Golden Gateway

Local Water Management Strategy

Prepared for City of Belmont

By Essential Environmental

June 2018

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1 INTRODUCTION

Essential Environmental has been commissioned by the City of Belmont to prepare this Local Water Management Strategy (LWMS) in support of a Local Structure Plan for the Golden Gateway Precinct located in Ascot. The study area is approximately 32 hectares in size and is located in the vicinity of Great Eastern Highway, Resolution Drive, Grandstand Road and Stoneham Street.

The site currently comprises of a mixture of commercial lots, the heritage listed Ascot Brick Works, places of public assembly (racecourse), public open space (including the Trust Land), and areas set aside for water supply, sewerage and drainage. The City of Belmont recognises the site as a promising opportunity for development due to its proximity to the Swan River and existing public open space. The proposed development will optimise the potential of the Golden Gateway Precinct by introducing high density commercial and residential areas, while maintaining the social and heritage values of the public open space and the Ascot Brick Works.

1.1 Principles and design objectives

Consistent with *State Planning Policy 2.9: Water Resources* (WAPC, 2006) and *Better urban water management* (WAPC, 2008a), a local water management strategy is required to be submitted to support any rezoning of land in a Local Planning Scheme or adoption of a Local Structure Plan to ensure that appropriate water management strategies are identified.

The position of this strategy within the state government planning framework is defined in *Better urban water management* (WAPC, 2008a) and *Planning bulletin no. 92, urban water management* (WAPC, 2008b) and is outlined in Figure 1.

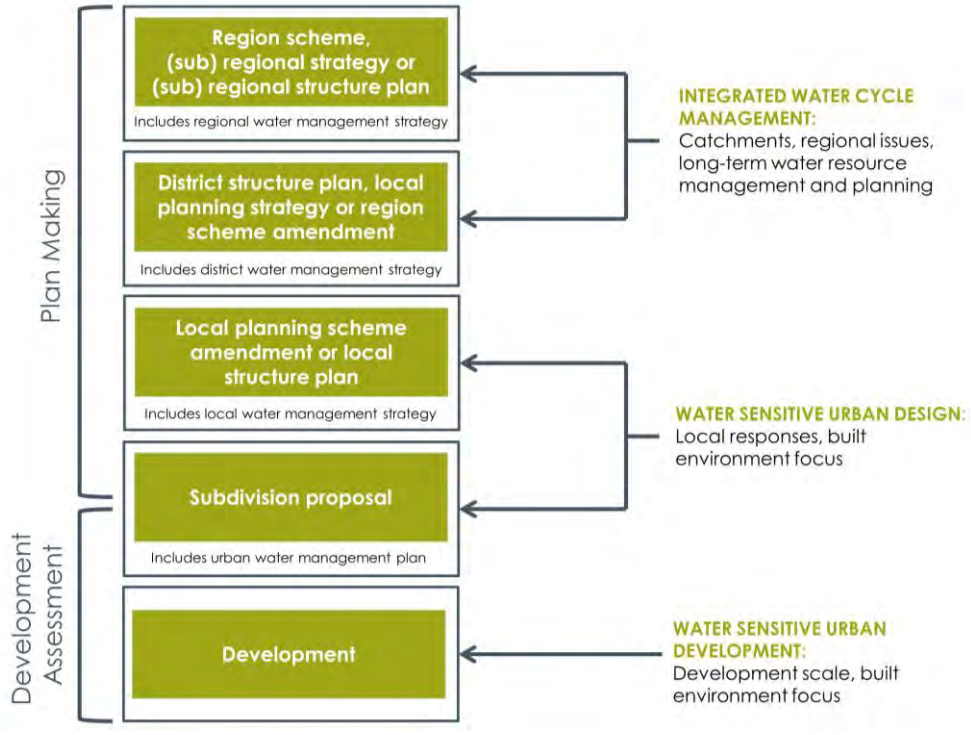

Figure 1: Integrating drainage planning with the land planning process (WAPC, 2008a)

In accordance with *Better urban water management* (WAPC, 2008a) preparation of a local structure plan is to be supported by a local water management strategy (LWMS) prepared in accordance with the Department of Water and Environmental Regulation's (DWER) *Interim: Developing a local water management strategy* (DoW, 2008a). The LWMS should demonstrate to the satisfaction of the WAPC in accordance with this plan and any approved DWMS:

- how the key principles and strategies of this plan have been addressed;
- how the urban structure will address water use and management;
- existing and required water management infrastructure; and
- detailed land requirements for water management.

The principles and strategies contained within section 4 of this *Local water management strategy* will be implemented as part of detailed land use planning and development requirements and are consistent with the framework and requirements in *Better urban water management* (WAPC, 2008a).

1.2 Planning background

The majority of the study area is zoned 'Urban' under the Metropolitan Region Scheme, with a small portion zoned 'Parks & recreation' and 'Mixed use' & 'Place of Public Assembly' under the City of Belmont Local Planning Scheme No. 15.

The City of Belmont Local Planning Scheme No. 15, adopted in December 2011, provides a district level framework to guide more detailed planning for the City. It requires local structure plans to be prepared to provide the level of detailed planning required to facilitate subdivision and development within the scheme area. The Western Australian Planning Commission and the City of Belmont are preparing a local structure plan to guide land use and development outcomes for the broader Golden Gateway precinct.

Figure 2 shows the Golden Gateway Precinct. A large portion of the Precinct is zoned 'Mixed use' in the Local Planning Scheme (LPS). The historical Ascot's beehive kilns and chimney stacks are located within this zone. A portion of the Precinct is zoned 'Place of Public Assembly (Racecourse)' accounting for portions of the Ascot Racecourse carpark and facilities. A small section of the precinct, approximately 6370 m^2, is zoned 'Parks and Recreation' under the Metropolitan Region Scheme. The waterway area in the Precinct is zoned 'water supply, sewerage and drainage' in the LPS. Water Corp owns the Lots in this zone and maintains the existing channels and piped drainage network system.

1.3 Previous studies

A number of previous studies have been undertaken that are relevant to this strategy area. In addition to *State Planning Policy* 2.9, these documents inform the strategies and management principles contained within this Local Water Management Strategy:

- City of Belmont Policy Manual (CoB, 2015);
- Developing a Local Water Management Strategy (DoW, 2008a);
- Stormwater Management Manual for Western Australia (DoW, 2004-07);
- Better Urban Water Management (WAPC, 2008a); and
- Decision Process for Stormwater Management in Western Australia (DWER, 2017a).

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 2: Study area location

Data source: DoP, CoB, Landgate. Created by: AT. Projection: MGA: zone 50.

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2 PROPOSED DEVELOPMENT

A brief summary of the current land use and proposed layout of the structure plan are provided below.

2.1 Key elements of the structure plan

The local structure plan will guide the subdivision and development of approximately 32 hectares in the Golden Gateway Precinct. The structure plan (Figure 3) contains:

- Predominantly a mixture of medium to high density residential areas with development between 2 and 15 storeys;
- Non-residential development at ground level in Mixed Use zones;
- Realignment of Stoneham Street, Resolution Drive and Grandstand Road;
- Upgrade of existing local roads to reflect an inner urban street character;
- Implementation of an east to west green spine replicating existing drainage; and,
- Retention of foreshore reserve Public Open Space (POS) surrounding the Swan River.

During the preparation of this report, the design of the local structure plan has been modified to incorporate water quality treatment and flood detention areas into the plan, based on the natural hydrology of the study area in order to minimise any potential environmental impacts resulting from redevelopment. Importantly, the existing drainage corridors are to be largely retained, rehabilitated and incorporated into a feature of the public open space.

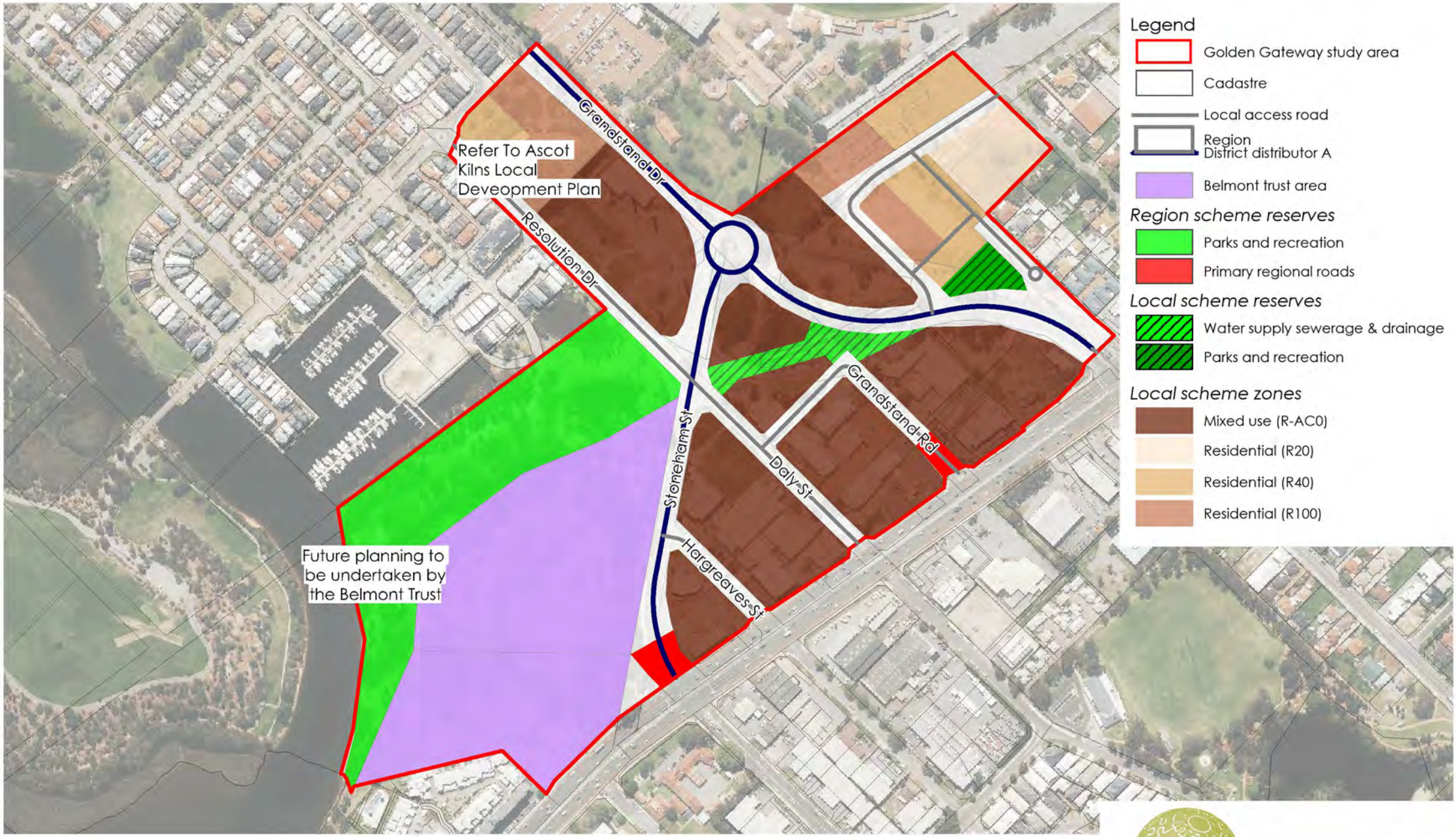
Planning for the Belmont Trust land (Figure 3) will be undertaken separate to this Structure Plan. This area has been considered in this Local Water Management Strategy to facilitate future planning and ensure links between that land, the Golden Gateway area and the river are maintained.

