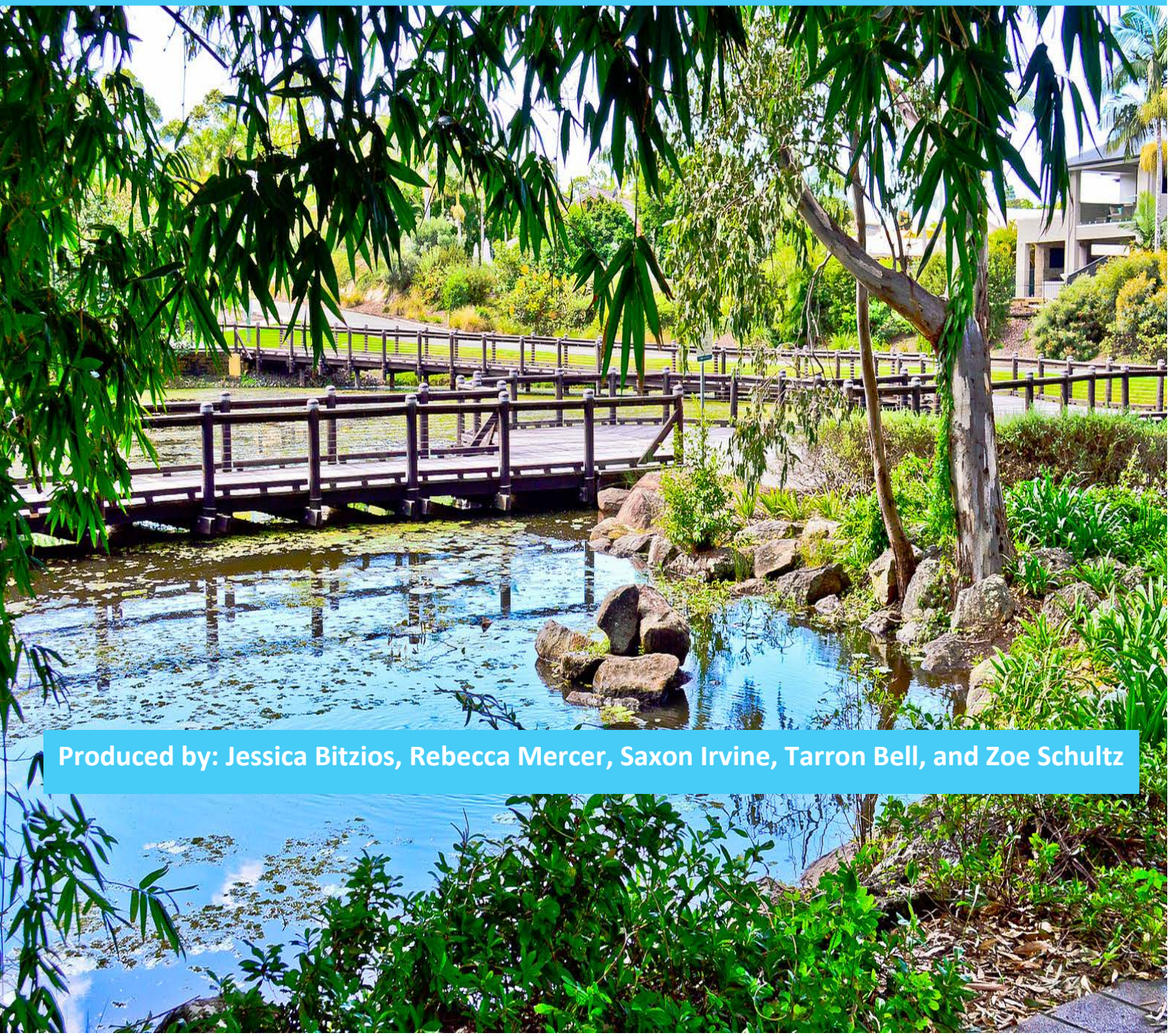
3512ENV Natural Resource Planning

Due: 22 September 2017

Making the Case for Landscape Scale Blue-Green Space Networks in the *Gold Coast Regional Botanic Gardens*



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EXECUTIVE SUMMARY

This discussion paper deals with the integration of blue-green space networks within the Gold Coast Regional Botanic Gardens, located at 230 Ashmore Road, Benowa, within the South-East Queensland (SEQ) region. Our team at Eco-Solutions have explored and researched the key concepts, definitions and roles related to Blue-Green Space Networks, Green Infrastructure (GI), Low-Impact Development (LID), Sustainable Drainage Systems (SuDS), and Water Sensitive Urban Design (WSUD). This prior research was necessary in order to define and understand how the key hydrological issues at the landscape and regional scale can be minimised or solved through the implementation of blue-green space networks.

The key hydrological issues currently facing the SEQ region include: (1) The availability of water in the face of altering drought and flood frequencies; (2) The maintenance of natural assets and water quality in the face of an increasing population; and (3) The management of climate change impacts and flood threats (Department of Energy and Water Supply 2013; Head 2014). Our team at Eco-Solutions began with preliminary studies regarding the key hydrological issues facing the SEQ region and the subject site, leading to extended studies on best management practice and innovative policy solutions applicable to the site. This research was integrated into the development of the Strategic Implementation Framework and our overall vision for the site:

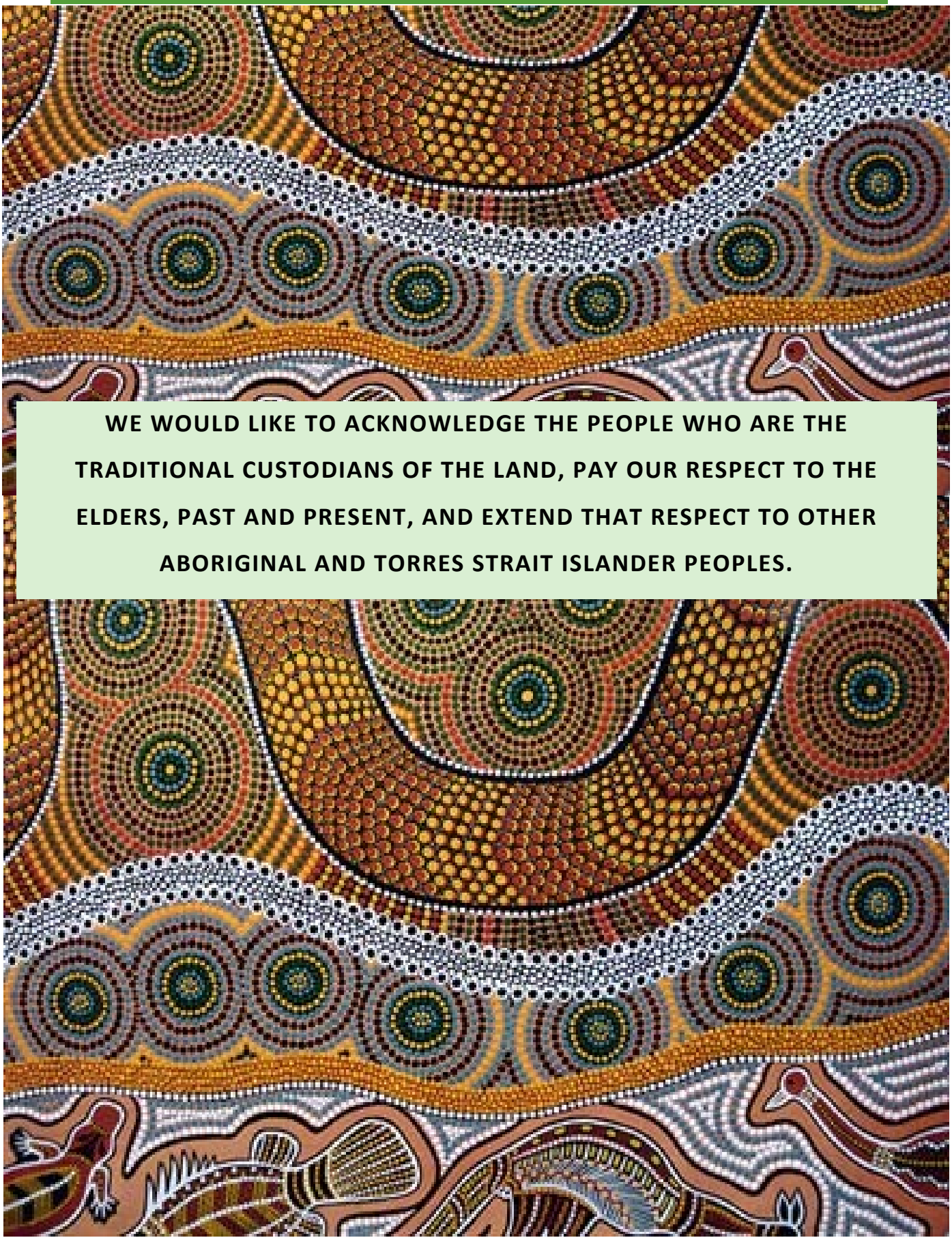
*"Our vision for the next 30 years is to enhance the current health and quality of the natural ecosystem and waterways throughout the Gold Coast Regional Botanic Gardens, whilst improving community capacity, connectivity and resilience towards extreme weather events and flooding" – **Eco-Solutions Team.***

The Strategic Implementation Framework included three key goals, which were then broken down into seven strategic priorities. These goals and strategic priorities focus on improving community capacity, connectivity and resilience towards extreme weather events and flooding. These seven strategic priorities will be executed in

regard to the three key trigger points, including: (1) Pesticide and storm water runoff; (2) Flooding; and (3) Climate change.

This discussion paper has effectively met its overarching objective of establishing blue-green space networks within the Gold Coast Botanic Gardens by recommending the following: bio-retention plantings, green bridge, green-roofed gazebos, and underground water tanks. It is also recommended that a co-management, grassroots development approach be implemented on the site. This will improve communication and collaboration between the community, key stakeholders, and federal, state and local government in order to encourage blue-green infrastructure.

ACKNOWLEDGEMENT OF COUNTRY



WE WOULD LIKE TO ACKNOWLEDGE THE PEOPLE WHO ARE THE TRADITIONAL CUSTODIANS OF THE LAND, PAY OUR RESPECT TO THE ELDERS, PAST AND PRESENT, AND EXTEND THAT RESPECT TO OTHER ABORIGINAL AND TORRES STRAIT ISLANDER PEOPLES.

