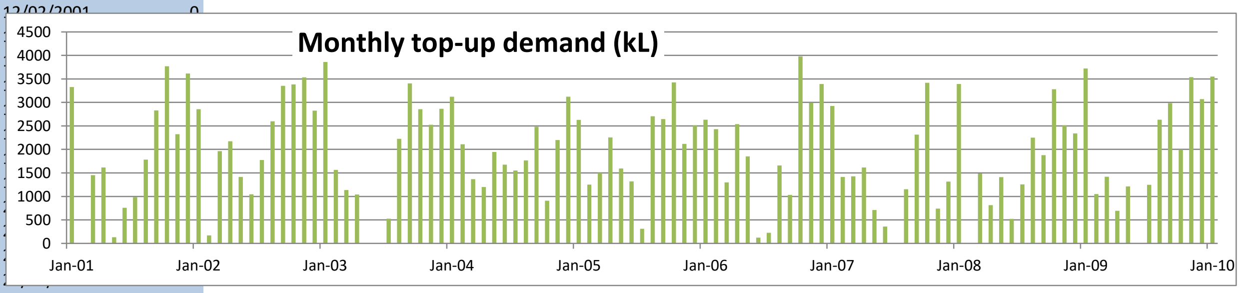
Lake Surface Area Contours

Level	Area (m2)	Storage
4.5	9422	0
5	11046	5117
5.5	12669	11046
6	14293	17786
6.5	15916	25339
7	17540	33703
7.5	17540	42473
8	17540	51243
8.5	17540	60013

Model Results	Total (ML)	
Change in Storage	-0.09	
INPUTS	39.7	Peak Annual
Direct Rainfall	151.5	23.19
Catchment Runoff	0.0	0.00
GW top-up	227.2	27.09
OUTPUTS	39.7	
Evaporation	366.3	36.71
Net seepage to GW	0.7	0.16
Overflow as Stormwater	11.8	3.96

Annual Demand	ML
Maximum	27.1
Minimum	17.4
Average	22.7





APPENDIX 4: FACILITIES & IRRIGATION WATER DEMAND MODELLING OUTPUT

Site Water Balance
UrbnSurf: Sydney Olympic Park
Sheet 1: Water Demands and Waste Generation

Domestic Uses

Dwelling Type		UrbnSurf facilities																	
No. households		1																	
Population / household		818			2.736			1.814			1.765			1.552			1.552		
Occupancy %		100			100			100			100			100			100		
Effective Population		818			0			0			0			0			0		
Use	Base Rate	Rate	Source	Waste	Rate	Source	Waste	Rate	Source	Waste	Rate	Source	Waste	Rate	Source	Waste	Rate	Source	Waste
Domestic Individual Usage	kL/pp/day																		
Shower	0.027	0.0184	DW	BW	0.027	DW	GW1	0.027	DW	GW1	0.027	DW	GW1	0.027	DW	GW1	0.027	DW	GW1
Kitchen sink	0.001	0	DW	GW2	0.001	DW	GW2	0.001	DW	GW2	0.001	DW	GW2	0.001	DW	GW2	0.001	DW	GW2
Bathroom basin	0.002	0.0023	DW	BW	0.002	DW	GW1	0.002	DW	GW1	0.002	DW	GW1	0.002	DW	GW1	0.002	DW	GW1
Dishwasher	0.003	0	DW	GW2	0.003	DW	GW2	0.003	DW	GW2	0.003	DW	GW2	0.003	DW	GW2	0.003	DW	GW2
Bath	0.001	0	DW	GW1	0.001	DW	GW1	0.001	DW	GW1	0.001	DW	GW1	0.001	DW	GW1	0.001	DW	GW1
Laundry trough	0.004	0	DW	GW1	0.004	DW	GW1	0.004	DW	GW1	0.004	DW	GW1	0.004	DW	GW1	0.004	DW	GW1
Toilet	0.005	0.003	RW	BW	0.005	NDW	BW	0.005	NDW	BW	0.005	NDW	BW	0.005	NDW	BW	0.005	DW	BW
Urinals	0.001	0.0005	RW	BW	0.001	NDW	GW1	0.001	NDW	GW1	0.001	NDW	GW1	0.001	NDW	GW1	0.001	NDW	GW1
Household Usage	kL/household/day																		
Leaks	0.029	0.029	DW	N/A	0.029	DW	N/A	0.029	DW	N/A	0.029	DW	N/A	0.029	DW	N/A	0.029	DW	N/A
Wetsuit washing	0.005	2.7812	DW	BW	0.005	DW	N/A	0.005	DW	N/A	0.005	DW	N/A	0	DW	N/A	0.005	DW	N/A
Evaporative cooling	0.006	0.012	DW	N/A	0.006	DW	N/A	0.006	DW	N/A	0.006	DW	N/A	0.006	DW	N/A	0.006	DW	N/A
Other	0.004	0	DW	N/A	0.004	DW	N/A	0.004	DW	N/A	0.004	DW	N/A	0.004	DW	N/A	0.004	DW	N/A
Other	kL/each/year																		
Household / Communal Pools	90	0	DW	N/A	0	DW	N/A	0	DW	N/A	0	DW	N/A	0	DW	N/A	0	DW	N/A