2.2 Current land use

Commercial properties are dominant along Great Eastern Highway south of Resolution Drive and Stoneham Street. The north and east of Resolution Dr contains a parcel of land approximately 5 hectares in size that is largely vacant, with the exception of a few mature trees, used as overflow parking servicing the Ascot Racecourse. This portion of land, as shown in Figure 3, also accommodates a 150 m Central Belmont Main Drain, which discharges via piped drainage under the Stoneham Street / Resolution Drive roundabout into the Ascot Waters compensation basin on the north-western boundary of the study area. North of the Ascot Waters Compensation Basin is a second compensation basin that services the Ascot Waters development. This compensation basin is herein referred to as 'Northern Drainage Lake'. The northern portion of the site contains the Perth Racing Administration Offices.

Historical aerial photography from Landgate suggests the land has been used for commercial purposes for over 50 years, with the majority of lots being approximately 1/3 hectare, accommodating warehouse facilities and such, predominantly adjacent to Great Eastern Hwy. The northern portion of the study area contains the Bristle kilns and Brick Works, which were established in 1929 and ceased operation in 1982 (Heritage Council, WA). The western portion of the study area, over the now Belmont Trust Land, was historically used for sporting purposes such baseball fields (Clark, 1952), and more recently as a temporary worksite for development in the area, such as the widening of the Great Eastern Hwy.

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 3: Proposed structure plan



Data source: TBB, DoP, CoB, Landgate. Created by: AT. Projection: MGA: zone 50.

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City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 4: Historical land use

Data source: CoB, Landgate. Created by: AT. Projection: MGA: zone 50.

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3 DESIGN CRITERIA

Any development within the Golden Gateway Precinct in Ascot should aim to meet the following specified design criteria using appropriate best management practices. Additional design criteria may need to be met, particularly where they are specific to particular precincts. These will be outlined in the relevant Detailed Area Plan or associated development guidelines.

3.1 Surface water management system

- The first 15mm of rainfall is to be retained within all lots through a combination of raingardens, water tanks and soakwell systems.
- Raingardens and tree-pits are to be installed in all new or upgraded streets to provide infiltration of the first 15mm of rainfall.
- Minor event runoff from events larger than 15mm total depth are to be managed in accordance with serviceability requirements of the City of Belmont.
- Roads and public open spaces are to be designed to cater for the surface overflow for more severe storm events with habitable floors at least 0.3 m above the 1% AEP flood or storage level at any location.
- Habitable floors are to be constructed at least 0.5m above the 1% AEP flood level in the Swan River adjacent to the development area.
- Water quality treatment systems and stormwater management structures should be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004-07) and *Australian Runoff Quality: A guide to water sensitive urban design* (Engineers Australia, 2006).

3.2 Groundwater management system

- Groundwater management systems are to be designed as free-discharging under normal operating conditions.
- Flows from groundwater management systems are to be treated prior to discharge.

4 EXISTING SITE CHARACTERISTICS

A summary of the existing environmental conditions in the study area are provided in this section, including determination of the opportunities and constraints for water management. The information presented incorporates data from the following reports:

- Lot 5, Resolution Drive Ascot Site Management Plan (GHD, 2013);
- Belmont Foreshore Precinct Plan (City of Belmont, 2014);
- Environmental Report: Golden Gateway (Essential Environmental, 2018a); and
- Central Belmont Main Drain Stage 2 – Upgrade Review (Water Corporation, 2009).

4.1 Location and climate

The climate for Golden Gateway study area is typically Mediterranean having hot summers and mild winters with low annual rainfall. Average annual rainfall recorded at the nearest Bureau of Meteorology (BOM) weather station (Perth Airport (no. 9021) approximately 4 km east of the site) since 1944 is 768 mm but has declined in recent years to an average of 670 mm since 2002. The minimum recorded annual rainfall was in 2006 at just 480 mm and the maximum recorded was in 1955 at 1,165 mm.

The majority of rainfall is experienced in the winter between May and September with the driest months being December to February (Figure 5).

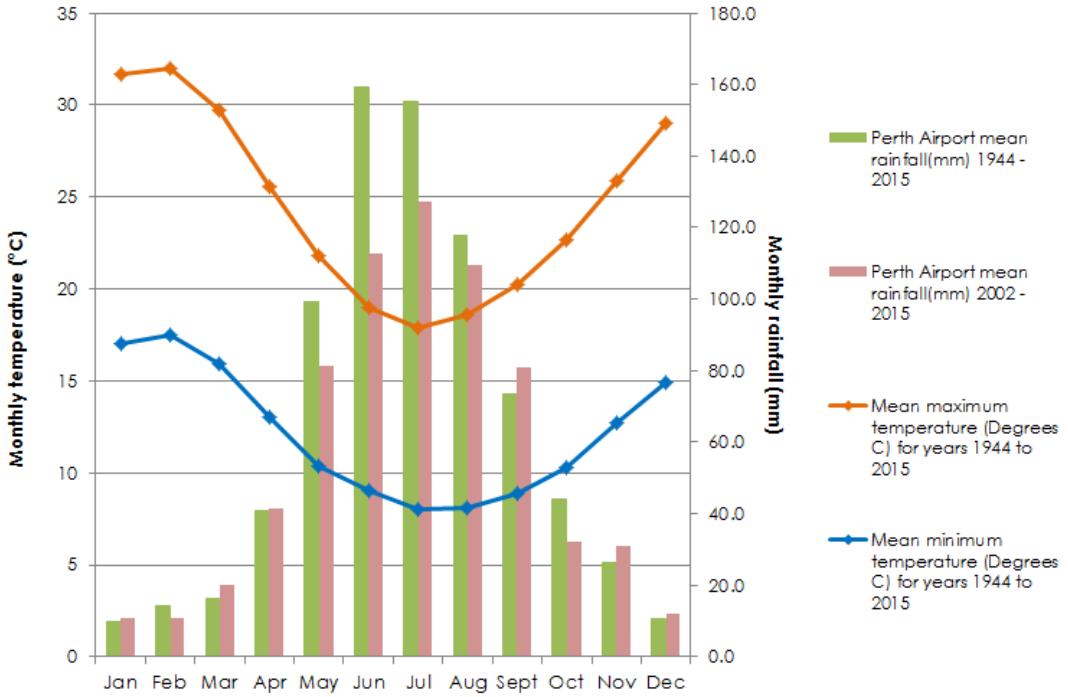


Figure 5: Climate summary data (Perth Airport, BoM, 2016)

Temperature recorded at the Airport (BOM station 9021) shows that the average maximum temperatures range between 17.9°C in July and 32°C in February, while average minimum temperatures range between 8°C in July and 17.5°C in February.

4.2 Topography

The study area grades down from Great Eastern Highway (between 6 – 8 m AHD) towards the Swan River or the Water Corporation drain and basin (approximately 1 m AHD), located along the north-western boundary. There are a few local depressions located adjacent to the Ascot Racecourse. The topography of the study area is shown in Figure 6.

4.3 Geology and Soils

The soils of the study area influence the ability to retain and infiltrate stormwater.

4.3.1 Surface geology and soils

The surface geology is described broadly as Guildford formation: Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate (WA surface geology 1:250,000 scale geological maps, Geological Survey of WA, and Geoscience Australia).

As shown in Figure 6, two-thirds of the north-western portion of the study area is classified as Ms2 – Sandy Silt, and the eastern third as S8 – Sand, described as follows:

- Ms2 – Sandy Silt: strong brown to mild grey, mottled, blocky, disseminated fine sand, hard when dry, variable clay content. This soil type is historically resourced for clay bricks and tile manufacture. It has a low permeability and low potential for erosion. Sandy Silt has a low shrink swell potential, however is prone to flooding.
- S8 – Sand: very light grey at surface, yellow at depth, fine to medium grained, sub rounded quartz, moderately well sorted. Sand of aeolian origin is used for construction purposes with a high permeability and low erosion potential. Well drained given a low water table.

Geotechnical investigations will need to be undertaken to provide site specific information to inform the redevelopment of individual sites within the structure plan area.

4.3.2 Acid sulfate soils

A review of Department of Water and Environment Regulation acid sulfate soils (ASS) risk mapping (DWER, 2017e) identifies two-thirds of the study area, predominantly coinciding with surface geology Ms2-Sandy Silt as containing a Class I 'high to moderate' risk of ASS and the remainder, coinciding with S8-Sand, classified as Class II 'moderate to low' risk occurring within 3 m of the natural soil surface. The ASS mapping is provided in Figure 7.