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1.0 INTRODUCTION

The aim of this report is to explore the concepts and roles related to blue-green space networks in relation to the integrated management of water resources throughout the South-East Queensland (SEQ) region. In order to explore these key concepts and roles, key definitions were developed in regard to blue-green space networks, as well as other forms of water management, including: Green Infrastructure (GI), Low-Impact Development (LID), Sustainable Drainage Systems (SuDS), and Water Sensitive Urban Design (WSUD). The importance of the research within this report is vital towards understanding how key hydrological issues can be minimised by implementing blue-green space networks at the landscape scale. The key hydrological issues currently facing the SEQ region include: (1) The availability of water in the face of altering drought and flood frequencies; (2) The maintenance of natural assets and water quality in the face of an increasing population; and (3) The management of climate change impacts and flood threats (Department of Energy and Water Supply 2013; Head 2014).

The site for this report is based on the Gold Coast Regional Botanic Gardens, located at 230 Ashmore Road, Benowa, within the SEQ region (Figure 1). SEQ's waterways are an integral part of our financial and social well-being, and the continuing rate of urbanisation puts our natural assets and waterways at risk. The management of natural resources in SEQ is guided by a non-statutory Regional Natural Resource Management (NRM) Plan (SEQ Catchments 2016). The NRM Plan aims to create a liveable and safe SEQ by managing the development and use of land and water, whilst protecting ecosystem services and natural resources.

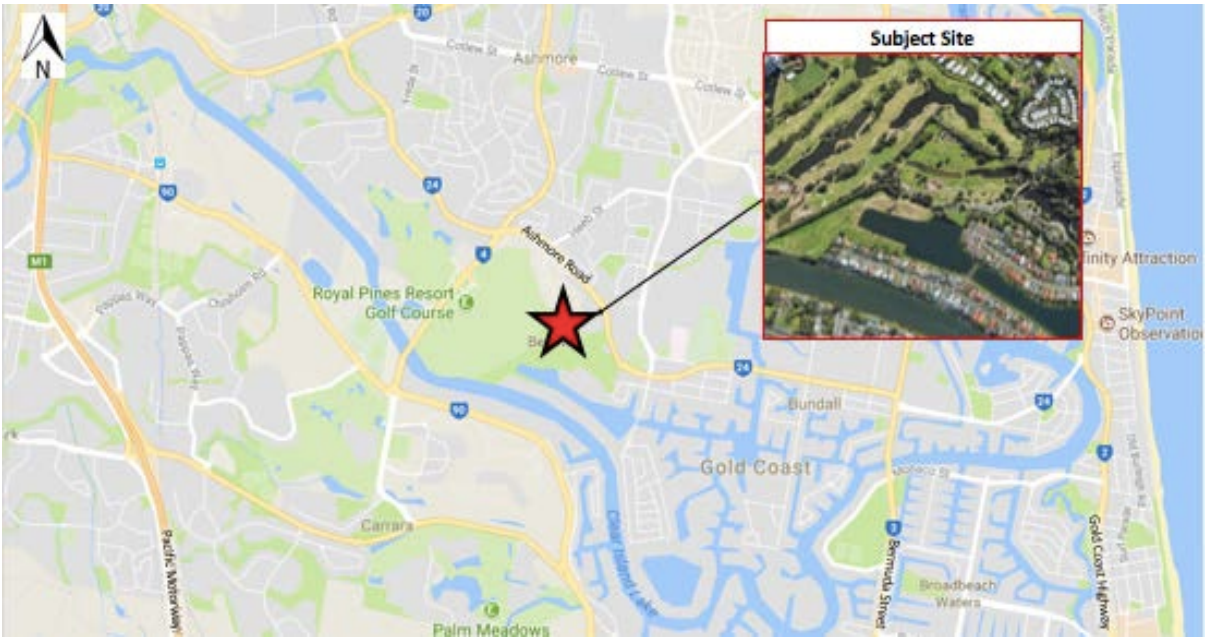


Figure 1 Location of the Botanic Gardens within the Gold Coast (Google Maps 2017).

This report will address the following key issues: (1) The key hydrological issues at the landscape scale within the SEQ region; (2) The emergent trends in water resource management available to regional landscape planners; (3) The best management practices and policy solutions implemented on an interstate and global scale; and (4) The development of a strategic implementation framework towards facilitating interconnected and innovative solutions between the sectors of urban and regional planning and water resource management.

The development of the Strategic Implementation Framework focuses on the inclusion of key goals and strategic priorities, towards the overarching vision of enhancing the current health and quality of the natural ecosystem and waterways throughout the Gold Coast Botanic Gardens, whilst improving community capacity, connectivity and resilience towards extreme weather events and flooding. Both the framework and research within this report will contribute towards the future implementation of blue-green space networks throughout the SEQ region.

1.1 KEY DEFINITIONS

1.1.1 BLUE-GREEN SPACE NETWORKS

Blue-green space networks can be defined as the creation of naturally-orientated water cycles by integrating Green Infrastructure (GI) and water management (known as WSUD in Australia). The 'blue' essentially encompasses lakes, man-made drainage/water features, natural water courses, and ponds, whilst the 'green' refers to greening landscapes (Stephenson 2013). This is achieved by connecting and protecting the hydrological and natural values of the urban landscape, whilst implementing measures to ensure resilience towards climate changes, extreme weather events and urbanisation. Blue-green space networks provide an array of benefits towards; the economy, environment, human health, and social liveability and well-being. These blue-green space networks are leading to the development of blue-green cities - a blue-green city aims to manage the demands of urban drainage and planning through integrated strategies and interaction between blue and green assets (i.e. water and land). These cities and networks may be the key towards the future resilience and sustainability of urban environments and processes. Figure 2 highlights the effects of blue-green space networks.

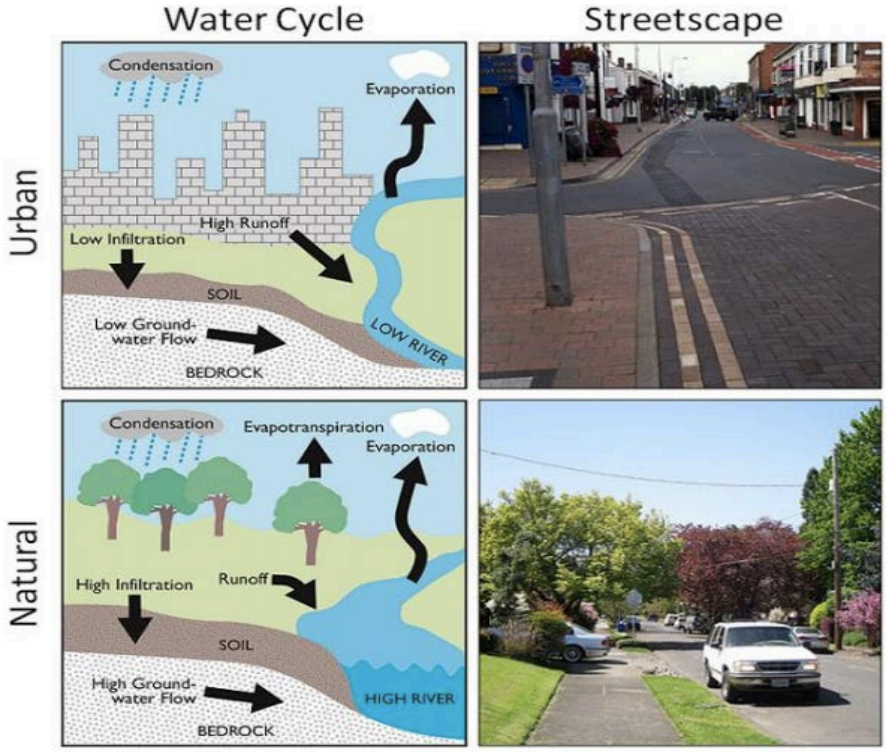


Figure 2 Blue-Green Space Networks Definition (University of Nottingham 2017).

However, a key barrier towards the adoption of blue-green space networks is the uncertainty regarding their hydrologic performance and their public need, as blue-green space networks need to be practical and supported by the local community and key stakeholders (Thorne et al. 2015, p. 1). By communicating the benefits that blue-green space networks provide to ecological, economic and socio-cultural spheres, this can increase community confidence in blue-green space networks as a preferred strategy towards the management of water (Ashley et al., 2015). In Figure 3 below, the aesthetic beauty of blue-green space networks is made evident through the connection of the natural environment and water.

Figure 3 The Beauty of Blue-Green Space Networks (World Landscape Architecture 2017).

1.1.2 GREEN INFRASTRUCTURE (GI)

Green Infrastructure (GI) can be defined as 'an interconnected network of green-spaces that conserves natural ecosystem functions and values and provides associated benefits to human populations' (Benedict 2002). GI began as a technique throughout America towards optimizing the development, management and planning of landscapes, and was often referred to as other synonyms such as green space management or greenway planning. The increasing realisation of the ecological, economic and social values of GI has led to the broadening implementation and research within global cities. GI is now seen as a more appropriate approach to the

delivery of multi-functional landscapes compared to other forms of development – this is a step towards efficient, greener and smarter methods of urban development (Figure 4).

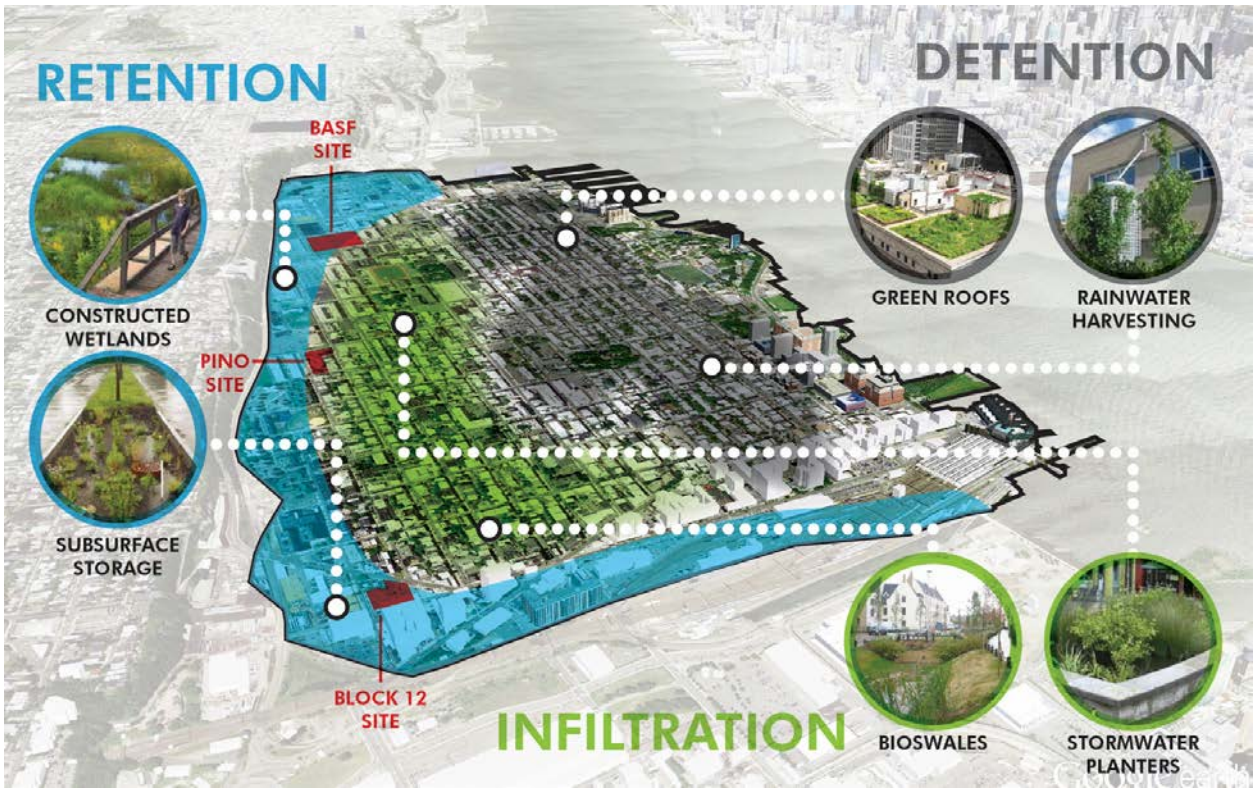


Figure 4 Green Infrastructure (Hoboken Green Infrastructure Strategic Plan 2015).