Domestic Irrigation							
Number Lots		0	0	0	0	0	0
Average Lot Area	m2	1500	600	250	150	2000	100
Irrigated area	%	12	25	25	25	22	50
Irrigation event depth	mm	10	10	10	10	10	10
Frequency (days/week)	days	2	2	2	2	2	2
Season length	months	9	9	9	9	9	9
Source		GNDW	GNDW	GNDW	GNDW	GNDW	GNDW
No. Irrigation Events		79.0	79.0	79.0	79.0	79.0	79.0
Irrigation Demand	kL/year	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Waste Streams	kL/year						
Greywater Type 1 (GW1)		0	0	0	0	0	0
Greywater Type 2 (GW2)		0	0	0	0	0	0
Black Water (BW)		8240	0	0	0	0	0
Lost (N/A)		15	0	0	0	0	0
Irrigation (IRR)		0	0	0	0	0	0
Overall Domestic Demand							
Drinking Water (DW)	kL/year	7198	0	0	0	0	0
Non-Drinking Water (NDW)		0	0	0	0	0	0
Rain Water (RW)		1058	0	0	0	0	0
Groundwater (GND)		0	0	0	0	0	0
Total Demand		8255	0	0	0	0	0
Total per capita demand	kL/pp/yr	10	######	######	######	######	######
Per capita DW demand		9	######	######	######	######	######

Public Irrigation

		Landscape batters	Gardens	Events Lawn	The Hill	Verges
Total Area	m2	1731	244	1939	200	2160
Irrigated area	%	25	100	100	100	25
Irrigation event depth	mm	10	10	16	10	10
Frequency (days/week)	days	2	2	2	2	2
Season length	months	8	8	8	8	8
Source		NDW	NDW	NDW	NDW	NDW
No. Irrigation Events		70.0	70.0	70.0	70.0	70.0
Irrigation Demand	kL/year	302.9	170.8	2171.7	140.0	378.0

Commercial Uses

	Base rate kL/year	Qty	Rate kL/year	Source	Waste	Total kL/year	Comment
Hospitality	570	2	570	DW	BW	1140	
Lagoon	46300	1		DW	N/A	0	46300

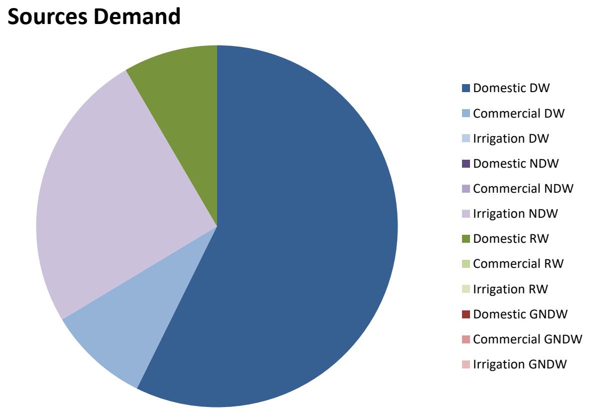
Site Water Balance
UrbnSurf: Sydney Olympic Park
Sheet 1: Water Demands and Waste Generation

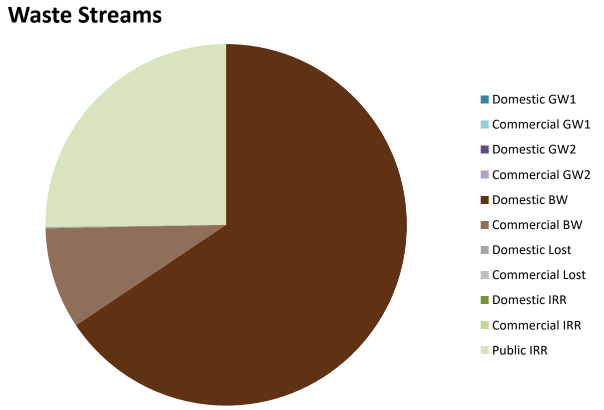
Demand Based Water Balance (kL/year)

	Domestic kL / year	Commercial kL / year	Public Irr' kL / year	Total kL / year	%	
Total Water Use	8255	1140	3163	12559	100.0%	12.559
Source Demand						
Drinking Water (DW)	7198	1140	0	8338	66.4%	8.3379
Non-Drinking Water (NDW)	0	0	3163	3163	25.2%	3.1634
Rain Water (RW)	1058	0	0	1058	8.4%	1.0577
Groundwater (GND)	0	0	0	0	0.0%	0
					100.0%	
Waste						
Greywater Type 1 (GW1)	0	0		0	0.0%	0
Greywater Type 2 (GW2)	0	0		0	0.0%	0
Black Water (BW)	8240	1140		9381	74.7%	9.3806
Lost (N/A)	15	0		15	0.1%	0.015
Irrigation (IRR)	0	0	3163	3163	25.2%	3.1634
					100.0%	