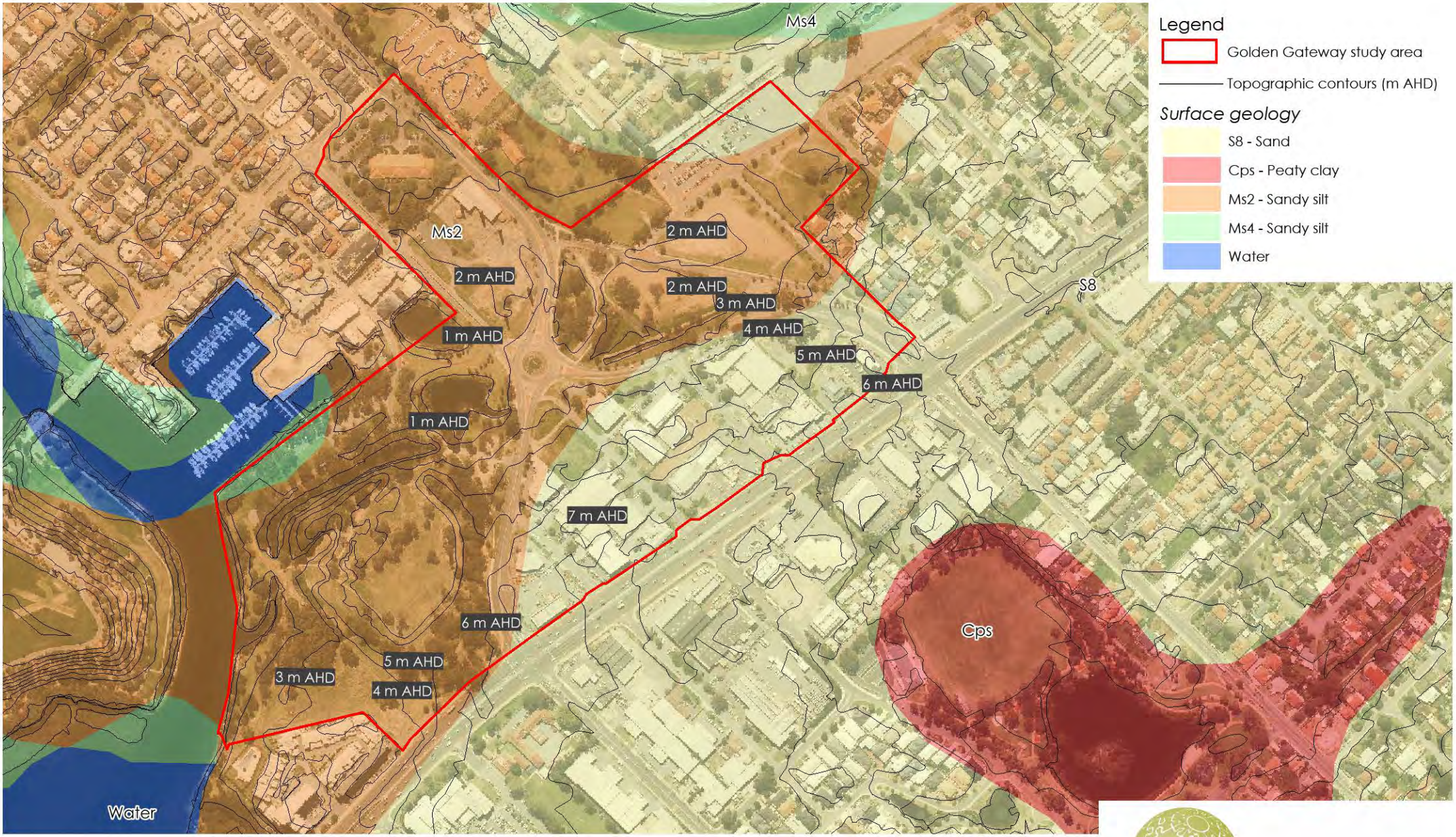
4.4 Groundwater Resources

Determining the groundwater depth and quality are crucial for forming total cycle water management strategies. These components are outlined below.

4.4.1 Public Drinking Water Source Area

There are no Public Drinking Water Source Areas within the study area.

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 6: Topography and surface geology



Data source: DMP, Landgate. Created by: AT. Projection: MGA: zone 50.

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City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 7: Acid sulfate soil risk

Data source: DEC, Landgate. Created by: RM. Projection: MGA: zone 50.

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4.4.2 Allocation Information

The Study area is located within the Perth Groundwater Area and City of Belmont Subarea. The Department of Water and Environmental Regulation's Water Register (2017b) shows no further allocation available within the study area, as shown in Table 1.

Table 1: Groundwater resource allocation and availability (as of February 2017)

Management Area	Management Sub Area	Resource	Allocation Limit	Allocated Volume	Remaining Volume
Perth	City of Belmont	Perth – Superficial Swan	1,497,000	1,836,634	-339,634
Perth	Perth South Confined	Perth – Leederville	4,500,000	5,860,333	-1,409,233
Perth	Perth South Confined	Perth – Yarragadee North	400,000	800,000	-400,000

There are no current groundwater licences within the study area. The City of Belmont currently has a groundwater licence allocation of 1,171,200 kL (licence no. 157042) with a draw point located along the Swan River just south-west of the study area for POS irrigation throughout the City. Within the study area, irrigation of POS is provided from the Ascot Water Compensating Basin, which is unmetered, but estimated to be approximately 56,000 kL/yr. It is understood from the City of Belmont that local groundwater conditions are saline and future abstraction of groundwater from the superficial aquifer for irrigation will not be possible.

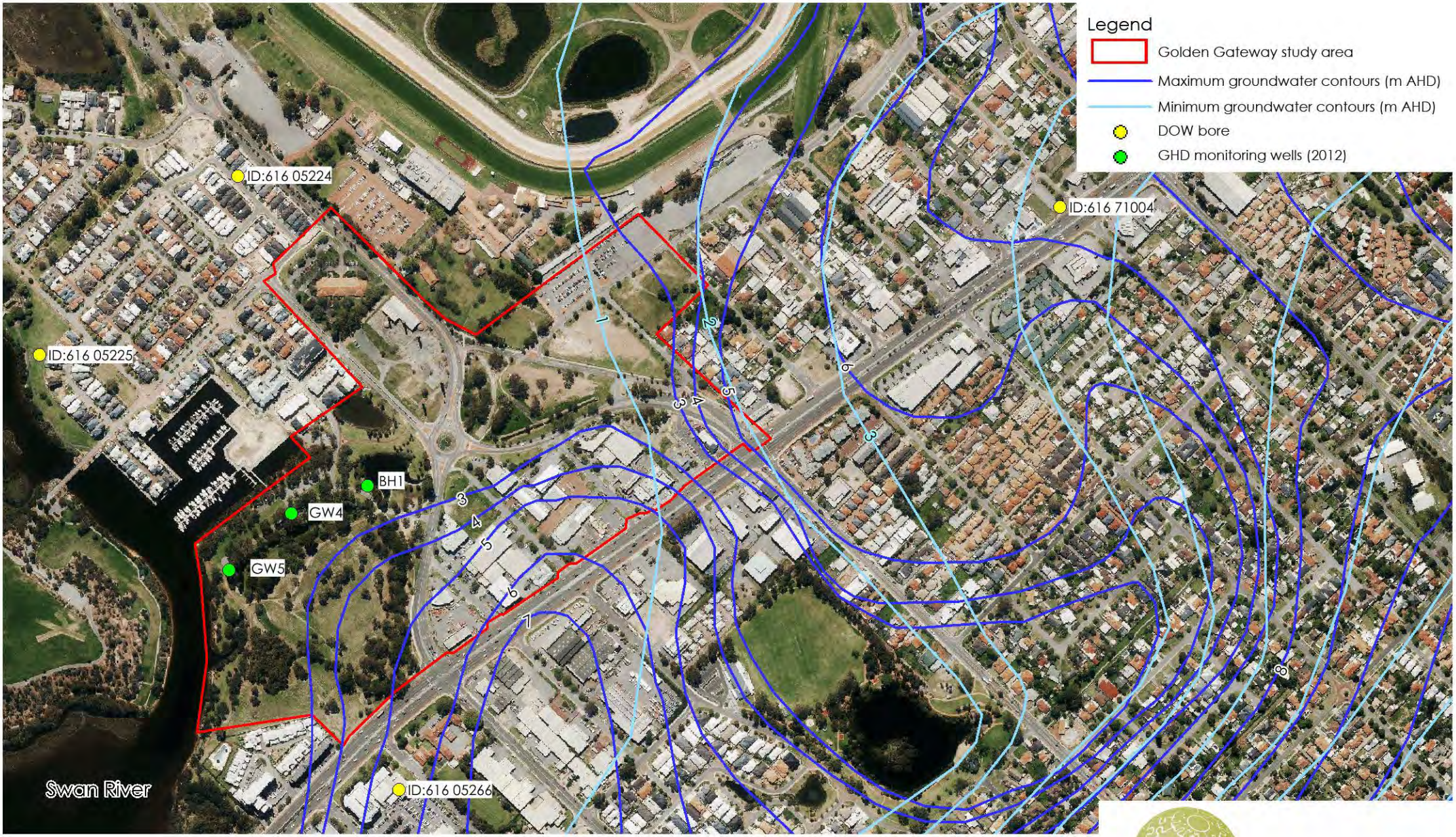
4.4.3 Groundwater Levels

The Department of Water and Environmental Regulation's Perth Groundwater Atlas (DWER, 2017c) provides groundwater level contours across the study area based on maximum level data from 1996, as shown in Figure 8. Maximum groundwater level contours generally follow the topography contours, with levels ranging from 6 m AHD near Great Eastern Highway to 1 m AHD in the northwest corner of the Site. These contours indicate a minimum depth of approximately 1-2 m across the Site in the existing commercial areas, and potentially shallower groundwater west of Stoneham Street. Minimum groundwater levels from the Perth Groundwater Atlas (DWER, 2017c) are also presented in Figure 8 and are based on summer groundwater levels from 2003. These contours demonstrate that the groundwater flow direction is general west towards the Swan River.

These contours are extrapolated from the DWER network of bores as provided in the DoW Water Information Network (2017d). No long term DWER monitoring bores are located within the study area however several other bores are located within the vicinity, though they have not been subject to ongoing monitoring. These bores provide a snapshot of groundwater levels that are neither maximum nor minimum levels but would be expected to be within the natural seasonal variation. The most recently sampled bore was in 2011 (ID: 61671004) situated 500 m east and hydrologically upstream of the study area showing a groundwater level 4.5 m below ground level (BGL). Considering this information together with another bore close to the study area (ID: 61605266) which last recorded data from 1999 of 4 m BGL, which indicates that the groundwater level may be lower than the mapped minimum groundwater atlas levels.

Groundwater levels from two bores located north of the study area (ID: 61605225 and ID: 61605224) were measured in 1996 at approximately 3 m BGL. These bores are part of the Ascot Water development, which topographically sits approximately 2 m higher than the northern section of the study area and has been built-up for the purposes of the development. Therefore it is reasonable to conclude that the groundwater level of these bores is less likely to be representative of levels within the study area than the surrounding locations.

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 8: Groundwater levels



Data source: WC, DEC, Landgate. Created by: AT. Projection: MGA: zone 50.

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As part of a contamination investigation of Lot 5 Resolution Drive, adjacent to the Water Corporation drain in the west of the study area, water levels in groundwater monitoring bores were measured. Groundwater was identified as between 1.56 m BGL (BH1) and 1.76 m BGL (GW5), which is consistent with mapping from the Perth Groundwater Atlas (DWER, 2017c).

4.4.4 Groundwater Quality

There have been limited assessments of groundwater quality within the study area. As part of the contamination investigations of Lot 5 Resolution Drive (GHD, 2013) (outlined in Section 4.6.4) three groundwater monitoring bores (Figure 8) were sampled for water quality. Results from this sampling indicated the following exceedances of Australian and New Zealand Environment and Conservation Council (ANZECC) guideline values:

- Concentrations of iron (3.9, 20 and 1.5 mg/L) were above ANZECC Fresh Water (0.3 mg/L) and Marine Water (1.0 mg/L) criteria;
- Concentrations of zinc (0.026, 0.009 and 0.017 mg/L) and were above ANZECC Fresh Water (0.008 mg/L) criteria in all bores and Marine Water (0.015 mg/L) criteria in bores GW4 and BH1;
- Concentrations of ammonia were above ANZECC Fresh Water (0.9 mg/L) and Marine Water (0.91 mg/L) criteria in GW4 (3.8 mg/L) and GW5 (4.9 mg/L);
- Concentrations of nitrate were above ANZECC Marine Water (0.005 mg/L) criteria in all bores and above Fresh Water (0.01 mg/L) criteria in GW4 (0.019 mg/L) and GW5 (0.019 mg/L); and
- Concentrations of total nitrogen exceeded ANZECC Fresh Water (2 mg/L) criteria in GW4 (5 mg/L) and GW5 (5.9 mg/L).

These exceedances were considered by GHD to be characteristic of the winter conditions in the Swan River and natural soils in the area rather than impact associated with fill material on this site. Note that the site management plan was not implemented.