1.1.3 LOW IMPACT DEVELOPMENT (LID)

Low-Impact Development (LID) is another innovative approach throughout America towards the management of storm water (Workman 2017). This approach is a system that mimics the natural hydrologic processes of a particular site by using design techniques that infiltrate, filter, store, evaporate, and retain runoff that is close to its source (EPA 2017). These techniques are based on the proposition that storm water management should not be seen as storm water disposal, management and transportation through large facilities located at the end of drainage zones, but rather as the management and transportation of storm water through small landscape features located at the surface level (Figure 5).

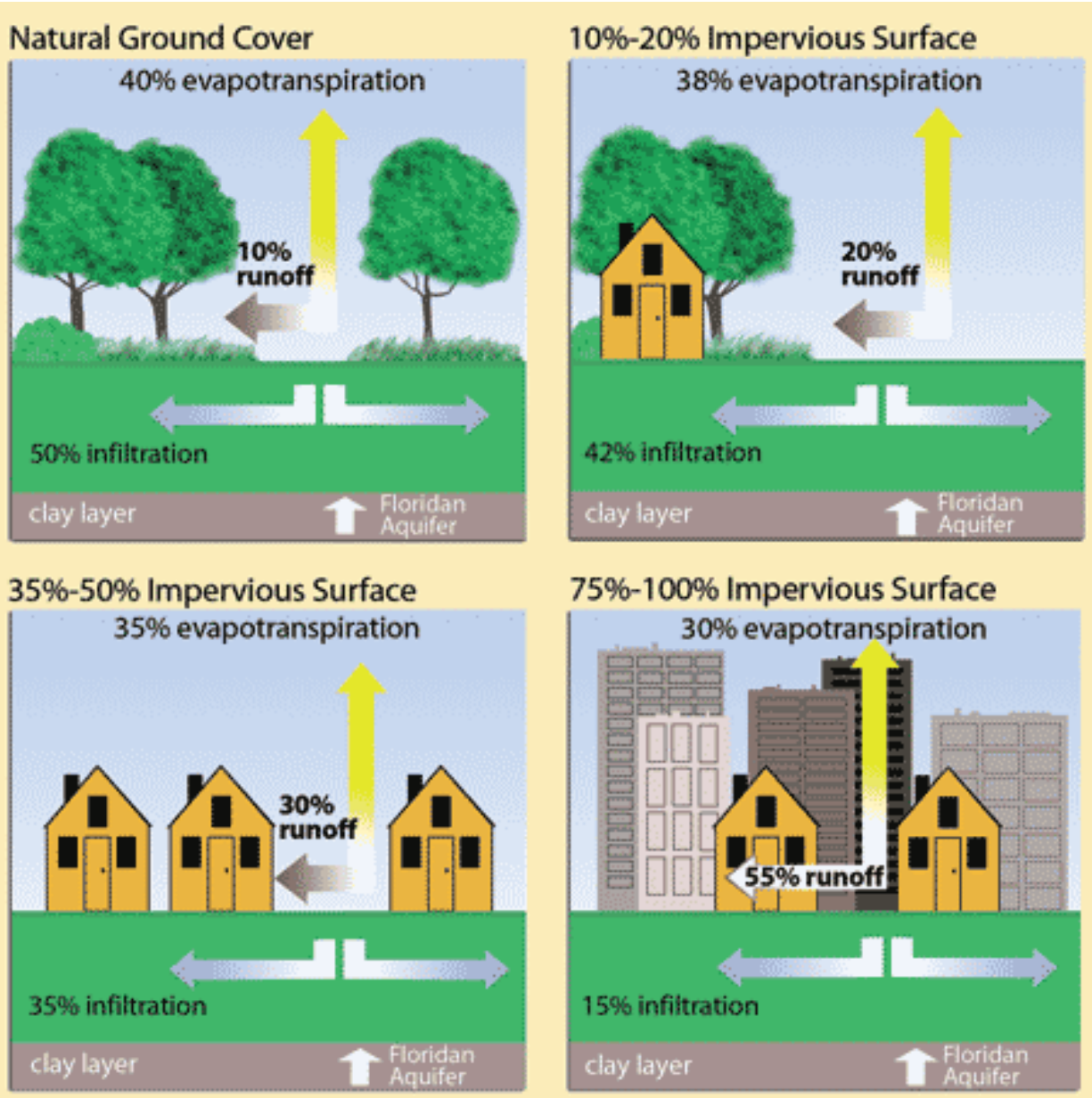


Figure 5 Low Impact Development (Sarasota Bay Estuary Program 2017).

1.1.4 SUSTAINABLE DRAINAGE SYSTEMS (SUDS)

Sustainable Drainage Systems (SuDS) can be defined as 'a principle for the management of surface water, based on managing surface water as close as possible to where it falls by imitating natural paths and processes' (Stephenson 2013). SuDS began as a technique throughout Europe, Ireland and the UK towards optimizing the attenuation, infiltration, flow and treatment of water (Stephenson 2013).

1.1.5 WATER SENSITIVE URBAN DESIGN (WSUD)

Water Sensitive Urban Design (WSUD) is another innovative approach towards the integrated and sustainable management of water and is considered a popular term in both Australia and on a global scale (Workman 2017). This approach is a system that improves, maintains and protects the health of waterways by integrating developments with the natural features of a site and promoting the integration of sewage management, storm water and water supply (Healthy Land & Water 2017). This technique is based on the proposition that natural runoff can be managed and mitigated through urban spaces with the incorporation of constructed wetlands, gross pollutant traps, infiltration trenches, porous paving, rain gardens, rainwater tanks, sediment basins, and swales.

1.1 LITERATURE REVIEW

1.2.1 BACKGROUND

Effective blue-green space networks are essential in combatting the future negative effects of climate change and subsequent extreme weather events (Voskamp & Van de Ven 2015). This literature review will include a critical analysis of several peer-reviewed sources that evaluate the positive and negative effects of blue-green space networks. In particular, this review will examine contrasting literature in regard to the strategies and techniques involved in the development of blue-green space networks.

1.2.2 THE IMPORTANCE OF BLUE-GREEN SPACE NETWORKS

To begin with, Australia is a country where the majority of residents live in towns or cities rather than rural areas, and most of these cities are located in close proximity to oceans, canals and/ or river systems (Joint Steering Committee for Water Sensitive Cities (JSCWSC 2009)). Highly credited authors, Voskamp & Van de Ven (2015) from the Deltares Institute of Applied Research in the Field of Water, highlight that anthropogenic climate change is increasingly causing flooding events that many cities built on waterways cannot withstand. Nieland & Mushtaq (2016) agree with this statement and insinuate that most cities throughout Australia do not have the correct infrastructure and policy implementation tools to mitigate against flooding following a severe weather event. Moreover, these flooding events result in; short term isolation,

damage to major and minor roads, significant loss of life and property, and threats to food security (MacMahon et al. 2015).

Considering this, there is evidence showing that, “public attitudes towards the issue do not appear to be following suit” (Whitmarsh 2011). Antilla (2005) found that the western media plays a significant role in the discourse of climate change where they plentifully broadcast articles that frame controversy, debate and uncertainty surrounding climate change, rather than mainstream climate science. This results in the broader public who are uneducated on climate change and its negative effects to the environment, society and economy, to become apathetic towards policies and implementation frameworks surrounding climate change (Antilla 2005). It is very difficult to implement change when there is minimal community support. This needs to be considered when implementing the solutions for the Gold Coast Botanical Gardens site.

Blue-green space networks are the antidote to severe flooding and poor water quality following a severe weather event (Dreiseitl 2017). Dreiseitl (2017) believes that land and water systems are constantly interconnected and should therefore be planned together rather than separately. Ghofrani et al. (2017, p.18) from the Faculty of Science, Engineering and Built Environment at Deakin University in Australia supports the above claims and explains that blue-green space networks are, “an important means of dealing with flooding/ extreme weather since it can consist of a network of interconnected water reservoirs, wetlands, and their associated (natural) open spaces developed along rivers, which serve several interrelated purposes…”. These purposes include; water storage, regulating the river system (prevention of floods), nature conservation, improving water quality, providing space for the growth of wetland crops, and providing a zone for recreational activities (Ghofrani et al. 2017).

However, Thorne et al. (2015) is doubtful that blue-green space networks will solve all of Australia’s flooding and water quality issues. He notes that there are limitations to current research on blue-green space networks regarding maintenance and improvement strategies once certain green and blue infrastructure is implemented (Thorne et al. 2015). Some examples of this blue-green infrastructure include; bio-retention filters, underground water storm water tanks, open space used for recreational activities, swales and permeable paving (Ghofrani et al. 2017). Our

consultancy suggests that blue-green infrastructure be implemented within the Gold Coast Botanical Gardens and this shall be discussed in Section 4.0 of this paper.

1.2.3 PROS AND CONS OF BLUE-GREEN SPACE NETWORKS

There is currently speculation within the academic community as to whether the pros of blue-green space networks outweigh the cons. This section of the literature review will outline the various pros and cons of blue-green space networks described within several peer-reviewed articles.