Performance

Population	818	people
POS Area	0	ha
Total Public Space Area	1	ha
Per Capita Domestic Total Water	15	kL/person/year
Per Capita Domestic Drinking Water	10	kL/person/year
POS Irrigation Rate	0.24	kL/m2/year
Total Public Space Irrigation Rate	0.50	kL/m2/year





Site Water Balance
UrbnSurf: Sydney Olympic Park
Sheet 2: Rainwater Supply Efficiency

urbaqua
land and water solutions

Rainfall Data

Source	Sydney Olympic Park
Reference	66195

Date	Rainfall mm
1/01/2001	0
2/01/2001	0
3/01/2001	0
4/01/2001	0
5/01/2001	0
6/01/2001	0.6
7/01/2001	0
8/01/2001	0
9/01/2001	0
10/01/2001	0
11/01/2001	0
12/01/2001	0
13/01/2001	0
14/01/2001	0
15/01/2001	0
16/01/2001	0
17/01/2001	0
18/01/2001	0
19/01/2001	0
20/01/2001	0.2
21/01/2001	0
22/01/2001	0
23/01/2001	0
24/01/2001	0
25/01/2001	0
26/01/2001	0.4
20/02/2001	0

Catchment / Storage Properties

catchment area	1010	m2
catchment IL	0.5	mm
effective storage vol	40	kL
initial storage	15	kL

Irrigation demand

Total Area	0	m2
Irrigated area	100	%
Irrigation event depth	16	mm
Irrigation event volume	0	kL
Frequency (days/week)	2	days
Season length	6	months

In-house demand

Annual Demand	1058	kL

Month	Factor	Days	kL/day	Visitors
Jan	0.14	31	4.8	329.980414
Feb	0.12	28	4.1	254.829558
Mar	0.12	31	4.1	284.167027
Apr	0.10	30	3.4	226.398121
May	0.07	31	2.3	160.755229
Jun	0.02	30	0.7	45.565046
Jul	0.02	31	0.7	47.5830033
Aug	0.02	31	0.8	56.1058966
Sep	0.07	30	2.3	153.966823
Oct	0.10	31	3.4	231.38105
Nov	0.11	30	3.9	259.353373
Dec	0.12	31	4.2	286.768513
Daily Av	0.1	Check	1057.7	

Irrigation Schedule

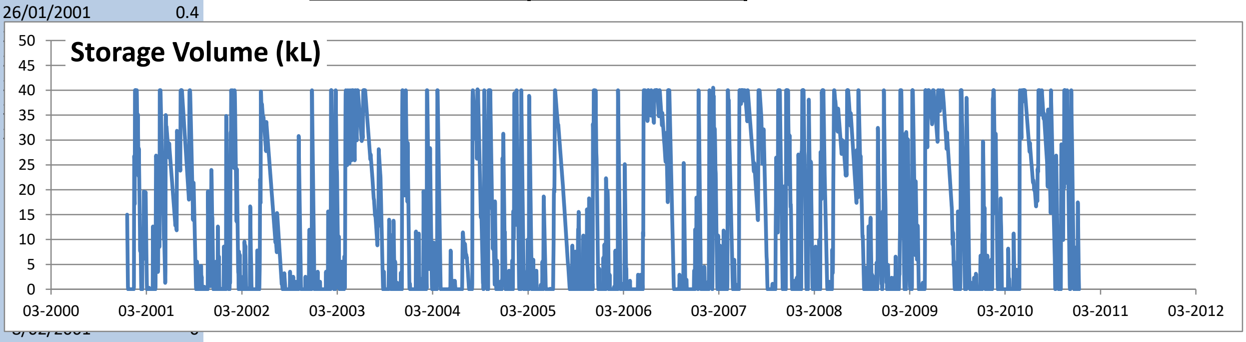
Month		Day	
Jan	TRUE	Mon	TRUE
Feb	TRUE	Tues	FALSE
Mar	TRUE	Wed	FALSE
Apr	FALSE	Thurs	FALSE
May	FALSE	Fri	TRUE
Jun	FALSE	Sat	FALSE
Jul	FALSE	Sun	FALSE
Aug	FALSE		
Sep	FALSE		
Oct	TRUE		
Nov	TRUE		
Dec	TRUE		