The City of Belmont has identified that groundwater in the area is saline and therefore not suitable for irrigation of landscaped areas.

4.5 Surface Water Resource

Existing surface water features within the study area may require protection from development or provide opportunities for modification to deliver the community an asset with social and ecological benefits. The surface water resources are outlined in below.

4.5.1 Natural Water Resources

The Swan River is adjacent to the western portion of the study area. The Swan River holds significant ecological value because it provides habitat for local and migratory birds and other fauna, with the majority of the River being identified as a conservation category wetland and environmentally protected area. Furthermore, the Swan River provides important social value for visual amenity, recreation on the river and its reserves. The Swan River also holds Aboriginal and European heritage significant values. The Department of Water and Environmental Regulation Floodway mapping indicates that a large area in the northern portion of the study area lies within the Swan River 100 year average reoccurrence interval (ARI) flood fringe (Figure 9).

A portion of the site is located within the Swan River Trust Development Control area (Figure 9). Land use planning and development within the Development Control Area is subject to

approval of the Department of Biodiversity, Conservation and Attractions under Part 5 of the *Swan and Canning Rivers Management Act 2006* and the *Swan and Canning Rivers Management Regulations 2007*. This area includes the waterways of the Swan and Canning rivers and the adjoining parks and recreation reserves.

Water management strategies for the study area will need to ensure protection of the Swan River, particularly with regards to water quality improvement. The catchments of the Swan Canning River system are the subject of the *Swan Canning Water Quality Improvement Plan* (SRT, 2008) which contains catchment management measures and control actions. It was developed as a part of the Coastal Catchments Initiative, with the following aim of reducing nitrogen and phosphorus inputs to the Swan-Canning river system.

The Belmont Foreshore Precinct Plan (City of Belmont, 2014) was prepared to guide development and landuse within the river setting and ensure that the landscape values of the river system are conserved or enhanced. The study area, particularly Trust Land and POS contains areas identified as parkland within the precinct plan, characterised by open lawns surrounding large individual trees. The precinct plan outlines strategic recommendations that will need to be incorporated into future planning of the Trust Land.

On the basis of predictive modelling, the *Swan Canning Water Quality Improvement Plan* reports the maximum acceptable load to the Swan and Canning rivers per year as 130 tonnes of total nitrogen (TN) and 14 tonnes of total phosphorus (TP). To meet these objectives the *Swan Canning water quality improvement plan* aims to:

- reduce the nitrogen load by 120 tonnes per year (49%); and
- reduce the phosphorus load by 12 tonnes per year (46%).

4.5.2 Drainage

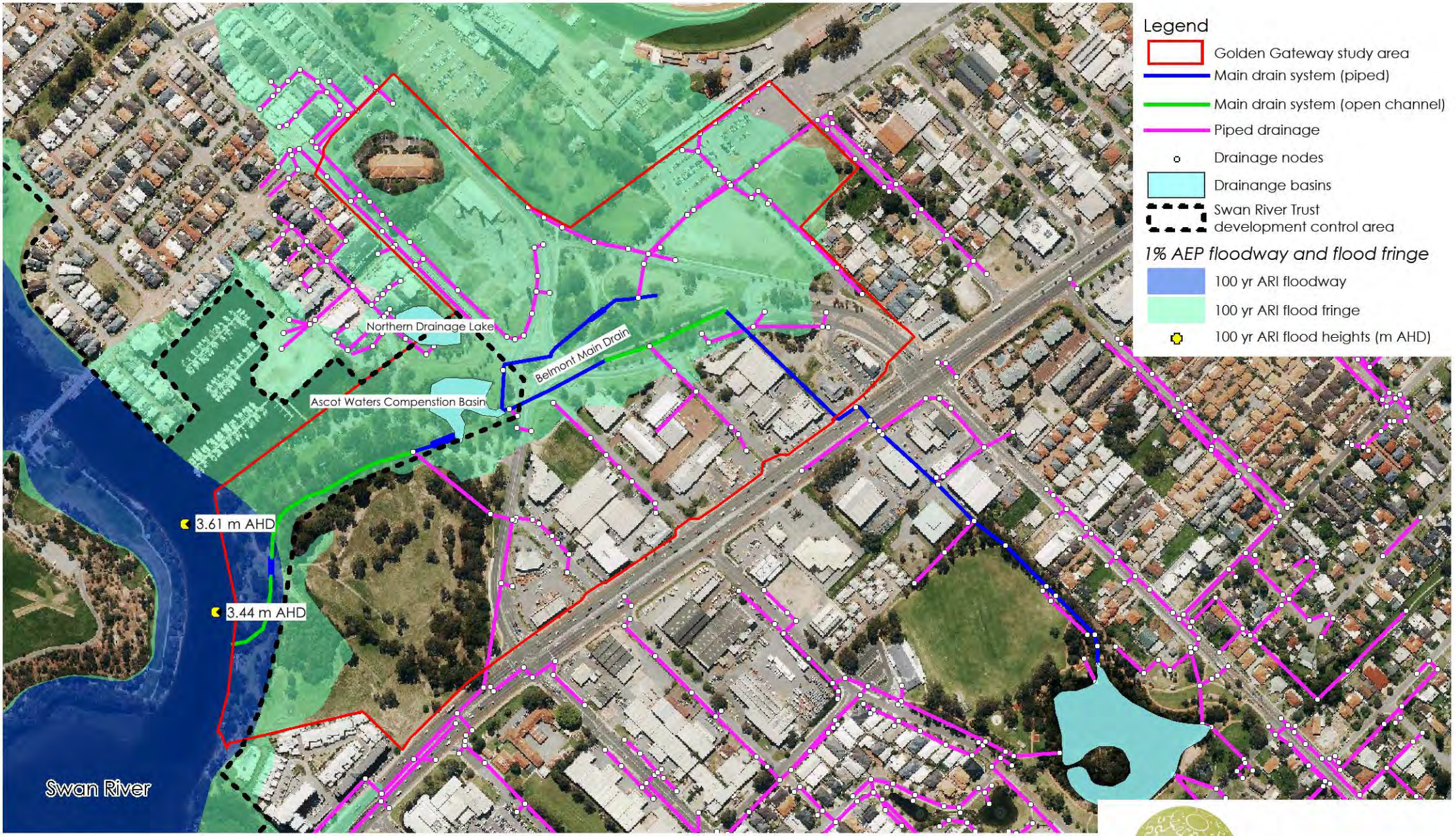
Drainage throughout the study area is part of the Water Corporation's Central Belmont Main Drain system and consists of a combination of piped drainage, open channels and constructed compensation basins. The study area is at the downstream end of a larger catchment within the City of Belmont that extends south and east covering are area of approximately 350 ha. This wider catchment includes the Centenary Park compensation basin.

The Belmont Main Drain system enters the study area under Great Eastern Highway through a 1500 mm pipe that flows from Centenary Park to north of Resolution Drive. This pipe discharges to an open drain that flows approximately 150 m to the west. This drain has a trapezoidal shape and straight alignment that was modified most recently in the 1980s (Figure 9).

It is understood that the Water Corporation planning for the system includes a number of capital works to modify the system upstream of the study area (Water Corporation, 2009). Within the study area, the open section of Belmont Main Drain between Stoneham Street and Resolution Drive is recommended to be piped for safety reasons. No other modifications to the Main Drain were recommended by the Water Corporation (Water Corporation, 2009) since it was found to operate satisfactorily in accordance with its design requirements.

Belmont Main Drain discharges under the Stoneham Street / Resolution Drive roundabout to the Ascot Waters Compensation Basin before extending another 350 m in an open drain towards the Swan River (Figure 9). The Ascot Water Compensation Basin controls flow rates and allows sediment settlement prior to entering the Swan River. A contaminated sites investigation was conducted by GHD and a Site Management Plan was subsequently developed in 2013 for the expansion of this compensation basin, though it was not implemented. The investigation identified issues of leachable metals, PAH and TPH fractions and asbestos (see section 4.6.4).

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 9: Surface water resources



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The remainder of the drainage, as shown in Figure 9, consists of traditional side entry pits and piped drainage along existing roadways. Inflows into the Ascot Waters Compensation Basin have been monitored by the City of Belmont with data available publically on the Water Information Reporting (WIR) Database. The data indicated that mean values of Total Nitrogen (0.96 mg/L) were below ANZECC guidelines values (1.2 mg/L), whilst Total Phosphorus (0.11 mg/L) was above (0.07 mg/L).

North of the Ascot Waters Compensation Basin and outside the study area is a second compensation basin servicing the Ascot Water development, the Northern Drainage Lake. The Northern Drainage Lake has experienced water quality issues in the past with two fish kill incidents occurring during July and September 2012. The first incident involved approximately 300 fish deaths and the latter 100-150 fish deaths. No incidents have occurred since 2012. Investigations were undertaken by the Swan River Trust in 2012 in response to the fish kills. Water quality testing indicated low concentrations of algae, and higher concentrations of organic matter resulting in oxygen-depleted water. In addition, it was identified that fish often become trapped in backwaters such as this lake.

4.5.4 Wetlands

Geomorphic wetland mapping (DCBA, 2017) demonstrates that there are no wetlands within the study area (Figure 10). The nearest significant mapped wetland is the Swan River to the west and downstream of the study area which is identified as a conservation category wetland.

4.6 Environmental and social

Several environmental and social factors are either influence or are dependent on management of the water cycle with the study area. A summary of these factors are provided below.

4.6.1 Conservation Area

An environmentally sensitive area, as mapped by the Department of Water and Environment Regulation surrounds the Bush Forever site as described above. This area is described as 'Temperate Saltmarsh' and listed as 'vulnerable' under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Temperate salt marshes are an important habitat for local and migratory bird species (Department of Environment, 2015).

4.6.2 Vegetation

There are no Bush Forever sites within the study area, reflecting the existing commercial land use through the study area. Notably there is no significant vegetation along the Belmont Main Drain upstream of the Stoneham Street / Resolution Drive roundabout.

Bush Forever site 313, Swan River Salt Marshes, exists to the north and west of the study area, as shown on Figure 10. The closest proximity of the Bush Forever site to the study area is adjacent to Trust Land at the south-western boundary. Apart from this point, the study area is largely disconnected from the Bush Forever site.

A portion of the vegetation along the banks of the Swan River has been identified as a Bush Fire Prone Area. A Bushfire Management Plan (Essential Environmental, 2018b) has been prepared for management of these areas.

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 10: Environmental and heritage features

Data source: DEC, DIA, Landgate. Created by: RM. Projection: MGA: zone 50.

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4.6.3 Heritage

A search of the Department of Planning, Lands and Heritage aboriginal heritage enquiry system showed one site overlaying the study area (Figure 10):

- Site ID 3753 – Registered site, Name: Perth, Type: Historical, mythological, hunting place, named place, natural feature.

One other site is adjacent to the study area, however not within the boundary, site ID 3536 - Registered site, Name: Swan River, Type: mythological.

The significant European Heritage feature of the study area is the Bristle Kilns; beehive and tunnel kilns, with associated chimney and floor ducts, located at 197 Grandstand Rd Ascot. The Kilns were first built in 1930, manufacturing terracotta, stoneware and steel products. Production ceased in 1982 (Heritage Council, 2012). The Kilns and chimneys remain and were placed on the State Heritage List in 2003.