Firstly, Ghofrani et al. (2017) states that blue-green infrastructure is improving the quality of land and water which in turn secures marine ecosystems, as well as drives biodiversity. This highlights that the aim of blue-green space networks is to try to get the subject area back into its most natural state and free from high-impact development. Furthermore, blue-green infrastructure mitigates against climate change and creates regions that are resilient to extreme weather events, through “the flexibility and adaptability of infrastructure” (Ghofrani et al. 2017, p.32). Voskamp & Van de Ven (2015) also agree that blue-green measures contribute towards the urban environments’ resilience to extreme weather impacts. As blue-green infrastructure “decreases global warming effects, moderates the temperature, and supplied air ventilation, it plays an important role as a moderator for climate” (Ghofrani 2017, p.32). This results in a reduction in the use of air conditioning and heating systems which will decrease electricity prices within each individual household. Wouters et al. (2015) suggests that another benefit of blue-green infrastructure is that it controls current quantities of storm water, as well as improves the quality of water within catchments.

Moreover, another benefit of blue-green spaces is that it creates space for recreational activities such as exercising and socialising (Ghofrani et al. 2017). This results in an improvement to human physical and mental health, which can in turn reduce health costs (Ghofrani et al. 2017). Ghofrani et al. (2017, p.32) further states that blue-green infrastructure allows people within the community to feel close with nature and provides opportunity to “support humans’ relationship with nature as it links people with forms, features, or processes”. Wouters et al. (2015) also claims that blue-green infrastructure has many societal benefits; particularly through the use of open space to encourage people to spend time outside with their families, neighbours and

communities. Finally, both Ghofrani et al. (2017) and Wouters et al. (2015) have stated that blue-green infrastructure enhances the ‘attractiveness’ and ‘beauty’ of a city, which can increase rates of tourism to the area. In regard to the subject site, the Gold Coast Botanical Gardens currently provides recreational and open space that encourages social interaction.

However, there is some uncertainty surrounding the concept of blue-green space networks. Thorne et al. (2015) highlights that there is doubt surrounding the hydraulic performance of WSUD drainage systems, and many people within the public are having difficulty accepting new policies and frameworks that surround blue-green infrastructure. Wouters et al. (2015, p.3) has a similar point of view and believes that, “the main constraints on implementing sustainable urban storm water and environmental management in a changing climate are not technological”. The challenge of blue-green space networks is the ability to effectively manage the shift in environmental vision, policy, design and planning culture within the wider community (Wouters et al. 2015). The city is required to negotiate all outcomes of the change from standard urban water principles to blue-green space networks with relevant stakeholders (Wouters et al. 2015). Wouters et al. (2015) explains that for this to occur, decision makers need to start valuing a more holistic planning approach rather than conventional engineering services. The most effective way to understand the pros and cons is to analyse certain case studies that show the successes and failures of a blue-green space network.

1.2.4 CASE STUDIES

In order to provide a balanced image of blue-green space networks that should be implemented on the Gold Coast, case studies in China, Houston and Singapore shall be explored.

Houston and China

Case studies from Houston and China can be compared and contrasted to determine the most effective strategies to combat flooding and poor water quality following extreme weather events on the Gold Coast.

Firstly, China is known as a ‘sponge city’ which is defined as, “a particular type of city that does not act like an impermeable system not allowing any water to filter through

the ground, but, more like a sponge, actually absorbs the rain water, which is then naturally filtered by the soil and allowed to reach into the urban or peri-urban aquifers" (Boselli n.d., p.1). This water is easily cleaned/ filtered and used throughout the city (Boselli n.d.). Harris (2015, p.1) similarly describes sponge cities as, "…a re-imagination of the urban environment where almost every raindrop is captured, controlled and reused". Furthermore, sponge cities have become extremely popular throughout China due to the fact that approximately half of China's cities have scarce water resources (Harris 2015). Voskamp & Van de Ven (2015) note that potable water throughout Australia is expected to decrease within the next 50 years, thus it is essential for Australia to begin adopting water safe practices, similar to that used in China.

Boselli (n.d.) outlines that the key issues that sponge cities aim to solve include; less water available in urban and peri urban areas, polluted water discharged into rivers or the sea, degradation of urban ecosystems and green areas due to sprawling, and increases in the intensity and frequency of urban flooding. Furthermore, Harris (2015) states that in order to solve these issues impervious surfaces need to be replaced with water sensitive infrastructure such as bioswales, permeable paving and ditches covered with native vegetation that will regularly collect and filter rainwater. Also, green rooftop gardens are an effective tool to cool air and building temperatures (Harris 2015). They are also used to collect rainwater that can be used/ recycled for up to half of the toilet water in that building (Harris 2015). Boselli (n.d.) suggests similar solutions to the abovementioned key issues, as well as the inclusion of contiguous open green spaces and a porous city design including bio-retention systems, groundwater infiltration and drainage systems.

However, Workman (2017) states that the process of transitioning from a traditional urban city to a sponge city is very expensive and involves continual investment, monitoring and maintenance. In fact, Boselli (n.d.) found that the Chinese government has chosen 16 pilot cities and allocated 400-600 million Yuan (approximately $95 million AUD) to each city for the implementation of innovative water sensitive strategies that would over time turn these areas into sponge cities.

On the other hand, Houston is known as a 'concrete city' where there is little greenery and water sensitive urban design principles (Fernandez & Fausset 2017). Houston is

subject to flooding after severe weather events due to their poor quality of green and blue infrastructure (Lewis 2017). Lewis (2017, p.1) has stated that the reason for large amounts of flooding events throughout Houston is due to “the city’s extraordinary amount of impervious surfaces- roofs, paved roads and parking lots”. Houston’s infrastructure in regard to water management is quite different to that of China (i.e. sponge cities). Table 1 below highlights the strengths and weaknesses of urbanised areas within Houston and China.

Table 1 Strengths and Weaknesses of Urbanised Areas in Houston and China

Houston	**China**
Strengths	
• Green and blue infrastructure includes green rooftops, wetland protection areas, mitigation of storm water runoff, open vegetated lands, storm water systems and drainage swales (Gabbatt 2017); • Open to radical planning due to recent flooding events from poor infrastructure (Gabbatt 2017); and • Demands a real world ‘test run’ of their storm water systems (Gabbatt 2017).	• Green and blue infrastructure includes green rooftops, retention ponds, storm water wetlands, permeable roads, bio-swales and ponds (Harris 2015); • There is a lot of government investment into blue-green spaces (Harris 2015); • Public/private partnerships (Harris 2015); • Involvement of all governance levels including community support (Boselli n.d.); • Reduction in flood risk (Harris 2015); • Lower burdens on drainage systems (Harris 2015); • Greener, healthier and more enjoyable urban spaces (Harris 2015); • Water is made more readily available through recycling (Boselli n.d.); • Cleaner groundwater (Boselli n.d.); • High level of public involvement (Harris 2015); • Reduction of pollutants in waterways and more clean water for the city (Harris 2015).

Weaknesses	
• There is low consideration of the natural water cycle (Fernandez & Fausset 2017) • A high number of impervious surfaces (Fernandez & Fausset 2017); • Concrete waterways which results in a lack of meander ability (Lewis 2017); • No strict zoning or planning laws (Lewis 2017); • There is unplanned urban sprawl in the area (Gabbatt 2017); and • Very expensive to change current operations to blue-green space networks (Gabbatt 2017).	• Increased groundwater pollution from urbanisation, which in turn results in an increase in health risks after heavy rainfall events (Boselli n.d.); • Damages to infrastructure and properties after a heavy rainfall event (Harris 2015); • There is less water available in urban and per-urban areas in China from urbanisation (Harris 2015); • Constant ongoing monitoring and maintenance with can take up a lot of time (Harris 2015); and • Can often be quite expensive due to ongoing investment (Harris 2015).

The Gold Coast needs to ensure that appropriate blue-green infrastructure is implemented, especially in areas close to large bodies of water. If the Gold Coast does not adopt these measures and mitigate against the future impacts of climate change, it may suffer the same dire consequences as Houston. The Gold Coast Regional Botanic Gardens plays an integral role in the mitigation of flooding and the education of blue-green spaces to the wider community. However, there are a number of improvements that can still be made which will be addressed throughout this paper.

Singapore

Singapore is globally well known for being an environmentally sustainable and clean garden city, where the city is placed within a garden rather than the garden placed in a city (Newman 2014). The ‘green movement’ began in 1963 by Prime Minister Lee Kuan Yew, who started a tree planting initiative in the hope to improve air quality within the city (Newman 2014). The development of green areas aimed to regenerate the natural systems throughout the city of Singapore back to its original structure pre-development (Newman 2014). Some of the approaches to naturalise the city include; green walls, green roofs, rooftop gardens, naturalisation of concrete canals, community gardens, green corridors, park connectors, and WSUD principles (bio-

filtration, swales, permeable paving and infiltration systems) (Newman 2014). These approaches aim to make urbanised areas resilient to flooding events, particularly as climate change effects become more common (Crow-Miller et al. 2017). Figure 6 illustrates blue-green infrastructure designs throughout Singapore.

Figure 6 Blue-green Infrastructure in Singapore (Newman 2014).

Urban green and blue infrastructure throughout Singapore has increased levels of tourism and has therefore produced more jobs (Crow-Miller et al. 2017). Moreover, when tourists return home after they have a positive experience with blue-green infrastructure, they are more likely to have increased awareness and demand for it (Crow-Miller et al. 2017). Blue-green space networks throughout Singapore has influenced many other countries in the Asian region to also naturalise their cities (Newman 2014). This has demonstrated that planning regulations and strategies surrounding blue-green spaces can be delivered in a cost-effective way if there is strong community support (Newman 2013). Newman (2013) believes that the next phase in the development of blue-green space networks is for other developed cities with different climatic conditions to adopt the same environmental principles as Singapore, which will quantity benefits including energy, health, biodiversity, water, economics, human appreciation and aesthetic qualities. The Gold Coast Regional Botanic Gardens can adopt some of the same principles that are used in Singapore in order to create a well-connected, sustainable and productive environment.

2.0 LEGISLATIVE & POLICY CONTEXT

Understanding and implementing Federal, State, Regional and Local policy, as well as incorporating stakeholders in the decision making process, enables effective collaboration between all governance levels and ensures environmental sustainability. To achieve optimal blue-green space networks in an urban built form, all levels of government and appropriate stakeholders have to integrate planning policies and strategies. The following government Acts and policies have been included as essential strategies to achieve ecological sustainability within the Gold Coast.

2.1 FEDERAL GOVERNMENT

2.1.1 DEPARTMENT OF THE ENVIRONMENT AND ENERGY

The Department 'designs and implements' Federal Government environmental policies and programs that aim to conserve the "environment, water and heritage, promote climate change action, and provide adequate, reliable and affordable energy" (The Department 2017). The matters that The Department encounter involve environmental sustainability and ecological protection. Our site objectives correlate with multiple environmental sustainability matters that fall under The Department, which include:

- Environmental Protection and conservation of biodiversity;
- air quality;
- natural, built and cultural heritage;
- coordination of sustainable communities' policy;
- urban environment; and
- environmental water use and resources relating to the Commonwealth Environmental Water Holder (The Department 2017).