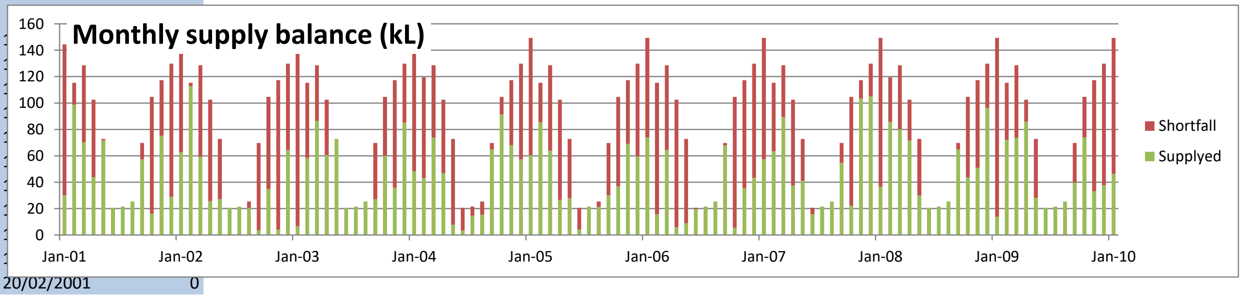
Model Results

	Total (kL / 10 years)	
Balance	-15	0%
Total Rainfall	8724	
Catchment Loss	528	6%
Total Runoff	8196	
Overflow	2800	32%
Captured and Reused	5411	62%

Use	Demand	Supplied	Shortfall
Irrigation	0	0	0
In-House	10585	5411	5174
Total	10585	5411	5174

Capture efficiency	62%
Supply reliability	51%





Site Water Balance
UrbnSurf: Sydney Olympic Park
Sheet 3: Recycling and Disposal Scenario 1

urbaqua land and water solutions

Non Drinking Water Generation

Waste Type	Generation (kL/yr) Calculated	Adopted	Disposal
Domestic Greywater Type 1	0	0	Sewer
Commercial Greywater Type 1	0	0	NDW
Domestic Greywater Type 2	0	0	On-Site
Commercial Greywater Type 2	0	0	On-Site
Domestic Blackwater	8,240	8,240	Sewer
Commercial Blackwater	1,140	1,140	Sewer
NDW Volume	0	3,163	WRAMS
On-site disposal	0	0	
Untreated Sewer Volume	9,381	9,381	

Rainwater and Groundwater Sources

Design Rainfall	mm/yr	864
Catchment	m2	1010
Reuse efficiency	%	51
Volume of rain water	kL	445
Available Groundwater	kL/yr	30,000
Available Drinking Water	kL/yr	100,000

Source Availability / Distribution

Non potable demand allocation

Source	Primary Demand (kL/yr) Calculated	Adopted	Available	Primary Supply	Excess Demand	Backup Source	Backup Demand	Backup Supply	Shortfall
DW	8,338	8,338	100,000	8,338	0	DW	613		
NDW	3,163	3,163	3,163	3,163	0	DW	0	0	0
RW	1,058	1,058	445	445	613	DW	0	0	0
GNDW	0	0	30,000	0	0	DW	0	0	0

Actual supply volumes

Resouce	Demand	Supplied	Excess
Drinking Water	8,338	8,951	91,049
Non-Drinking Water	3,163	3,163	0
Rain Water	1,058	445	0
Groundwater	0	0	30,000

Excess Non-Drinking Water

Total Disposal	0	kL/year
Average Disposal	0	kL/day
Storage Volume	0	kL
Rainfall Runoff Coefficient	0.1	mm/mm
Daily Duration of Irrigation	3	hr/day
Effective EVT (% pp-evt)	80	%
Infiltration Rate	0.5	mm/hr
Irrigated Area	2,000	m2
Infiltration potential	3	kL/day

Waste Water Balance	ML	%
Recycled NDW	3,163	25%
Onsite Disposal	0	0%
Total Onsite Reuse / Disposal	3,163	25%
Treated NDW Offsite Disposal	0	0%
Untreated Offsite Disposal	9,381	75%
Total Offsite Disposal	9,381	75%

Month	Days	PP-EVT mm	Rainfall mm	Runoff mm	Excess EVT mm	Seasonal Factor	Disposal Volume kL	Infiltration Capacity kL	Potential EVT kL	Potential Disposal kL	WW Storage kL	Onsite Disposal kL	Disposal to Sewer kL
Jan	31	272	12.2	1.22	206.62	1	0	93	331	424	0	0	0
Feb	28	228	20.1	2.01	164.31	1	0	84	263	347	0	0	0
Mar	31	205	18.3	1.83	147.53	1	0	93	236	329	0	0	0
Apr	30	141	40.3	4.03	76.53	1	0	90	122	212	0	0	0
May	31	99	97.5	9.75	-8.55	1	0	93	-14	79	0	0	0
Jun	30	74	148.3	14.83	-74.27	1	0	90	-119	0	0	0	0
Jul	31	82	147.9	14.79	-67.51	1	0	93	-108	0	0	0	0
Aug	31	96	114.2	11.42	-25.98	1	0	93	-42	51	0	0	0
Sep	30	122	79.6	7.96	25.96	1	0	90	42	132	0	0	0
Oct	31	174	41.2	4.12	102.12	1	0	93	163	256	0	0	0
Nov	30	210	32.1	3.21	139.11	1	0	90	223	313	0	0	0
Dec	31	253	10.6	1.06	192.86	1	0	93	309	402	0	0	0
					Daily Average Factor	1.0							
					Disposal Balance		0	1095	1406	2545		0	0
						%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!