4.6.4 Contamination

A search of the Department of Water and Environmental Regulation Contaminated Sites database found no contaminated sites within the study area. Lot 5 Resolution Drive (160 Stoneham Street) is listed as "Possibly Contaminated, Investigation Required".

The Ascot Waters Compensation Basin was assessed by Douglas Partners (2009) to determine the occurrence of acid sulphate soils and waste classification in support of expanding the basin. A Preliminary and Detailed Site Investigation was developed by GHD along with a Site Management Plan for this area (GHD, 2013). A summary of the contamination issues identified through these investigations include:

- Soil (Inorganic): Exceedances of metals (As, Ca, Mn, Hg, Ni, Pb, Zn, Al, Fe) above Ecological Investigation Levels and Health Investigation Levels were minimal and asbestos was considered to be low risk (though further investigations are required);
- Soil (Organic): Hydrocarbons were localised and not considered to pose a risk to ecological or human receptors;
- Groundwater (Inorganic): Three groundwater bores were sampled to test for Fe, Zn, Ni, NO_3, NO_2, Total Nitrogen and Total Phosphorus with results generally consistent with winter conditions in the Swan River and natural soils in the area; and,
- Groundwater (Organic): Samples were analysed for BTEX, Total Recoverable Hydrocarbons (TRH) and Polycyclic Aromatic Hydrocarbons (PAH) with all reported below the DER Domestic Non-Potable Water Criteria (GHD, 2013).

Further details are provided in the Golden Gateway Local Structure Plan Environmental Report (Essential Environmental, 2018a).

4.7 Summary

Based on the review of the geological, hydrological and environmental information for the study area, the key considerations for water management are as follows:

- No additional groundwater allocation (beyond existing licences) available for irrigation of public open space;
- Saline groundwater conditions unsuitable for irrigation;

- Groundwater is generally shallow across the study area, approximately 1-2m below the surface in some areas;
- Potentially high risk of acid sulfate soils present in parts of the site with sandy silt soils;
- Former land uses may have contributed to legacy nutrients within groundwater;
- Limited water sensitive urban design features throughout the existing development areas;
- Water Corporation planning includes replacing the open Central Belmont Main Drain between Resolution River and Stoneham Street with a piped system for safety concerns; and,
- The Swan River which presents a number of considerations including the 100yr ARI flood fringe, conservation category wetland mapping and the Swan River Trust Development Control Area in the west of the study area.

5 WATER MANAGEMENT STRATEGY

Water management strategies for the study area have been prepared in accordance with the guiding documents, policies and strategies (Section1), the intended redevelopment (Section 2) and the site considerations (Section 4). Strategies for water sustainability, stormwater, groundwater, and water quality improvement are outlined in this Section.

5.1 Water sustainability initiatives

- Ensure the efficient use of all water resources in the redeveloped urban form and aim to achieve highest value use of fit-for-purpose water;
- maintain opportunities for future generations by using water more efficiently.

A broad scale water demand model has been developed, using Essential Environmental's Water Balance Tool, to identify the various post-development water demands from residential and non-residential areas. Summary results of this water balance modelling are presented in Table 2 and details are provided in Appendix 2. The modelling is based on yield estimates for the Golden Gateway area, excluding the Belmont Trust land. A separate demand model will be required for that area as planning progresses.

The analysis is based on the development comprising 46 townhouses and 3,412 apartments, with an approximate population of 6,250 residents. Analysis assumes the use of standard water efficiency measures within households and irrigation of up-to 25% of townhouse lot areas and 5% of apartment lot areas consistent with current State Government policies (watering for 2 days per week through summer). These demands are consistent with a target of less than 100 kilolitres per person per year.

The most significant public non-drinking water demand for the redevelopment will be public open space irrigation. As discussed in Section 4.4.4, the saline groundwater conditions prevent the local abstraction of groundwater for irrigation and therefore an alternative source is required. The City may consider stormwater capture, reuse and harvesting options during further detailed design of the redevelopment and public spaces, for example using paving design to collect local runoff. To further reduce demand, landscaping within the redevelopment will use hydrozoning and smart meters.

Other non-drinking water demands include toilets and washing machines in homes and garden irrigation. Although there is no proposal to provide for these demands through a non-drinking water scheme there remains potential for significant reductions in scheme water use to be achieved through water efficiency measures within individual apartment buildings potentially including stormwater harvesting and or greywater reuse.

Table 2: Annual summary water demands

Scenario	Drinking	Non-drinking	Total
Residential (kL)	213,707	176,314	390,021
Commercial (kL)	900	600	1,500
Public Open Space (kL)	-	10,058	10,058
Total (kL)	**214,607**	**186,972**	**401,579**
Estimated Household Consumption (kL/person/year)	34	28	62

5.2 Water servicing

The strategy area is located in an area served by the Water Corporation's integrated water supply scheme. All dwellings will be connected reticulated drinking water distribution network. Similarly, the strategy area is located in an area served by the Water Corporation's integrated sewerage scheme and will be connected to a reticulated sewerage network.

5.3 Stormwater management

The key objectives for surface water management are:

- Protection of wetlands and waterways (receiving environments) from the impacts of urban runoff; and,
- Protection of infrastructure and assets from flooding and inundation;

The following planning measures are adopted to achieve the above objectives:

- Residential, industrial or commercial premises in existing or proposed areas must have their floor levels elevated 500 mm above the 1% AEP flood level (100yr ARI) in the Swan River and 300 mm above the 1% AEP flood level in the local drainage system;
- Runoff from events greater than the 100% AEP (1yr ARI) interval event and up to the 20% AEP (5yr ARI) event in residential areas and 10% AEP (10yr ARI) event in commercial/industrial areas are to be managed in accordance with the serviceability requirements of *Australian Rainfall and Runoff* (Engineers Australia, 2001) minor/major system;
- The design of the redeveloped urban areas should incorporate current best practice in water-sensitive urban design to mitigate the potential impacts on regional water quantity and quality from redevelopment and the legacy conditions within the catchment;
- Retrofitting of stormwater management systems to achieve improved water quality outcomes should be maximised through the installation of biofilters (raingardens), amended soils and the use of structural controls to address litter, sediment and vegetative materials at source;
- Modification of the existing Central Belmont Main Drain and local drainage systems to suit the urban form whilst maintaining drainage capacity and peak flow rates; and,
- Water-sensitive urban design and best management practices promoting on-site retention of the first 15 mm of rainfall form the basis of the surface water quantity management strategy for minor events.

5.3.1 Small event management

The development will retain no less than the first 15 mm of rainfall on-site within lots and streets. It is understood that Water Corporation system has sufficient capacity for redevelopment of the study area, however retention of the 15mm event will allow water quality objectives to be achieved (Section 5.5).

Retention of runoff within lots (multi-story mixed use development) will be achieved through a combination of raingardens, water tanks and soakwell systems. Rainfall captured from roof areas is suitable for non-potable reuse in-house (toilets, laundry) and ex-house (garden areas), and will assist in achieving the water sustainability objectives outlined in Section 5.1. The suitability of a roof runoff capture and reuse system will be determined during detailed design of each building. Where these systems are not viable, roof runoff will be captured and infiltrated in underground infiltration systems within the lot boundaries. Developments will be

required to provide on-site retention within raingardens for runoff from other impervious areas on lots (pavement, carparks).

Upgrading of local roads to deliver an inner urban street character will provide the opportunity to incorporate water sensitive urban designs. Raingardens and tree-pits (e.g. see Figure 11) with the streetscape will be installed to provide infiltration of the first 15mm of rainfall. Similarly, the realignment and upgrade of the distributor roads (Resolution Drive, Grandstand Road and Stoneham Street) to four lane roads with a central median will require retention and infiltration of the first 15mm. This will be achieved through the installation of bio-retention swales within the median.

Raingardens, swales and tree-pits will be connected to the downstream environment via subsoil drainage discharging to the road drainage system to prevent local groundwater levels from rising and becoming a nuisance to the future community.

Within the Belmont Trust land, the retention and treatment of the first 15mm of rainfall will occur outside of the Swan River Trust Development Control Area. Vegetated buffer zones/verges should be installed in POS between waterways and turf area to help prevent herbicides, fertilisers and grass clippings entering waterways where practical.

Typical volumes required for retention and infiltration of the first 15mm of rainfall within lots and road reserves are provided in Table 3.

Table 3: Typical on-site retention volumes

Area type	System type (assumed)	Volume to be provided
Road reserve	Raingardens or tree-pits	0.9 m^3 per 100 m^2
Single residential lot	Soakwells	0.5 m^3 per 100 m^2
Multi-residential lots	Underground infiltration system	9.4 m^3 per 1000 m^2 lot
Apartment building	Underground infiltration system	9.5 m^3 per 1000 m^2 lot
Mixed use building	Underground infiltration system	9.5 m^3 per 1000 m^2 lot

5.3.2 Minor event management

Stormwater in excess of the capacity of on-site retention systems will be conveyed through the existing drainage system consisting of local road drainage, Central Belmont Main Drain Basin and compensating basin. Owing to the current commercial land use within the study area, redevelopment to mixed Commercial/Residential towers will have minimal impact on the impervious areas and runoff characteristics within the catchment. Therefore the existing system is considered sufficient for future land uses.

The significant modification to the system will be the conversion of the open drain between Resolution Drive and Stoneham Street, as recommended in the Water Corporation (2009) review of the system. It was recommended that this drain is replaced with a 1500mm pipe for safety reasons. Replacing the drain with a pipe will also allow for realignment of the system consistent with other services and future POS alignments.

Any changes to the Water Corporation drainage system will need to be undertaken in consultation with the Water Corporation and will require further detailed design, justification and agreement. This includes consideration of the modifications outlined above to ensure that

the capacity of the main drain is sufficient to meet the conditions of the Water Corporation's operating license.

Downstream of Stoneham Road, within the Swan River Trust Development Control Area, the existing compensation basin and drain that discharges to the Swan River will not be modified.

Potential raingarden and median swale locations are provided in Figure 12 and an example of a median swale or biofilter is provided in Figure 13.

5.3.3 Floodplain (major event) management

Major flood runoff (1% AEP) will be conveyed via overland flow within the road reserve to the compensating basin and drain prior to discharging to the Swan River.

To ensure there is adequate protection from major flood events in the Swan River, the habitable flood level of any buildings within the study area will be a minimum of 500mm above the 1% AEP (100yr ARI) flood levels as shown in Figure 9. This is most relevant for the northern portions of the study area that are located within the Swan River flood fringe. The nearest 1% AEP flood level for the study area, located at the outlet of the Central Belmont Main Drain system is 3.44 m AHD and therefore the minimum habitable floor level throughout the study area would be 3.94 m AHD.