The Department works with other levels of Australian government (State and Local) and relevant stakeholders who are responsible for implementing environment and heritage policies.

2.1.2 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (EPBC)

The EPBC Act is an integral piece of environmental legislation that is administered by the Australian Government Department of the Environment. This Act provides legislation that provides “environment and heritage protection and biodiversity”, between the Australian states and territories (EPBC 2017). The objectives of the EPBC coincide with the goals that our site plan to achieve. The aims of the act are as follows (points derived from EPBC 2017):

- provide protection for the environment;
- conserve Australia's biodiversity;
- enhance the protection and management of important natural and cultural places; and
- promote ecological sustainable development through the conservation and ecological sustainable use of natural resources.

The purpose of the EPBC Act is to protect important environmental and cultural values by employing legislation based on the “guiding principles of ecological sustainable development” set by the Department of the Environment (EPBC 2017). Our proposal has to comply with the EPBC Act as it will impact on the surrounding ecological green/blue spaces, even if our goals are to promote ecological sustainability.

2.2 QUEENSLAND GOVERNMENT

2.2.1 ENVIRONMENTAL PROTECTION ACT 1994 (EPA)

The object of the EPA is to “protect Queensland’s environment while allowing for development that improves the total quality of life, both now and in the future, in a way

that maintains the ecological processes on which life depends" (EPA 2017). This Act aims to achieve ecological sustainable development throughout Queensland by implementing the following 4 phases:

- establishing the state of the environment and defining environmental objectives;
- developing effective environmental strategies;
- implementing environmental strategies and integrating them into efficient resource management; and
- ensuring accountability of environmental strategies (EPA 2017).

The objectives relating to environmental sustainability and blue green infrastructure that the EPA Act aims to achieve are integrated into Queensland's State and Local policies. Our site shall aim to integrate the guidelines set by this Act in order to protect the natural environment.

2.2.2 WATER ACT 2000

The Water Act provides a framework for the "sustainable management of Queensland's water resources" (Water Act 2017). This Act is relevant to our proposal as the main aim of the Water Act is to provide a "sustainable and secure water supply … for the south-east Queensland region and other designated regions" (Water Act 2017). This Act applies for 10 years, after which it is to be "reviewed and either replaced or extended for up to 10 additional years" (State of Queensland 2017). Our development aims to meet the purpose of the Water Act and to achieve sustainable management and efficient use of water. The Water Act and our proposed development both aim to "sustain the health of ecosystems, water quality, water-dependent ecological processes … reversing degradation that has occurred" (Water Act 2017). Within the Water Act there are water plans to "support the large scale infrastructure projects in a sustainable manner" (State of Queensland 2017). The Water Act also "allows for the Minister to review or amend a water plan, informed by science and consultation" (State of Queensland 2017).

2.2.3 ENVIRONMENTAL PROTECTION (WATER) POLICY 2009 (EPP)

This policy applies to all waters throughout Queensland. This policy is part of the Water Act 2009 and is to "identify environmental values and management goals for Queensland Waters" (EPP 2009). The concepts of the EPP are to enhance and protect the environmental values of Queensland's waters. Our proposed development aims to achieve the management goals and the water quality objectives of the EPP, as our team plans to enhance the surrounding water systems, especially by decreasing the amount of run-off from the neighbouring golf course.

2.3 REGIONAL GOVERNMENT

2.3.1 SHAPING SEQ

Shaping SEQ is collaborative plan that involves 12 local government areas and has been implemented by the Queensland Government. This plan has been put into effect due to Queensland's increased urbanisation that is putting more pressure on the existing blue-green infrastructure. Theme 4 – Sustain from the Shaping SEQ Plan (2017) includes the promotion of ecological and social sustainability. The aim for this theme is to nurture the natural systems and provide 'inter-urban breaks' to ensure that urban areas preserve the surrounding ecological biodiversity. This theme coincides with the main objective of the Botanical Gardens site.

2.3.2 SOUTH EAST QUEENSLAND WATER STRATEGY

The South East Queensland Water Strategy (The Strategy) ensures that water security is able to support the needs of 'urban, industrial and rural growth and the environment' (Queensland Water Commission 2010). The Strategy has adopted policy measures since 2009 to encourage efficient water use in the SEQ region these include:

- ensuring that all new buildings are water-efficient;
- ensuring that existing buildings become more water-efficient;
- moving business and industry towards best practice water efficiency; and

- minimising system losses (Queensland Water Commission 2010).

The Strategy will be reviewed and updated every five years to align with the review of the SEQ Regional Plan 2009-2031 (Queensland Water Commission 2010). This allows for better integration of new technologies, better water efficiency and meeting community expectations as demand and attitudes change.

2.3.4 HEALTHY LAND AND WATER - SOUTH EAST QUEENSLAND (SEQ)

Healthy Land and Water SEQ looks into creating a collaborative effort between various stakeholders and local governments in providing accurate evidence-based tools and innovative solutions with assessing the land, water quality and biodiversity within South East Queensland (Healthy Land and Water 2017). This comes down to connecting communities with the importance of biodiversity and outlining strategies to sustain these sensitive spaces and networks. Healthy Land and Water liaises with various stakeholders in providing land use based planning to achieve sustainable outcomes (Healthy Land and Water 2017).

2.4 LOCAL GOVERNMENT

2.4.1 CITY PLAN

The City Plan supersedes the 2009 Sustainable Planning Act (SPA), aligns with the Planning Act 2016 and commences on the 3rd July 2017 (City of Gold Coast 2017). The City Plan's objective is to implement policies that align with the City of Gold Coast's intentions for "the future development in the City Plan area, over the next 20 years" (City of Gold Coast 2017). Six themes are targeted by the City Plan as important in "shaping future growth and managing change across the city" (City of Gold Coast 2017). These points include:

- creating liveable places;
- making modern centres;

- strengthening and diversifying the economy;
- improving transport outcomes;
- living with nature; and
- a safe, well-designed city (City of Gold Coast 2017).

Although each theme is important to ensure that sustainable development is achieved, only the four highlighted themes are relevant to the proposed redevelopment of the Botanic Gardens site. However, all the themes could be argued to be addressed by implementing green/blue infrastructure spaces within cities. The City Plan aims to change how development is regulated to better design greenfield areas in the 'city's urban areas' (City of Gold Coast 2017). Nature conservation, scenic amenity and recreation needs are of important focus for the City Plan, as the aim is to "protect … from inappropriate development and support small-scale opportunities" (City of Gold Coast 2017). It is important for our proposal to align with the key guidelines and policies set by the City of Gold Coast's City Plan.

2.4.2 SEQ NRM PLAN

The SEQ NRM Plan (2016, p.1) identifies "management of the use and development of land and water, and protection and management of ecosystem services" as the guiding principles to managing the SEQ natural assets. There are ten natural assets that are targeted to enable the region to remain liveable in the future (SEQ NRM Plan 2016). This report focuses on seven out of the ten SEQ NRM principles to provide appropriate policies that shall be used for the implementation of blue-green infrastructure to the development site.

The seven targeted principles are as follows:

- waterways;
- wetlands;
- seagrasses and mangroves;
- outdoor recreational areas;

- scenic amenity;
- air quality; and
- community (SEQ NRM Plan 2016).

Natural assets play an essential role in providing resilience in urban areas to the impacts of extreme weather events (SEQ NRM Plan 2016). This includes providing “physical barriers to storms, cyclones and other extreme events” (SEQ NRM Plan 2016, p.3). Redeveloping the site by introducing wetland and fauna management strategies, will build resilience and mitigate against the negative impacts that threaten biodiversity, in order to achieve “human wellbeing and economic prosperity” (SEQ NRM Plan 2016, p.3).

The SEQ NRM organisation has already delivered “2,350 kilometres of creek stabilisation works, 11,460ha of bushland management and revegetation and 16,523ha of weed management” (SEQ NRM Plan 2016, p.5). This has been the result of investment and the cooperation of Federal, State and Local governments and 96 community groups, landholders and industry groups (SEQ NRM Plan 2016). Local government is the major investor in implementing blue-green strategies in urban areas by implementing regulations, coordinating on-ground works and funding key community groups as well as the SEQ NRM organisation.

Table 2 highlights the current SEQ NRM targeted actions and plans for improving the existing blue-green spaces as well as the key stakeholders involved (SEQ NRM Plan 2016). The information included in the below table outline the key actions relevant to our site as well as the relevant stakeholders who implement or follow the appropriate policies.

Table 2 SEQ NRM Actions and Involved Stakeholders

Actions for Wetlands	**Key Stakeholders and Plans**
Implement restoration activities in wetlands to improve wetland functions.	Catchment Action Plans (Resilient Rivers), Local Government Catchment, Wetlands and Waterway Plans.
Minimise changes to wetlands by future development in urban areas	Local and State Government Land Use Plans
Maintain all known wetlands including catchment areas	Catchment Action Plans (Resilient Rivers)
Actions for Bushlands	**Key Stakeholders and Plans**
Plan to maintain core bushland areas including management of vegetation and revegetation	SEQ Regional Plan, Local Government Plans, SEQC Strategic Investment Plan
Implement fauna solutions before infrastructure projects are undertaken and retrofitting priority areas	SEQ Regional Plan, Local Government Plans

The policies that are addressed in this report, aim to protect the natural ecosystem in SEQ. The local level policies are essential for implementing the correct strategies to achieving the targets set by the Federal and State governments. The Acts and policies include a range of strategies that need to be considered and implemented for environmental sustainability is to be achieved in SEQ.

The following conceptual plan illustrates the current institutional arrangements and relationships with stakeholders within the Gold Coast (Figure 7).