APPENDIX 5: BROADSCALE SITE WATER DEMAND MODELLING OUTPUT

Site Water Balance
UrbnSurf: Sydney Olympic Park
Sheet 1: Broadscale water balance

Inf Model

Rainfall Data		**Pan Evap Data**		**EVT Data**			**Initial loss**	**Runoff coeff**
Source	Sydney Olympic Park	Source	Riverview Obsre	Source	Average Sydney	Vegetation	10	0.9
Reference	66195	Reference	66131	Reference	MUSIC V6	Hardstand	1	1

Date	Rainfall mm
1/01/2001	0
2/01/2001	0
3/01/2001	0
4/01/2001	0
5/01/2001	0
6/01/2001	0.6
7/01/2001	0
8/01/2001	0
9/01/2001	0
10/01/2001	0
11/01/2001	0
12/01/2001	0
13/01/2001	0
14/01/2001	0
15/01/2001	0
16/01/2001	0
17/01/2001	0
18/01/2001	0
19/01/2001	0
20/01/2001	0.2
21/01/2001	0
22/01/2001	0
23/01/2001	0
24/01/2001	0
25/01/2001	0
26/01/2001	0.4
27/01/2001	1
28/01/2001	27
29/01/2001	0.4
30/01/2001	0
31/01/2001	113
1/02/2001	67
2/02/2001	9
3/02/2001	2
4/02/2001	0
5/02/2001	0
6/02/2001	26
7/02/2001	12
8/02/2001	0
9/02/2001	0
10/02/2001	0
11/02/2001	12
12/02/2001	0
13/02/2001	0
14/02/2001	0
15/02/2001	10
16/02/2001	0
17/02/2001	0.4
18/02/2001	0
19/02/2001	0
20/02/2001	0
21/02/2001	9
22/02/2001	0.6
23/02/2001	0
24/02/2001	0
25/02/2001	0
26/02/2001	0
27/02/2001	0
28/02/2001	0

Month	Pan Evap	Evap factor	Reference EVT		Deep rooted veg EVT Factors	
	mm/day	Wetland	mm/month	mm/day	Native	Non-native
Jan	6.0	1.00	180	5.8	0.10	0.20
Feb	4.9	1.00	135	4.7	0.10	0.20
Mar	3.9	0.70	128	4.1	1.00	1.10
Apr	3.0	0.70	85	2.8	1.00	1.10
May	2.2	0.70	58	1.9	1.00	1.10
Jun	1.9	0.70	43	1.4	1.00	1.10
Jul	2.0	0.70	43	1.4	1.00	1.10
Aug	2.8	0.70	58	1.9	1.00	1.10
Sep	3.8	0.70	88	2.9	1.00	1.10
Oct	4.7	0.70	127	4.1	1.00	1.10
Nov	5.3	0.70	152	5.1	1.00	1.10
Dec	5.9	1.00	163	5.3	0.10	0.20
Jan	6		180	5.8		

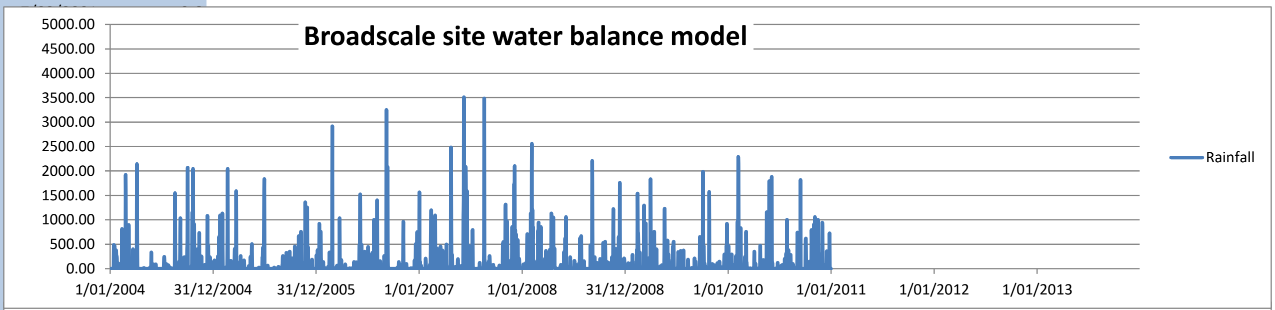
Model Inputs	Scenario 1	Scenario 2	
Note:	Predevelopment	Postdevelopment	
Total site area (ha)	4.07	2.32	(excludes Lagoon)
% shallow rooted veg	0.00%	10.00%	
% deep rooted veg (non-native	0.00%		
% deep rooted veg (native)	26.00%	17.00%	
% Wetland/drainage	2.00%		
% Hardstand/roof	72.00%	73.00%	
	100%	100%	