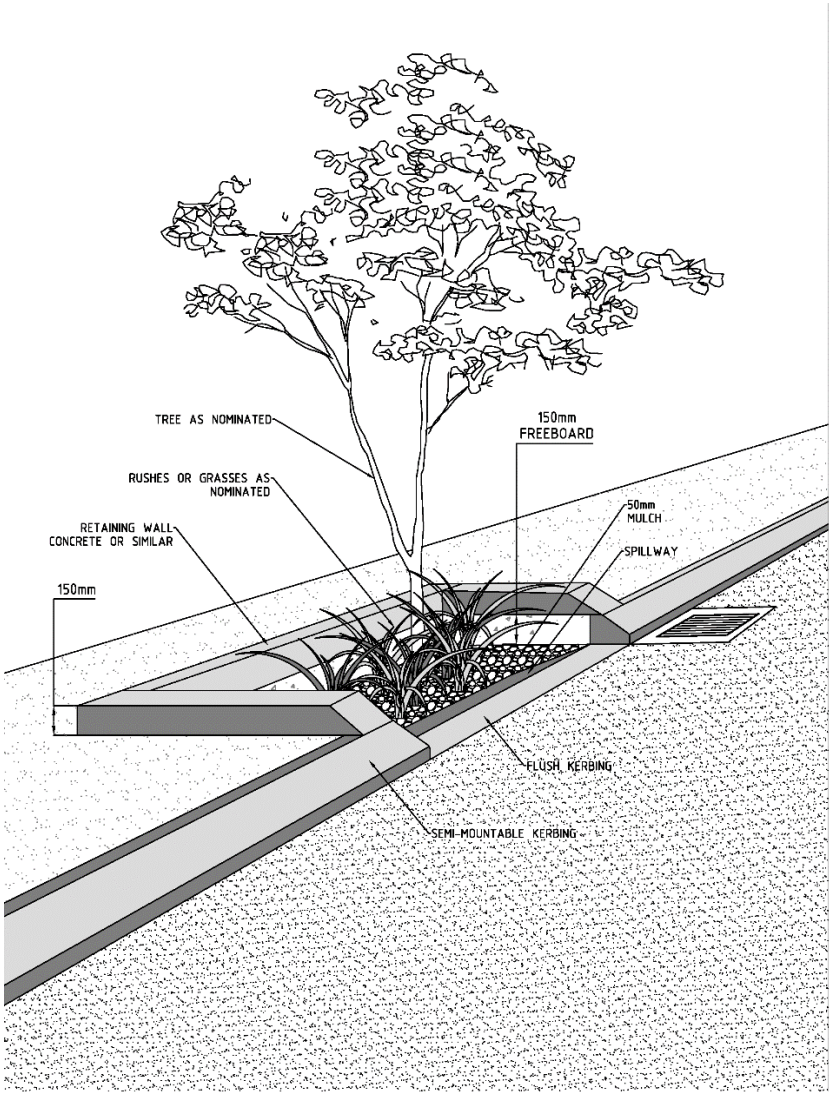
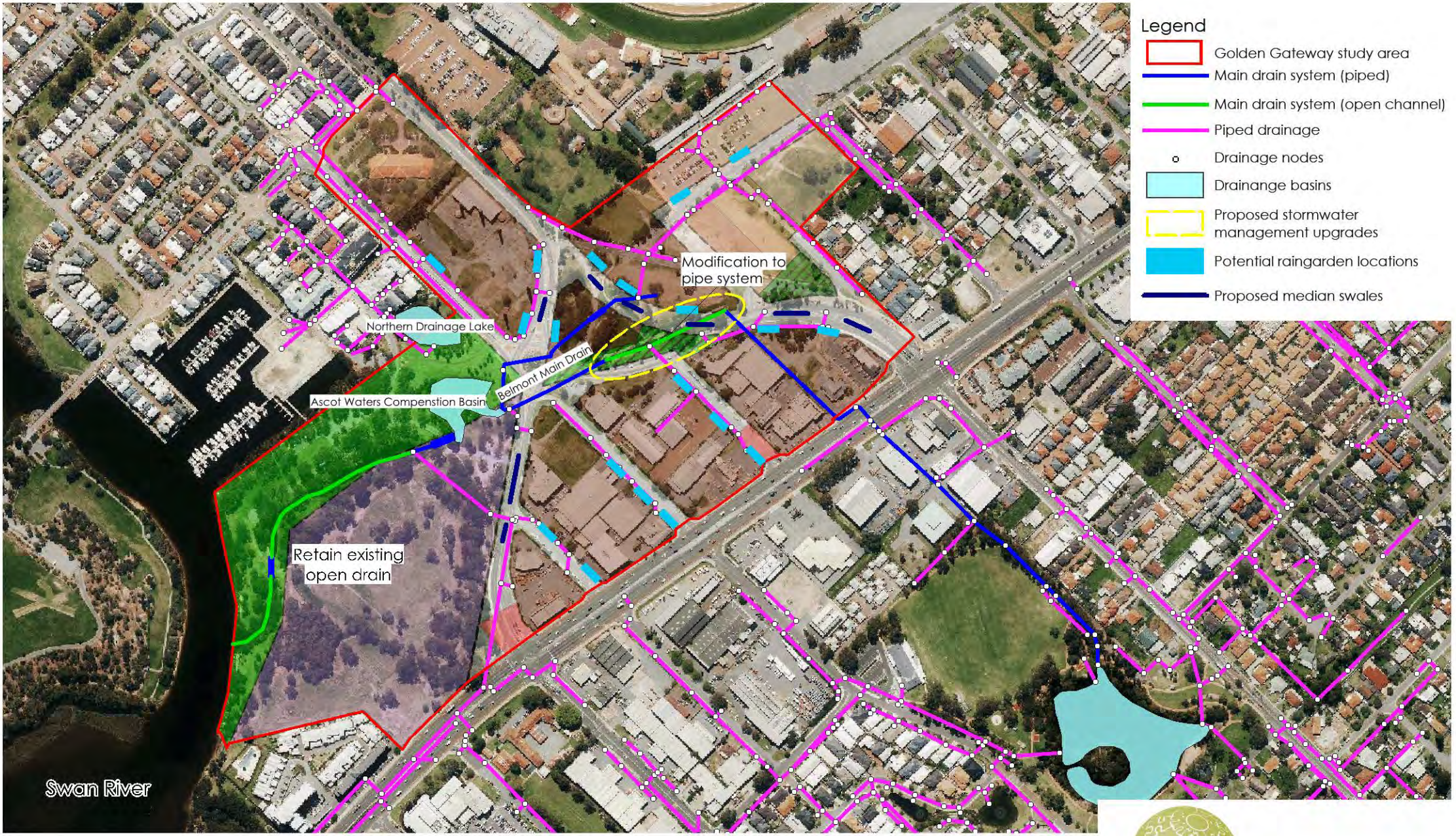


Figure 11: Typical roadside tree pit or raingarden

City of Belmont: Golden Gateway - Local Water Management Strategy
Figure 12: Stormwater management system



Data source: WC, DEC, Landgate. Created by: AT. Projection: MGA: zone 50.

Scale 1: 5,500
@ A4

0 110 m

N

essential environmental

Figure 13: Typical median swale or biofilter

5.4 Groundwater management

The key objectives for groundwater management are:

- Protecting infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture;
- Protecting groundwater dependent ecosystems from the impacts of urban runoff; and,
- Managing and minimising changes in groundwater levels and groundwater quality following redevelopment.

The following planning measures are adopted to achieve the above objectives:

- Retain existing surface levels as a minimum to ensure adequate separation;
- Limit basements in areas of shallow groundwater; and,
- Use of subsoil drainage below bio-retention areas, raingardens and tree pits to minimise local groundwater rise.

Groundwater levels throughout the study area have been derived from regional contouring information and snapshot measurements. The results indicated that there is potential clearance for basements to be installed, with two storey basements possible closer to Great Eastern Highway. Detailed designs of any infrastructure below the existing surface level (such as basements) will require further onsite monitoring to determine local groundwater levels and separation. Where levels are shallow, design will need to account for these conditions and may include tanking or other forms of damp-proofing.

Any temporary lowering groundwater for construction, either for basements or sewer, may require dewatering licences from the Department of Water and Environmental Regulation (discussed further in Section 6.3.1) and ASS Management Plans.

5.5 Water quality management

Site specific targets have been proposed for estuarine catchments of the Swan Coastal Plain as a part of background work undertaken by the Department of Water and Environmental Regulation during the development of the UNDO water quality modelling tool. The targets were developed based on consideration of the sensitivity of the receiving water body and the proximity of the development site. Applying this approach, the study area would lie within the suggested 'proximity zones' of the estuarine portion (<1000 m) owing to the proximity to the Swan River. This would indicate that the following targets could be applied:

- 2.7 kg/ha/yr of Nitrogen
- 0.15 kg/ha/yr of Phosphorous

UNDO (Urban Nutrient Decision Outcomes) is a simple empirical decision support model with a flexible framework that evaluates nutrient reduction decisions for new urban developments on the Swan Coastal Plain. It has been developed by the Department of Water and Environmental Regulation to provide urban development proponents with an easy to use tool for assessment by local and state government authorities.

An UNDO model has been developed for the site with two sub-regions identified (1: Area outside of the Swan River Trust Development Control Area and 2: within the Swan River Trust Development Control Area). These sub-regions have been defined as recommended by the type of drainage strategy proposed for each. The model was run for existing conditions and the proposed redevelopment scenarios. For both scenarios, the area outside of the Swan River

Trust Development Control Area is assumed to be served by piped drainage, while the smaller area within the Control Area features open drains.

Results of UNDO modelling, in the form of a report which is generated by the software containing details of all assumptions and inputs, are provided in Appendix 3 (Proposed Redevelopment) and Appendix 4 (Existing Conditions).

The outcomes of UNDO modelling indicate that on-site retention of the first 15 mm of rainfall within soakwells and bio-retention systems on lots and raingardens in streets will provide discharge loads of:

- 0.39 kg/year/hectare of total nitrogen
- 0.01 kg/year/hectare of total phosphorous

These loads are well within the recommended targets for developments within estuarine catchments of the Swan Coastal Plain that have been developed for a discussion paper as a part of supporting information for the UNDO modelling tool by the Department of Water and Environmental Regulation.

For comparison, the existing conditions scenario returned discharge loads of:

- 0.80 kg/year/hectare of total nitrogen
- 0.10 kg/year/hectare of total phosphorous

The existing loads are within targets, but they demonstrate that improvement that can be achieved through redevelopment of the study area and implementation of water sensitive urban design.

5.6 Management of disease vectors and nuisance insects

The presence of permanent or seasonal water bodies close to residential areas provides the potential for Mosquitos and Chironomid Midges to become a nuisance to the resident population. This strategy does not propose to construct any new permanent or semi-permanent water bodies. However, the construction of above ground water quality treatment systems is proposed. These systems will need to be designed to minimise detention times throughout the year.

Additionally, there are constructed and natural water courses and water bodies in surrounding land where there is potential for mosquitoes and midges to breed. This strategy cannot influence the design or management of water systems in surrounding land areas but is required to recognise their presence and propose strategies that can assist with managing their potential impacts on the developing land and future community.