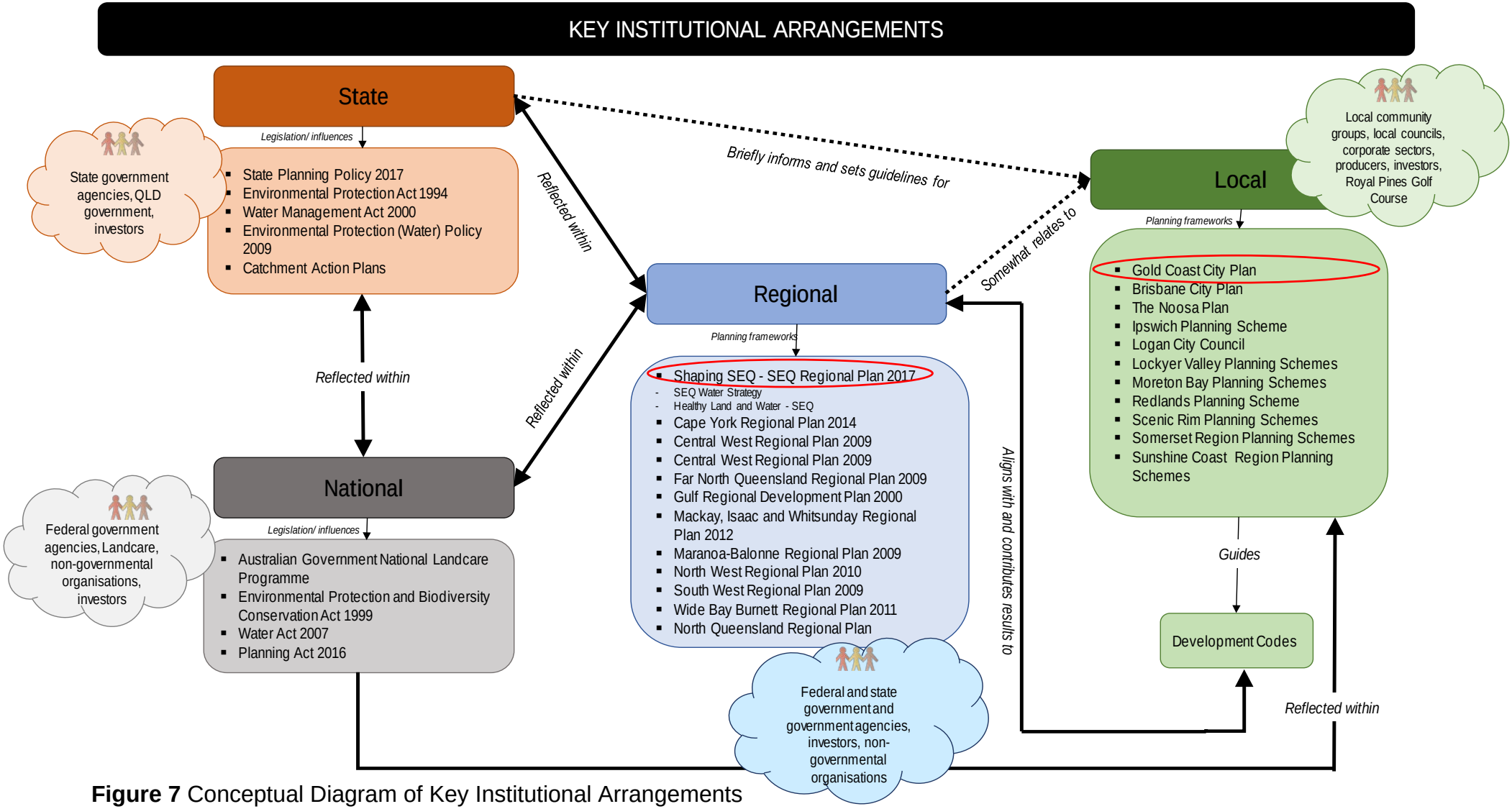


Figure 7 Conceptual Diagram of Key Institutional Arrangements

3.0 SITE DESCRIPTION

3.1 SITE HISTORY

In 1999, Rosser Park in Benowa was named the Gold Coast Regional Botanic Gardens due to its close proximity to the Nerang river, site size and surrounding community support (City of Gold Coast 2017). The master plan was completed in 2002 and then followed by construction works. Today, the Gold Coast Regional Botanic Gardens has more than 20,000 local Australian native plants, multiple water sensitive urban design features, and is continually supported by local communities (City of Gold Coast, 2017).

The Gold Coast Botanic Gardens is located within the heart of the growing Benowa suburb, extends towards the riverside of the Nerang River and is located beside the Royal Pines Golf Course. The unique location of the Botanic Gardens, including its large array of flora species, has created a public space for many surrounding residents and tourists to enjoy both leisurely and recreationally. The current features of the site make for a great place to enjoy as a family, a local resident, a school student, or as a tourist (City of Gold Coast 2017). As there is a high quantity of water both within and surrounding the site, the flood prone land has the potential to be utilised as a thriving wetland ecosystem. This will increase both the amenity and sustainability of the site.

3.2 LOCAL PLANNING FRAMEWORK

3.2.1 GOLD COAST CITY PLAN

The subject site is located within the authority of the City of the Gold Coast; therefore, as mentioned above in Section 2.0, the applicable planning document is the Gold Coast City Plan. An overview of the proposed upgrade against the relevant provisions of the Gold Coast City Plan is provided below.

3.2.2 OVERLAYS AND ZONES

The subject site is located within the open space zone of the Gold Coast City Plan (Figure **8**). The City of Gold Coast (2017) states that, “the purpose of the open space zone code is to provide for district, local and regional scale parks that serve the recreational needs of a wide range of residents and visitors”.

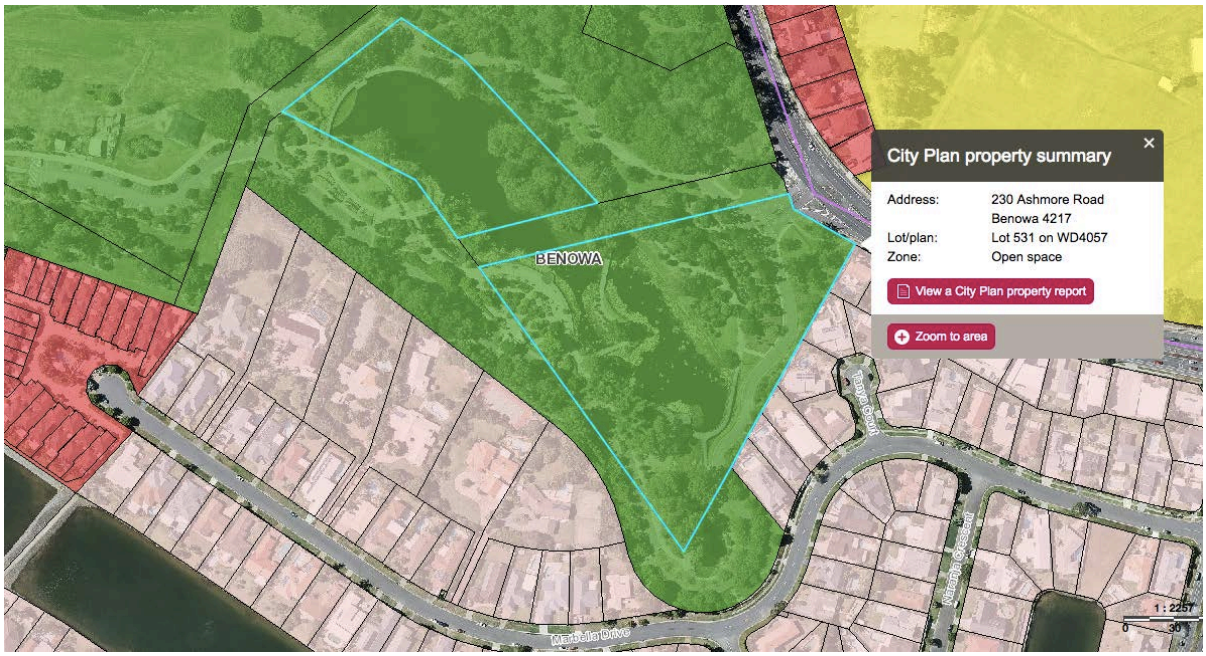


Figure 8 230 Ashmore Road within PD Online (PD Online 2017).

The nature of the proposal is of a very small scale and involves the implementation of blue-green infrastructure and WSUD principles within an open space zonation. Due to its close proximity to the Nerang River, the quality of waterways throughout this zone shall be enhanced. The changes to the site will not impact the current amenity in maintaining the use of recreational and social spaces, or the existing streetscape character of the Gold Coast Regional Botanic Gardens.

3.2.3 GOLD COAST CITY PLAN OVERLAYS

The subject site triggers the following overlays under the Gold Coast City Plan, including:

- acid sulfate soils;
- airport environs;
- coast erosion hazards;

- environmental significance;
- flooding; and
- landslide management (PD Online 2017).

3.2.4 ACID SULFATE SOILS

The subject site triggers the 'Acid Sulfate Soils' overlay within the Gold Coast City Plan (GCCP) (Figure 9). The proposal is unlikely to require any significant earthworks; however, an Acid Sulfate Soils Management Plan can be provided during the implementation of the bio-retention plantings, the boardwalk and the transformation of the off-the-leash if requested by the City of Gold Coast.

Figure 9 Acid Sulfate Soils Overlay Map (PD Online 2017).

3.2.5 AIRPORT ENVIRONS

The subject site is identified within the 'Airport Environs' overlay within the GCCP. The proposal is compliant with the height provisions set out in the Building Height Restrictions in the Open Space Zone. As there are similar developments near this site, our team are confident that at the proposed development will pose no risk on the site.

3.2.6 COAST EROSION HAZARDS

The subject site is located within the 'Coast Erosion Hazards' overlay within the GCCP (Figure 10). The proposal is unlikely to be affected by any erosion hazards; however, an Engineer Report can be prepared during the implementation of the bio-retention plantings, the boardwalk and the transformation of the off-the-leash dogs field if requested by the City of Gold Coast.

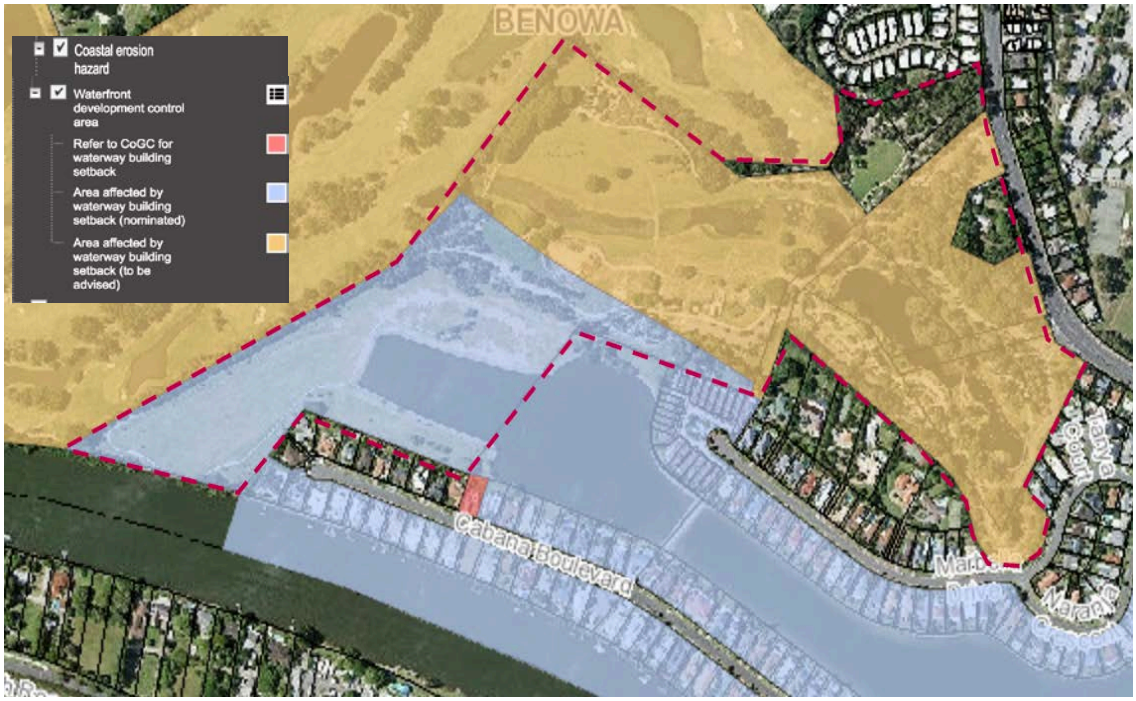


Figure 10 Coastal Erosion Hazard Overlay Map (PD Online 2017).