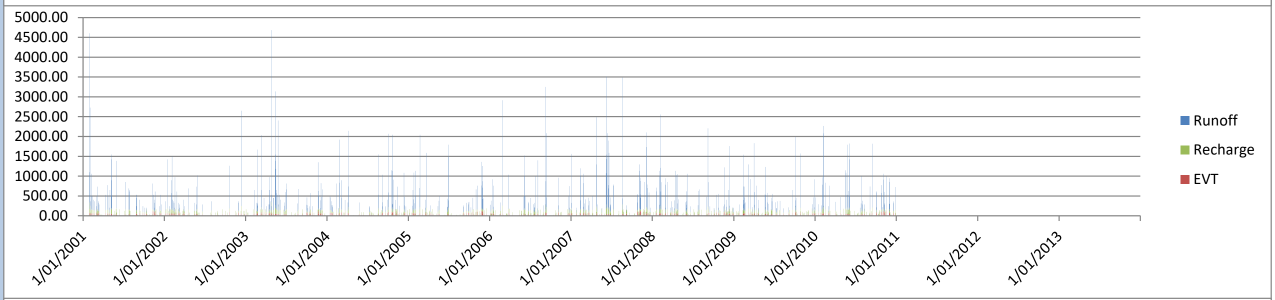
Average annual results					
Rainfall (10y ave)	35.190	20.039		ML	
WRAMS		3.160			
EVT (10y ave)	3.982	5.253	Natural & irrigation	ML	
% EVT	11%	23%			
Recharge (10y ave)	6.647	3.692		ML	
% Recharge	19%	16%			
Runoff (10y ave)	24.561	14.254		ML	13.804
% Runoff	70%	61%			
	100%	100%			

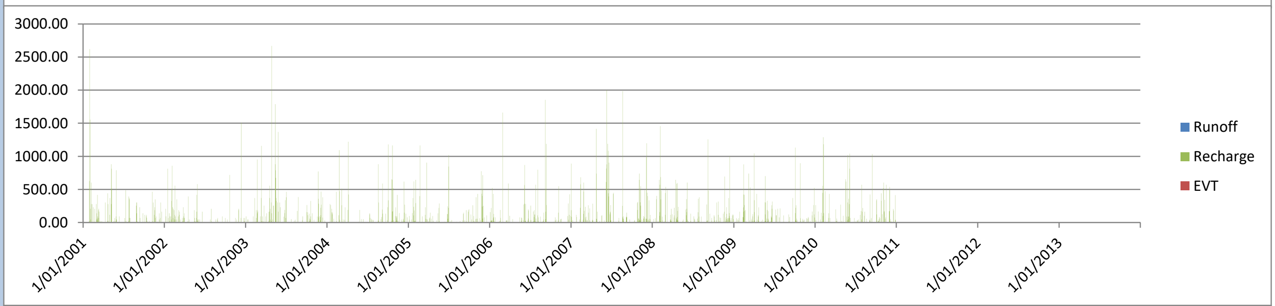
Average monthly results - Recharge

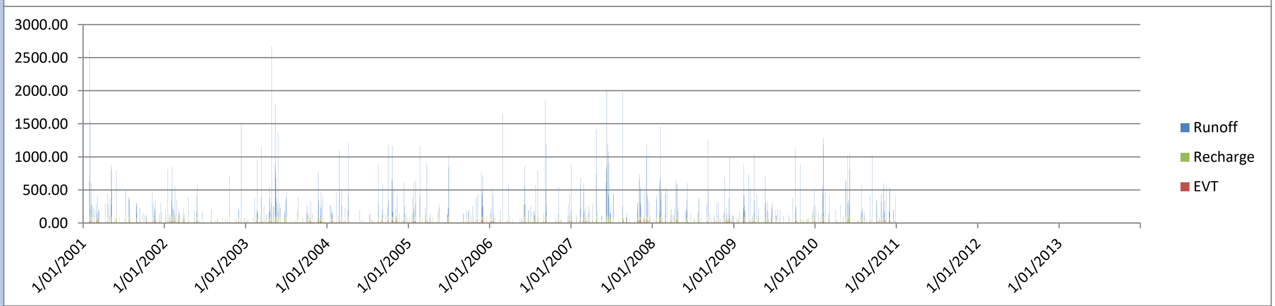
Month	Average rainfall	
Jan	2.392	0.500
Feb	5.563	0.797
Mar	2.383	0.545
Apr	3.143	0.536
May	3.509	0.654
Jun	3.663	0.704
Jul	1.879	0.506
Aug	1.458	0.349
Sep	2.144	0.386
Oct	2.788	0.470
Nov	3.261	0.538
Dec	3.007	0.663