Physical, chemical and biological control methods can be used to manage mosquito populations. Methods which are likely to be employed (and their order of priority) include:

- Engineering and Landscape design and construction will aim not to create any new permanent or semi-permanent water bodies;
- Improved water quality, minimising nutrient loads and thereby reducing potential for algal blooms and fish kills; and,
- Should Mosquitos and Chironomid Midges become a nuisance, pesticides (larvicides and/or adulticides) will be used as required to kill mosquito larvae in breeding sites.

6 IMPLEMENTATION

The success of the water management strategies outlined in this document is dependent on their implementation through further planning, detailed design, construction and maintenance.

6.1 Urban Water Management Plans

Urban Water Management Plans (UWMPs) are the final water management documents within the state government planning framework outlined in Section 1.1. These documents are prepared as a condition of subdivision (in support of local development plans) to demonstrate that designs achieve the objectives, strategies and design criteria outlined in this LWMS. Where subdivision is proposed in an area that is not covered by a local development plan, the City of Belmont and/or the Department of Water and Environmental Regulation may request preparation of a UWMP if additional information is required to demonstrate compliance with this strategy.

Urban water management plans should be prepared in consultation with the City of Belmont and the Department of Water and Environmental Regulation and be based on local site investigations appropriate to the proposal and level of risk to water resources. The UWMPs should be consistent with the requirements of the Department of Water and Environmental Regulation's *Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions* (DoW, 2008b), recognising that the area is a redevelopment area rather than a greenfield site. Specifically, these documents should include detailed engineering and landscaping designs, design of bio-retention systems and measures to manage impacts from construction.

Where an urban water management plan is not requested by the City of Belmont and/or the Department of Water and Environmental Regulation, development should be undertaken consistent with the objectives, strategies and design criteria in this local water management strategy.

6.2 Pre-development monitoring

The requirement for any further groundwater monitoring is dependent on proposed building designs and any proposals for lowering of the existing surface. This is particularly relevant for any proposed basements. Onsite monitoring should be undertaken, preferably over winter months, to determine groundwater levels. These levels should then be correlated with long term Department of Water and Environmental Regulation groundwater data to calculate maximum groundwater levels and any design considerations for the site.

Results of this groundwater monitoring should be presented in the corresponding urban water management plan for assessment by the City of Belmont and Department of Water and Environmental Regulation.

6.3 Construction

Construction activities have the potential to directly and indirectly impact local water resources and water management measures are required.

6.3.1 Licencing

Water will be required for construction activities such as dust suppression. Although the superficial aquifer is fully allocated, as discussed in Section 4.4.2, temporary groundwater abstraction licences should be sought for construction activities to reduce the demand on potable resources.

Where dewatering will be undertaken for construction, for example with basements and sewer installation, a dewatering licence should be submitted to the Department of Water and Environmental Regulation. Furthermore, where there is a risk of ASS, the licence application should be supported by an ASS and Dewater Management Plan to ensure risks are mitigated.

The Department of Water and Environmental Regulation issues licences to take water from water sources under section 5C of the Rights in Water and Irrigation Act 1914. Such licences may be granted for dewatering activities for construction purposes. The DWER does not issue licences or approvals for the disposal of dewatering effluent. It is the licensee's responsibility to ensure that it obtains all necessary approvals for the disposal of dewatering effluent from relevant authorities and that the dewatering effluent does not cause injury or damage to any persons or property. Relevant approval authorities include the City of Belmont and the Department of Biodiversity, Conservation and Attractions.

6.3.2 Construction Management

To ensure downstream waterways are protected, developers, builders and landscapers must implement best management practices to control erosion and sedimentation. Contractors and staff should be notified of specific construction management requirements including appropriate disposal of waste material, erosion control and dust suppression.

6.4 Roles and Responsibilities

Key tasks, roles and responsibilities relating to delivery of urban water management objectives are outlined in Table 4.

All development is to be in accordance with the objectives, strategies and design criteria in this Local Water Management Strategy. Additional design criteria may need to be met, particularly where they are specific to particular precincts. These will be outlined in the relevant Local development plan, urban water management plan or associated development guideline.

Engineering and building drawings submitted to Council for development approval are to be supported by clear and auditable documentation, providing details outlining the water management requirements including any proposed staging, and demonstrating compliance with design criteria.

Where required, the City of Belmont may seek the advice of the Department of Water and Environmental Regulation regarding water management measures outlined in any development application.

Table 4: Summary of roles and responsibilities

Planning action	Water planning requirement	Timing and responsibility	Additional comments
Golden Gateway Structure Plan	Supported by LWMS which includes objectives, strategies and criteria to be met as part of planning and development	LWMS accompanies the structure plan City of Belmont	LWMS may be revised as detailed planning progresses or information comes to light
Local Development Plan (LDP)	Supported by an urban water management plan (UWMP) which demonstrates how the proposed development meets the objectives, strategies and criteria in the LWMS.	Required prior to any subdivision or development occurring Proponent	Where development is proposed to include amendments to Water Corporation drainage infrastructure the UWMP will need to include detailed designs for the modified drainage infrastructure agreed by the Water Corporation. Any proposed excavation will need to be supported by groundwater level monitoring and appropriate licence applications.
Subdivision	Must meet the requirements of the relevant UWMP (and LWMS)	Should not occur until LDP and UWMP completed Proponent	Unlikely that a UWMP will be required due to the small scale nature of likely subdivision
Development	Must meet the requirements of the relevant UWMP (and LWMS)	Should not occur until LDP and LWMS completed Proponent	Should be consistent with relevant design guidelines

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APPENDIX 1 – LWMS CHECKLIST

Local water management strategy Item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	☑	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		☑	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	
Landscape – proposed POS areas, POS credits, water source, bore(s), lake details (if applicable)	Landscape Plan	☑	
Design criteria			
Agreed design objectives		☑	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	
Site Conditions – existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☑	
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	
Environmental – areas of significant vegetation, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	☑	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	☑	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	☑	
Water sustainability initiatives			
Water supply & efficiency measures – private and public open spaces		☑	
Fit-for-purpose strategy and agreed actions. If non-potable supply, support with water balance		☑	
Wastewater management		☑	
Stormwater management strategy			
Flood protection – peak flow rates, volumes and top water levels at control points,100 year flow paths and100 year detentions storage areas	major event Plan Long section of critical points	☑ ☑	
Manage serviceability – storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	minor event Plan	☑	

Local water management strategy Item	Deliverable	☑	Comments
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	small event Plan Typical cross sections	☑ ☑	
Groundwater management strategy			
Post development groundwater levels and fill requirements (including existing and likely final surface levels), outlet controls, and any subsoils	Groundwater/subsoil Plan	☑	
Actions to address acid sulfate soils or contamination		☑	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		☑	
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	
Implementation			
Developer commitments		☑	
Roles, responsibilities, funding for implementation		☑	
Review		☑	

APPENDIX 2 – WATER BALANCE MODELLING

Site Water Balance
City of Belmont: Golden Gateway
Sheet 1: Water Demands and Waste Generation

Domestic Uses

Dwelling Type		Lifestyle			Traditional			Cottage			Terrace			Apartment			Other		
No. households		0			0			0			46			3412			0		
Population / household		2.736			2.736			1.814			2.4			1.8			1.552		
Occupancy %		100			100			100			100			100			100		
Effective Population	0	0			0			0			110.4			6141.6			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	0.05	0.05	DW	GW1	0.05	DW	GW1	0.05	DW	GW1	0.05	DW	GW1	0.05	DW	GW1	0.05	DW	GW1
Kitchen sink	0.008	0.008	DW	GW2	0.008	DW	GW2	0.008	DW	GW2	0.008	DW	GW2	0.008	DW	GW2	0.008	DW	GW2
Bathroom basin	0.006	0.006	DW	GW1	0.006	DW	GW1	0.006	DW	GW1	0.006	DW	GW1	0.006	DW	GW1	0.006	DW	GW1
Dishwasher	0.003	0.003	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	0.001	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	0.004	DW	GW2	0.004	DW	GW2	0.004	DW	GW2	0.004	DW	GW2	0.004	DW	GW2	0.004	DW	GW2
Toilet	0.033	0.033	NDW	BW	0.033	RW	BW	0.033	RW	BW	0.033	NDW	BW	0.033	NDW	BW	0.033	DW	BW
Washing machine	0.042	0.042	NDW	GW2	0.042	RW	GW2	0.042	RW	GW2	0.042	NDW	GW2	0.042	NDW	GW2	0.042	NDW	GW2
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
Car washing	0.002	0.002	DW	N/A	0.002	DW	N/A	0.002	DW	N/A	0.002	DW	N/A	0	DW	N/A	0.002	DW	N/A
Evaporative cooling	0.006	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	0.006	DW	N/A
Other	0.004	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	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	46	12	0
Average Lot Area	m2	1500	386	245	393.2	6228.6	100
Irrigated area	%	12	25	25	25	5	50
Irrigation event depth	mm	10	10	10	10	5	10
Frequency (days/week)	days	2	2	2	2	2	2
Season length	months	9	9	9	9	9	9
Source		GNDW	NDW	NDW	NDW	NDW	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	3572.2	1476.2	0.0
Domestic Waste Streams	kL/year						
Greywater Type 1 (GW1)		0	0	0	2298	127864	0
Greywater Type 2 (GW2)		0	0	0	2298	127864	0
Black Water (BW)		0	0	0	1331	74026	0
Lost (N/A)		0	0	0	689	48603	0
Irrigation (IRR)		0	0	0	3572	1476	0
Overall Domestic Demand							
Drinking Water (DW)	kL/year	0	0	0	3592	210115	0
Non-Drinking Water (NDW)		0	0	0	6596	169718	0
Rain Water (RW)		0	0	0	0	0	0
Groundwater (GND)		0	0	0	0	0	0
Total Demand		0	0	0	10189	379833	0
Total per capita demand	kL/pp/yr	#DIV/0!	#DIV/0!	#DIV/0!	92	62	#DIV/0!
Per capita DW demand		#DIV/0!	#DIV/0!	#DIV/0!	33	34	#DIV/0!