3.2.7 LANDSLIDE MANAGEMENT

The subject site is located within the Landslide Hazard overlay within the GCCP, with a range of 'moderate' (Figure 11). As there are many dwellings in the surrounding zone under the same overlay, the proposal is unlikely to pose a risk to the site or its surroundings; however, a Geotechnical Report can be prepared during the

implementation of the bio-retention plantings, the boardwalk and the transformation of the off-the-leash dogs field if requested by the City of Gold Coast.

Figure 11 Landslide Hazard Overlay Map (PD Online).

3.2.8 ENVIRONMENTAL SIGNIFICANCE (WATERCOURSE & WETLANDS)

The subject site is located within the Environmental Significance (Watercourse and Wetlands) overlay within the GCCP (Figure 12). As there are many dwellings in the surrounding zone under the same overlay, our team are confident that the proposal will pose no risk to the site or its surroundings; however, an Ecological Site Assessment can be prepared during the implementation of the bio-retention plantings, the boardwalk and the transformation of the off-the-leash dogs field if requested by the City of Gold Coast.

Figure 12 Environmental Significance Overlay Map (PD Online 2017).

3.2.9 FLOODING

The subject site is located within the 'Flood' overlay within the GCCP (Figure 13). It has been observed that the subject site and surrounding residential streets regularly flood after a high-rainfall event. The proposed development aims to mitigate against flooding through the use of blue-green infrastructure. Our team is confident that the proposed development will pose no risk to the site or its surroundings. A Flood Assessment shall be prepared during the implementation phase of the strategic direction.

Figure 13 Flood Overlay Map (PD Online 2017).

3.3 STATE AND PLANNING FRAMEWORK

The State Planning Policy (SPP) mapping identifies that the subject site is affected by an array of erosion prone zones and erosion tide inundation, in addition to flood prone areas and storm tide flooding. The site is currently listed as a flood prone zone under the GCCP; therefore, a Flood Assessment Report will be required to identify storm water discharging routes in order to maintain the installed blue-green infrastructure and WSUD. In Figure 14 below, an extract of the SARA mapping is shown.

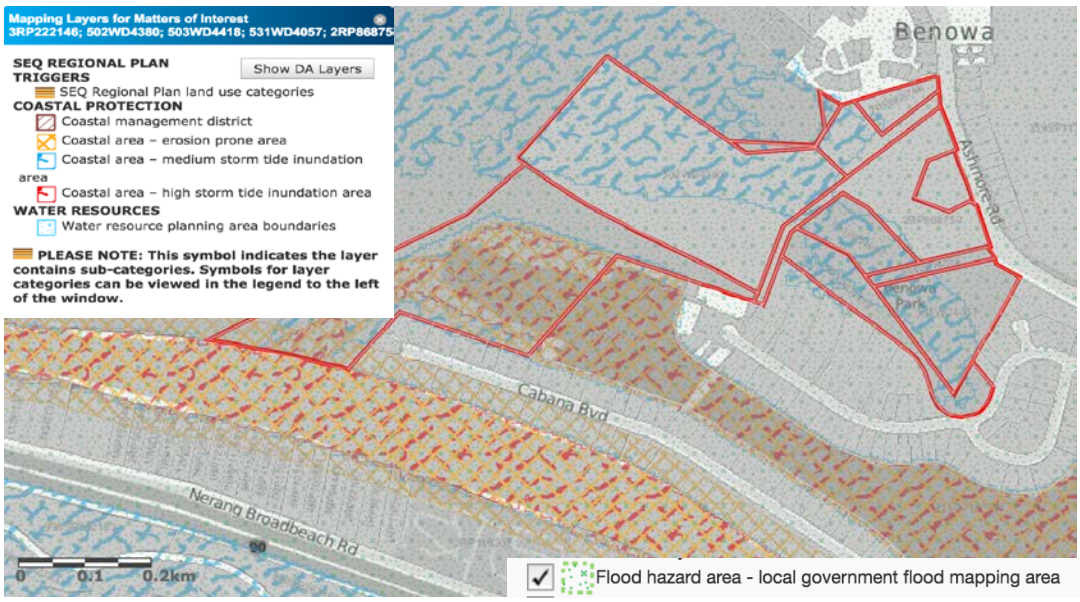


Figure 14 SARA Mapping of Relevant Overlays (SPP Mapping 2017**).**

SARA mapping identifies that the subject site falls within the urban footprint; thus, the proposal will not require any referral to SARA (Figure 15)

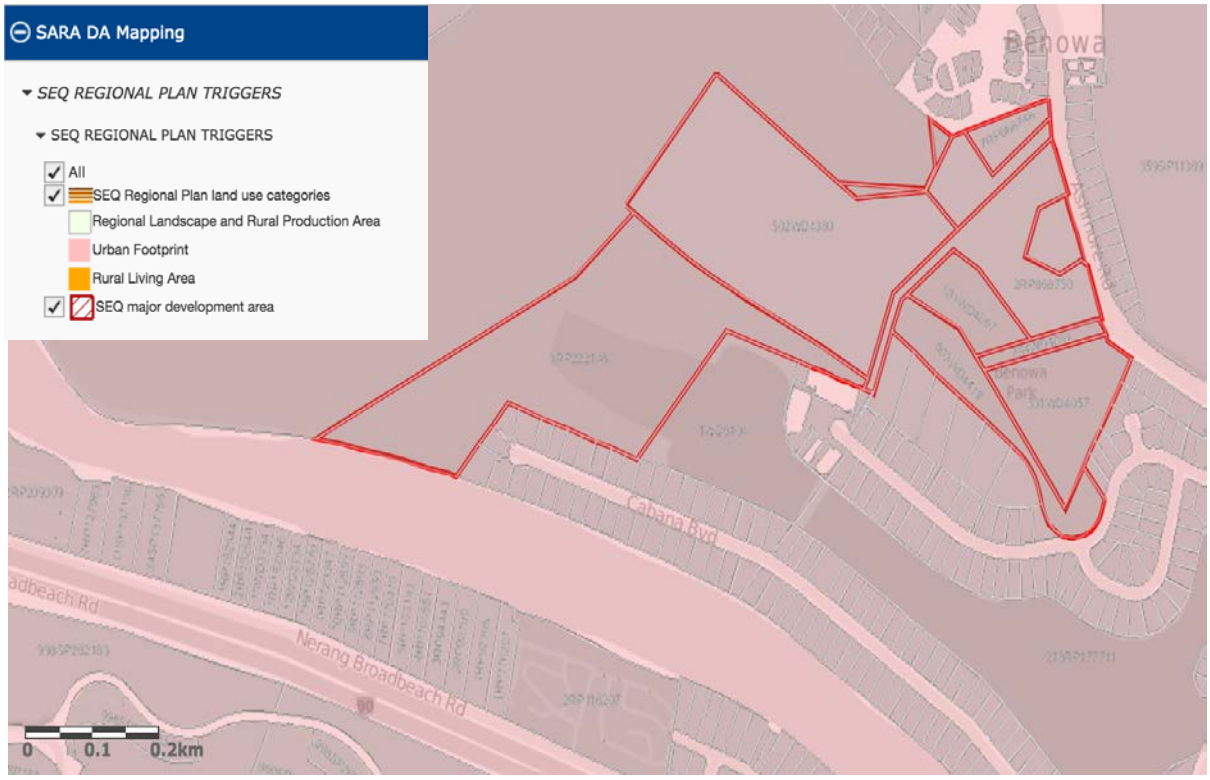


Figure 15 Urban Footprint on Site (SARA DA Mapping 2017)

4.0 IDEAS FOR THE SITE

Eco Solutions has identified relevant issues within the Gold Coast Regional Botanic Gardens. The following recommendations have been prepared in order to mitigate against flooding and improve the quality of water within and surrounding the site.

4.1 RECYCLING STORMWATER RUNOFF FROM THE GOLF COURSE

The Royal Pines Resort Golf Course is situated next to the Gold Coast Regional Botanic Gardens. As golf courses use large quantities of fertilisers and pesticides for the maintenance of their property, the runoff from rainfall is heavily contaminated and pollutes nearby water bodies and waterways. It is proven that fertilisers and pesticides generate a negative impact on the aquatic life and water quality of its surrounding area. Studies have shown that 5 per cent to 10 per cent of pesticides applied are lost in runoff, and in worst case scenario this can be as high as 30 per cent (Freeman 2008).

As natural landscapes change due to urban development, the way water infiltrates and flows is changed, causing various adverse environmental impacts (O'Donoghue 2016). In order to reduce the impacts and improve the biodiversity and health of the waterways, mitigation strategies and solutions must be implemented. Various golf courses, nationally and internationally, currently utilise stormwater harvesting to collect, treat, store, and reuse stormwater runoff. The utilisation of this feature can result in the following benefits:

- Lowers runoff volumes to reduce the impacts of flooding and return natural soil moisture levels
- Significantly improve the water quality of surrounding waterways
- Improve the sustainability, livability, and resilience of cities
- Provides and alternative water source fit for supplying golf courses and open spaces

- Most cost effective stormwater management system

Stormwater recycling is rising as a sustainable option for meeting the water demands for golf courses and other open spaces, while providing the opportunity to treat any excess stormwater that is high in nutrients and pesticides (Brisbane City Council 2008).