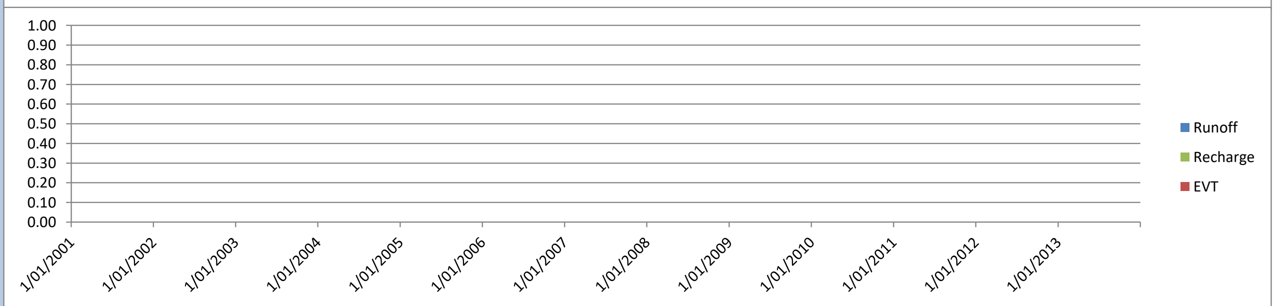
1/03/2001	12
2/03/2001	2
3/03/2001	6
4/03/2001	3
5/03/2001	2
6/03/2001	18











9/05/2001	22

APPENDIX 6: WATER TREATMENT MONITORING PLAN

Water Quality Management

Water Treatment Monitoring Plan

Summary

A	4 Apr 17	Original	SS	
Rev	Date	Changes	Author	Acceptance

Supporting Documents

This document must be read in conjunction with

The full version of Water Quality Management Plan DOC-303-WQMP001
And
The Water Treatment Plant O&M (DOC-303- -)

Water Quality Management

The operator must maintain a formal written water quality log book with no less than 7 years historical record.

A person calibrating on line and or off line instruments must record that event in the water quality log book.

Large rain events are expected to have adverse effect on the water treatment plant capability to return the routine volume of treated water to the surf pond and discharge to the environment simultaneously. During periods which the treatment plant is discharging water to the environment treated water quality will be diminished. Management may review public access to the surf pond during times of extreme rainfall.

Discharged Water

Water discharged to the environment will be within the ideal operating range for chemical parameters tabled on page 6 of this document and pathogen parameters as tabled on page 7.

Surf Pond Water Monitoring

Three level surveillance model

Green	All observations and water appearance and analysis measurements indicate water quality parameters are within ideal target range as stated below.	Operator is to maintain routine sampling frequency.
Amber	Activated by ANY analysis measurement outside of the ideal target range. Includes water temperature, turbidity, chemistry and aesthetic values.	Immediate actions 1. Report to design engineer 2. Re sample and analyse, check calibration of on line measurement instruments. 3. Implement design engineers recommendations* 4. Repeat sampling daily to confirm positive trend 5. Amber sign post information for surf pond users
Red	Activated by ANY 1. Water chemistry parameter outside of the ideal target range for 5 consecutive days. 2. Water chemistry parameter above or below a critical value. 3. Pathogen analysis measurement above a critical value.	Immediate actions Steps 1 - 5 as per Amber surveillance but with red sign colour. a) Interview workers and regular surfers and discuss water quality concern for identifying potential source of contamination. b) A range of actions to be implemented after management committee decision from a no public access shutdown, to PPE protected worker only access to the pond, to draining the pond. c) Nominal reactions are stated in the protocol’s table below. But management is to review these on a case by case basis. d) Management to create public and worker health action plan based on probability and consequence review. e) Report and plan to be presented to relevant authority within 24 hours of second analysis confirmation.

*Management may pre-empt the design engineer’s recommendation only if based on similar incident history, but MUST inform the design engineer.

Water analysis methods and sampling frequency

Parameter	Analysis technique	Initial Frequency of monitoring & recording	Large Rain event	Sampling location	Expected Long Term Frequency of monitoring & recording
Appearance	Visual Hand held Clarity wedge Hand held Colourimetry	daily		Minimum 6 locations around the pond	weekly
pH	On line	Continuously automated		Overflow launder	Continuous automated
Salinity	On line indirect conductivity				
Turbidity	Off line – hand held instrument	Daily - midday			Daily - midday
ORP					
Zinc soluble	Nata Laboratory	Weekly			Twice yearly
Zinc Total					
Total N					Monthly
Total NOx					
Total P					
Soluble Reduced S					
Total SOx					
Total organic content				Sampled at both overflow launder and filter backwash	quarterly
Viruses & Protozoa					
Total (Thermotolerant) Coliforms					Monthly
E coli					
Enterococci					
Total Legionella			Daily		
Total Algae					
Toxic Algae					
Cryptosporidium				Filter backwash	
Giardia (Lambia)					

All on line measurements will be calibrated and confirmed to hand held instruments on a weekly basis.
Large rain event = >100mm in a 24 hour period.