Public Irrigation

		Passive POS	Active POS	Verge / Garden Beds	School	Other
Total Area	m2	49014	0	8458	0	0
Irrigated area	%	25	75	25	50	25
Irrigation event depth	mm	10	16	10	12	10
Frequency (days/week)	days	2	2	2	2	2
Season length	months	8	10	8	10	8
Source		NDW	GNDW	NDW	GNDW	GNDW
No. Irrigation Events		70.0	87.0	70.0	87.0	70.0
Irrigation Demand	kL/year	8577.5	0.0	1480.2	0.0	0.0

Commercial Uses

	Base rate kL/year	Qty	Rate kL/year	Source	Waste	Total kL/year	Comment
Shopping centre DW	0.6	1500	1	DW	BW	900	WC assumption
shopping centre NDW	0.4	1500	0	NDW	BW	600	WC assumption

Site Water Balance
City of Belmont: Golden Gateway
Sheet 1: Water Demands and Waste Generation

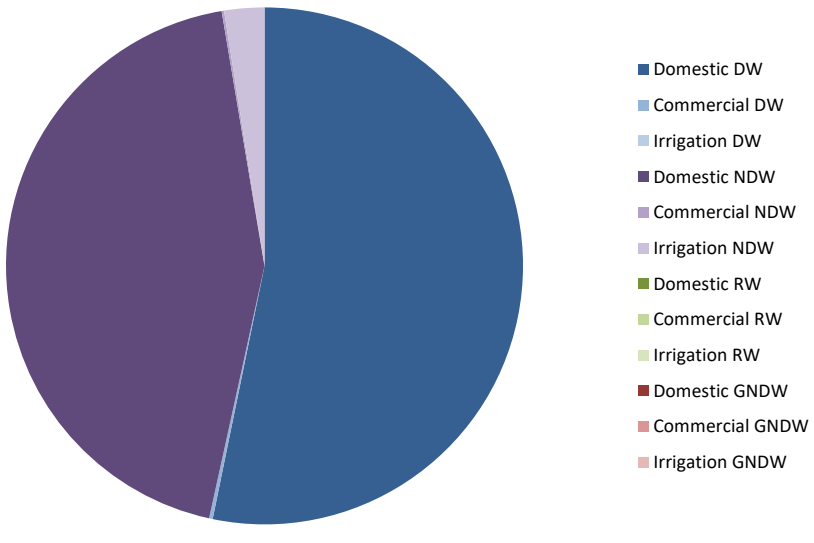
Demand Based Water Balance (kL/year)

	Domestic kL / year	Commercial kL / year	Public Irr' kL / year	Total kL / year	%
Total Water Use	390021	1500	10058	401579	100.0%
Source Demand					
Drinking Water (DW)	213707	900	0	214607	53.4%
Non-Drinking Water (NDW)	176314	600	10058	186972	46.6%
Rain Water (RW)	0	0	0	0	0.0%
Groundwater (GND)	0	0	0	0	0.0%
					100.0%
Waste					
Greywater Type 1 (GW1)	130162	0		130162	32.4%
Greywater Type 2 (GW2)	130162	0		130162	32.4%
Black Water (BW)	75357	1500		76857	19.1%
Lost (N/A)	49292	0		49292	12.3%
Irrigation (IRR)	5048	0	10058	15106	3.8%
					100.0%

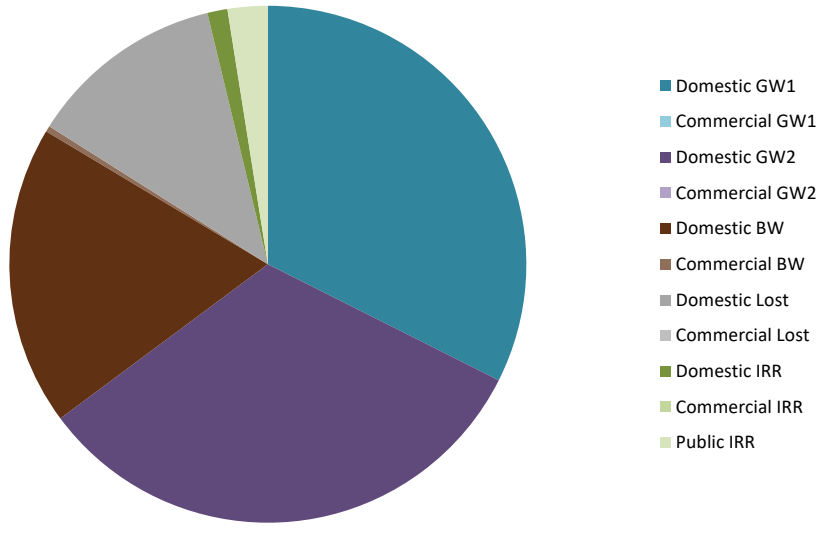
Performance

Population	6252	people
POS Area	5	ha
Total Public Space Area	6	ha
Per Capita Domestic Total Water	62	kL/person/year
Per Capita Domestic Drinking Water	34	kL/person/year
POS Irrigation Rate	0.18	kL/m2/year
Total Public Space Irrigation Rate	0.18	kL/m2/year

Sources Demand



Waste Streams



APPENDIX 3 – UNDO MODELLING (PROPOSED REDEVELOPMENT)

Government of Western Australia
Department of Water

Project: Golden Gateway

Date: 02-Mar-17

Version: Version 1.1.0.16333

Subregion name: Outside POS

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	74	20.13	29.18	2.05
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	3	0.82	0.00	0.00
Road reserve	23	6.26	0.00	0.00

Total area (ha)	Total percent (%)
27.20	87

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
6.30	0.23

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
0.41	0.01

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	0	0.00	0.00	0.00
400-500 m²	0	0.00	0.00	0.00
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	100	20.13	29.18	2.05

Total area (ha)	Total percent (%)
20.125188	74

Nitrogen input (kg)	Phosphorus input (kg)
29.18	2.05

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	0	0.00
Non-native gardens	0	0.00
Not fertilised	100	0.82
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
0.82	3

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	80	5.00
Road reserve - impervious	0	0.00
Road reserve - native garden	0	0.00
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	20	1.25

Total area (ha)	Total percent (%)
6.255126	23

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**Yellow sand (Spearwood)**
Depth to groundwater (m)	**2**	Fill depth (m)	**0.3**
Groundwater slope (%)	**1**	Approximate PRI of imported fill	**11**
Soil PRI	**5.9**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: SRT DC Area

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	4.06	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
4.06	13

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
5.23	0.15

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
0.32	0.01

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	0	0.00
Non-native gardens	0	0.00
Not fertilised	100	4.06
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
4.06	100

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Open channel drains**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**N**
Depth to groundwater (m)	**1**		
Groundwater slope (%)	**1**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

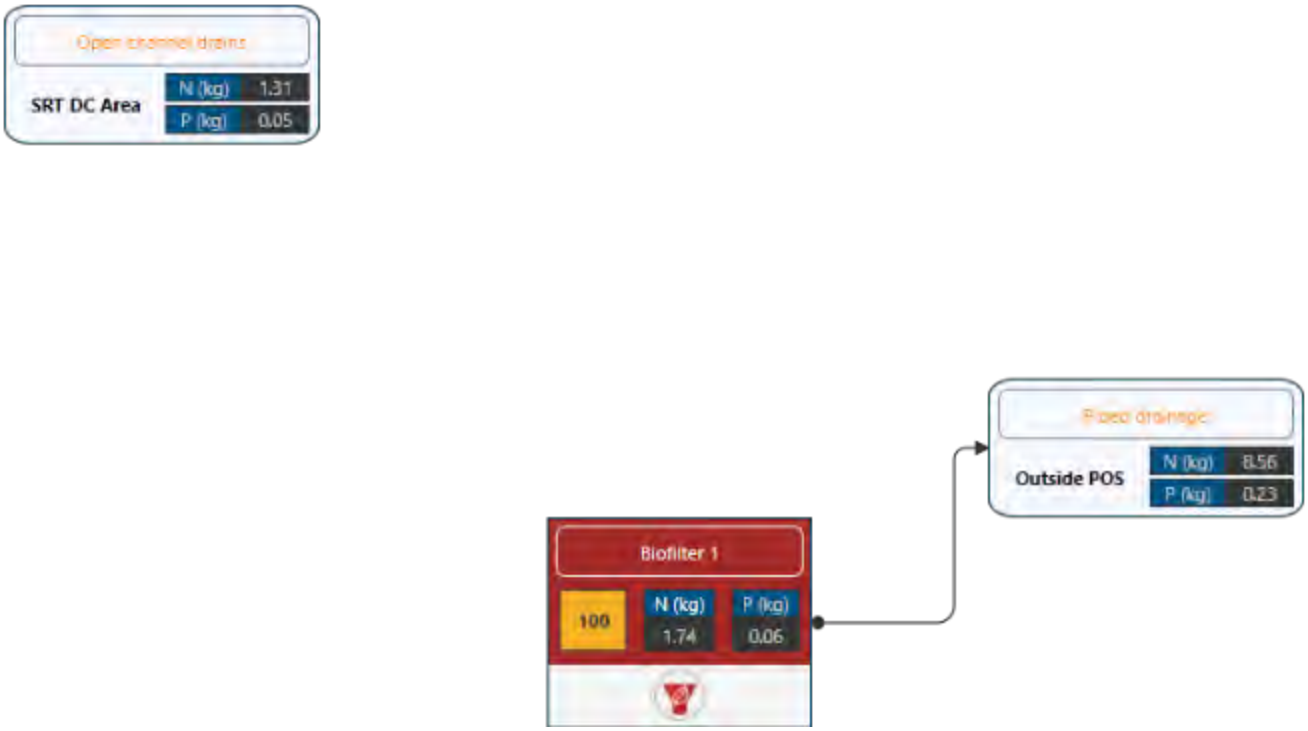
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Biofilter	Biofilter 1	16.00	0.27	Sandy soils – Runoff only (infiltration on lots)	0.07	0.00
Load removed					**0.06**	**0.00**
Net export					**0.33**	**0.01**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Outside POS	27.20	0.01	0.41
SRT DC Area	4.06	0.01	0.32

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
0.39	**0.01**	**0.06**	**0.00**	**0.33**	**0.01**

Treatment diagram



APPENDIX 4 – UNDO MODELLING (EXISTING CONDITIONS)

Government of Western Australia
Department of Water

Project: Golden Gateway Existing Revised

Date: 02-Mar-17

Version: Version 1.1.0.16333

Subregion name: Outside POS

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	35	9.44	226.36	53.81
Rural living	0	0.00	0.00	0.00
Public open space	45	12.14	0.00	0.00
Road reserve	20	5.39	0.00	0.00

Total area (ha)	Total percent (%)
26.97	87

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
13.62	2.15

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
0.88	0.11

Commercial, Industry and Schools

Landuse	Percent (%)	Area (ha)
Light industrial	20	1.89
Heavy industrial	0	0.00
Commercial / Offices	80	7.55
Schools	0	0.00
Public buildings	0	0.00

Total area (ha)	Total percent (%)
9.44	35

Nitrogen input (kg)	Phosphorus input (kg)
226.36	53.81

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	0	0.00
Non-native gardens	0	0.00
Not fertilised	100	12.14
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
12.14	45

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	80	4.32
Road reserve - impervious	0	0.00
Road reserve - native garden	0	0.00
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	20	1.08

Total area (ha)	Total percent (%)
5.394	20

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**2**		
Groundwater slope (%)	**1**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: SRT DC Area

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	4.03	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
4.03	13

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
5.23	0.15

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
0.32	0.01

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	0	0.00
Non-native gardens	0	0.00
Not fertilised	100	4.03
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
4.03	100

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Open channel drains**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**N**
Depth to groundwater (m)	**1**		
Groundwater slope (%)	**1**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Load removed					**0.00**	**0.00**
Net export					**0.80**	**0.10**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Outside POS	26.97	0.11	0.88
SRT DC Area	4.03	0.01	0.32

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
0.80	**0.10**	**0.00**	**0.00**	**0.80**	**0.10**

Client: City of Belmont

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
Draft	V1	RP	HB	Electronic	March 2017
Report for Submission	V2	RP	HB	Electronic	March 2017
Resubmission	V3	RP	HB	Electronic	April 2018
Revision	V4	RP	HB	Electronic	June 2018

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