Expected and Target Water Properties

During non surf use the surf pond will be vacuumed causing the turbidity, insoluble zinc, organic matter and pathogen levels reporting to the treatment plant to increase. Unless otherwise mentioned, water parameters during the vacuum operations will remain as per during surf use.

	Expected Pond overflow during surf use	Target Treated Water returning to pond	During vacuum operations, water entering treatment plant
pH	8.0	7.6	8.0
Salinity	This will increase when evaporation exceeds rainfall		
Turbidity	10 NTU	2NTU	30NTU
ORP	0-100mV	>700mV	
insoluble Zinc	2mg/L	0.5mg/L	2.5mg/L
Total N	1mg/L	0.1mg/l	
Total P	0.1mg/L	0.01mg/L	
Total organic content	1mg/L	0.1mg/L	1.5mg/L
Total Algae*	<1mm^3/L		<100mm^3/L
Toxic Algae	<1000 cells/mL		<100 cells/mL
Viruses		Treated water to have a reduction of 50% of virus, during Surfing, 33% during vacuum	
Bacteria			
Total Legionella	<10,000counts/L	Treated water to have a reduction of 66% of all legnionella, during Surfing, 44% during vacuum	
Harmful Legionella	<100counts/L		
Total (Thermo) Coliforms	<10c/100ml	ALL treated water to be free of these pathogens	<100c/100ml
E coli			
Salmonella			
Enterococci			
Protozoa and Trematodes			
Cryptosporidium	zero		Zero
Giardia (Lambia)			

*If the water contains a known toxic alga then the Toxic Algae count shall take precedence over the total Algae volume.

** Treated water is not expected to be totally free of algae, legionella, viruses and protozoa during vacuum.

Surf Pond - Water Quality Related Management Protocols

	Ideal Target	Recommended Action/reaction	Critical Reaction Points	Recommended Action/ reaction
Aesthetic Appearance	Free from all forms of pollution, free from algae bloom	Localised cleaning	Gross pollutants (floating and submerged)	Remove from pond immediately
Water Temperature	16 - 24C		Below 15C	All surfers must have torso wet suits
			Below 10C	All surfers must have full body wet suits
			Above 26C	Maximum surfing time 60 minutes
			Above 34C	Cease Surfing
pH	Between pH 7 and 8 at surf pond over flow launder	Below pH 6. 5 add alkali to the return water, Above 8.5 add acid to the return water	Below 5.5	Cease Surfing
			Above 9.0	Cease Surfing
Salinity	<2,500 mg/L as TDS	Salinity is not a health issue, Salinity may be increased to assist with pathogen control and electro chlorination efficiency		
Turbidity	Filtrate turbidity is the critical parameter as UV efficient must be maintained via good filtrate clarity.		>5NTU	Review process plant efficiency
			>10NTU	Confirm process plant additives
			>20NTU	Revise process plant design
ORP	>700mV post filtration, post chlorination	Service the electro chlorinator, investigate treatment plant efficiency	<700mV	Review salinity and electro chlorination efficiency
insoluble Zinc	<100mg/L	Use flocculant to enhance filtration removal	>100mg/L	Review process plant efficiency and confirm process plant additives
Total N	<1mg/L	Investigate bio nutrient removal beds, Enhance bio nutrient removal, and reduce the total alga count if high.	>5 TN	Review water treatment process capability
			>10 TN	Seek short term resolution then Revise process plant design
Total P	<0.1mg/L	Investigate bio nutrient removal beds, Enhance bio nutrient removal, Review water treatment process capability for TP	>2.0mg/L	

	Ideal Target	Recommended Action/reaction	Critical Reaction Points	Recommended Action/ reaction
Total organic content	<2mg/L		5mg/L	Review process additives
Total Algae*	0.5mm^3/L	Investigate aluminium coagulation and UV process step efficiencies	20mm^3/L	Cease human contact with the water
Toxic Algae	0.05mm^3/L		10mm^3/L	
Toxic Viruses	<10counts/100ml	Increase UV power	>100counts	Involve health consultants in decision
Bacteria				
Total Legionella				
Harmful Legionella				
Total Coliforms	<10counts/100ml	If target is exceeded Review process plant performance Increase filtration performance Increase electro chlorination	>100counts	Manually Clean all surf pond surfaces whilst vacuum in proximity to cleaning
E coli			>1000 counts	Drain the surf pond
Salmonella				
Enterococci				
Protozoa and Trematodes				
Cryptosporidium	NO identified measurement	Management decision	Any identified measurement	Management decision
Giardia (Lambia)				

Client: UrbnSurf (Sydney) Pty Ltd

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
Preliminary draft	V1	HBr	SSh	Electronic	March 2017
Draft for client review	V2	HBr	SSh	Electronic	April 2017
Copy for consultation	Rev 0	HBr	SSh	Electronic	April 2017
Revised following consultation	Rev 1	HBr	SSh	Electronic	May 2017

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