The Kogarah Town Centre in NSW has established a stormwater recycling facility that collects and filters excess stormwater runoff before storing it in underground tanks as an alternative water source for gardens and toilets (Brisbane City Council 2008). This case can be applied to the collection and storage of excess stormwater runoff from the Royal Pines Golf Course and surrounding area. The implementation of underground tanks on the border of the golf course and the botanical gardens will allow for both properties to utilise this wastewater. Stormwater is a valuable alternative to water that can also reduce the detrimental impacts that urban developments can have on waterways. Featuring underground tanks for stormwater recycling will help control the quality and quantity of stormwater runoff from the golf course. Furthermore, it is proposed that the underground water tanks hold up to 180,000 litres of stormwater runoff. As the integration of this system creates a more natural water cycle and improves water pollution, it will assist in re-establishing the pre development conditions of the site (Brisbane City Council 2008).

4.2 BIORETENATION PLANTINGS

Stormwater runoff generated from rainfall is significantly higher in urban areas due to hard impervious surfaces of development. This runoff collects the sediments and pollutants of surrounding areas and flows into nearby water bodies and waterways which in turn affects aquatic life and water quality. Although open spaces and green areas can improve infiltration, saturation in heavy rainfall periods will still cause stormwater runoff (O’Donoghue 2016). Further measures must be implemented in order to improve water quality.

Bio filtration plants have the ability of removing impurities from stormwater runoff (Department of Planning and Local Government 2010). Planting vegetative filter strips provide surface area for the plants to absorb pollutants and sediments and hold them in the soil while they are broken down by microorganisms. Vegetative biofilters with large roots also open the soil to allow runoff to infiltrate rather than enter the waterways (Freeman 2008). Whilst improving the aesthetics, air quality, and noise pollution of the area, these plants are also another solution to mitigating the pesticide and fertiliser runoff from the golf course.

The University of Massachusetts researchers have found that there are some plant species that can reduce runoff from certain pesticides up to 94% (Freeman 2008). Vegetative buffer strips can also; remove sediments by filtration, reduce runoff volumes, reduce flow velocity in high rain periods, and provide multi-use habitats. Pollutant removal is achieved by binding them to organic matter and soil particles through settling, and infiltrating into the subsoil. Soil microorganisms digest and process nutrients and hydrocarbons found in stormwater runoff (Figure 16). Vegetative filter strips must involve adequate quantities of bio filtration plants in order to maximise contact time between the runoff and soil surface to optimise pollutant removal (Department of Planning and Local Government 2010).

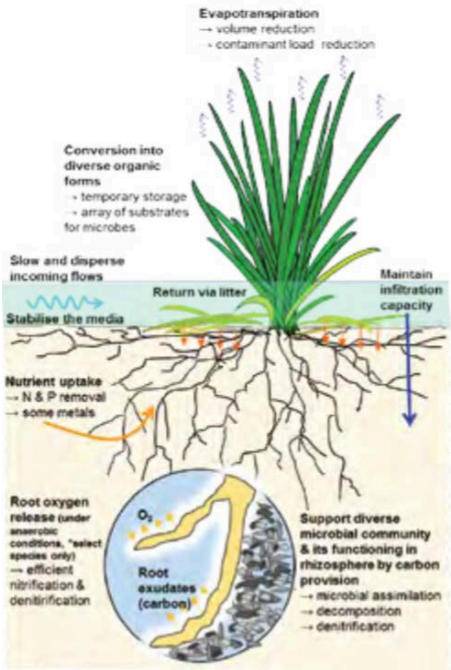


Figure 16 The Process of Runoff Filtration through Vegetation (City of Gold Coast 2007)

Plant species selection needs to consider both aesthetic and functional requirements. The most suitable plant species for the Gold Coast required to be tolerable to short periods of inundation punctuated by longer periods. Planting for bio-filtration vegetative strips should include groundcovers for stormwater treatment and erosion protection, shrubs for glare reduction and aesthetic, and trees for shading and landscape value (City of Gold Coast 2007). Vegetation should be densely planted and carefully established in order to grow effective and low-maintenance bio-filtration strips (Monash University 2014).

Grasses, sedges, and rushes support bacterial transformation of nutrients and other pollutants, slow water velocity, trap sediments, and stabilise soil (Monash University 2014). These plants are highly effective for filtering stormwater runoff before reaching the waterways. An example of a plant that is highly effective at nutrient removal is Carex Appressa, commonly known as tall sedge (CRC for Water Sensitive Cities 2015) (Figure 17). This plant and numerous others with similar bio-filtration abilities are suitable for the Gold Coast (City of Gold Coast 2007). Integrating bio-filtration plants in vegetative strips into the Gold Coast Regional Botanical Gardens is a highly effective and useful feature that provides significant environmental benefits.

Figure 17 *Carex Appressa* (City of Gold Coast 2017)

4.3 RIPARIAN VEGETATION

The area where aquatic systems merge with the terrestrial environment is known as the riparian zone. All stormwater runoff must pass through this zone before entering the waterways. The vegetation composition of the riparian zone includes emergent aquatic and semi-aquatic grasses, scrubs, and trees (Figure 18). The presence of riparian vegetation prevents soil erosion increasing bank strength and maintains a

level of stability. A healthy riparian zone also significantly improves the quality and health of a waterway and provides habitat for various aquatic species (Periott n.d.).

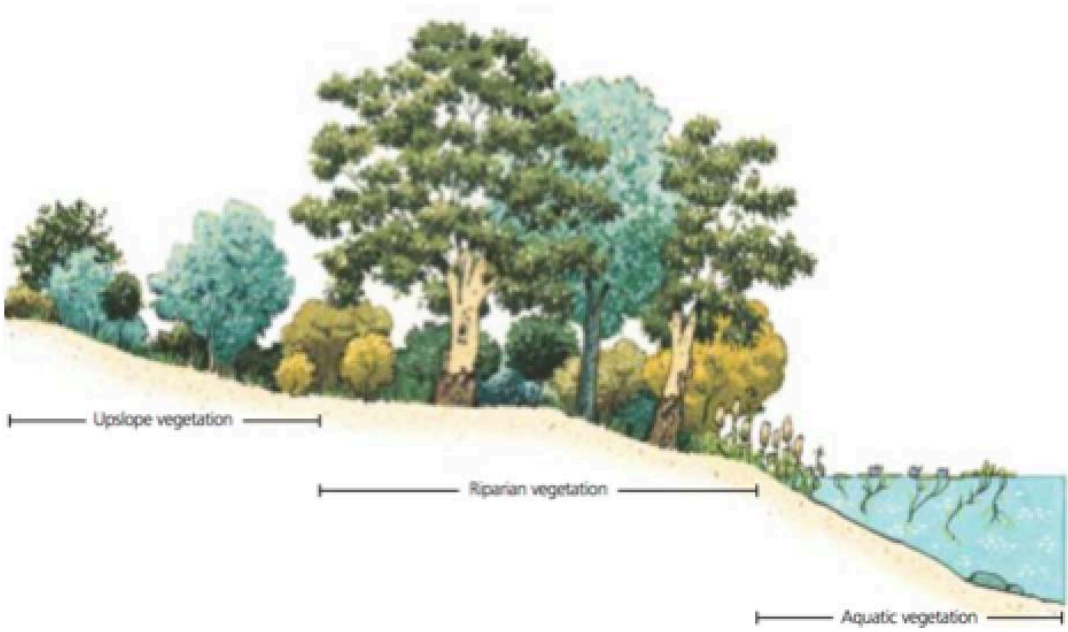


Figure 18 A range of vegetation is needed for a healthy and effective riparian zone (Lovett & Price 2007)

The canal system ending at the botanical gardens currently lacks in riparian vegetation as shown in Figure 25. This allows for all stormwater runoff to directly enter the waterway carrying all the pollutants and sediments that have been picked up on the way. A lack of riparian zone leads to poor water quality and extensive erosion, which can also cause serious downstream impacts (Haigh & Cibilic 2009). Therefore, in order to improve the water quality and the health of the waterway the riparian zone must be revegetated.

To effectively integrate a healthy riparian zone into the botanical gardens and nearby canal system, a range of appropriate and native trees, shrubs, and groundcover vegetation must be planted. Revegetation of the bank surrounding the canal system will;

- act as a buffer, trapping sediment, pollutants, and nutrients, preventing them from entering the waterway;
- stabilise the soil and reduce erosion; and

- shade the waterway protecting it from high temperatures that may cause algal blooms and weed growth (Haigh & Cibilic 2009).

Constructing a riparian zone in an area with no current riparian vegetation is a difficult project as it must be protected and maintained closely. This is especially during the implementation process, as it is the most vulnerable to failure. Successful establishment of a riparian zone surrounding the canal system will certainly lead to restoration of pre-development conditions of the site.

4.4 GREEN BRIDGE

Green bridges are generally used to decrease negative impacts from highways/roads on wildlife populations within the region; however, in this scenario, the implementation of a green bridge from the Botanic Gardens to Lot 616 on Nerang Broadbeach Road will allow employees, residents and students to actively commute to local schools, services and public spaces (Figure 19). This will increase accessibility within the area, as well as increasing active transport.

Figure 19 Green Bridge Positioning (Google Maps 2017).

For example, the Eleanor Schonell Bridge in Brisbane is Australia's first bus, cycle and pedestrian bridge that links Dutton Park to the University of Queensland (UQ) (Figure 20).

Figure 20 Eleanor Schonell Bridge in Brisbane (Brisbane City Council 2014).

The design of the green bridge can essentially increase community involvement through education - a section of the green bridge will be dedicated towards an aesthetic flow map of the Gold Coast waterways that shows the importance of blue-green infrastructure in conjunction with waterways, and how the community can contribute towards the management and protection of these natural assets. The green bridge will also incorporate artwork sourced by the community and interactive features involving the importance of WSUD and their ecosystems. The design of the bridge will incorporate a lattice shell tunnel that acts as a support structure for vegetation similar to a green bridge plan for Salford, UK (Figure 21) (Grozdanic 2013). This green bridge is designed as a living organism that changes with the seasons, whilst providing transition from urban development to green space.

Figure 21 Draft Design of Green Bridge (Grozdanic 2013).

The implementation of the green bridge will increase accessibility within the area, as well as increasing active transport. The Australian Government endorses measures to increase all aspects of active transport throughout Australian communities; therefore, the design and funding of cycling and walking initiatives is considered an important matter (Australian Government 2017). The Australian Government's investment in infrastructure includes the building of new cycling and pedestrian infrastructure as part of The National Cycling Strategy 2011-2016. Therefore, as the green bridge will increase both accessibility and active transport, this bridge may be funded by the Government.

4.5 BOARDWALK

On the Gold Coast, boardwalks are generally implemented through the riparian vegetation, consisting of mostly mangroves, along creeks and estuaries (MangroveWatch 2013). They provide amenity for community involvement as they create a scenic pathway through riparian communities. As boardwalks are raised they lessen vegetation destruction by human activity, while providing connectivity and allowing for the natural beauty of the surrounding area to be experienced.

A popular and successful example of a boardwalk on the Gold Coast is the Baree Badalla 'Mangrove Tree Haven' wetland reserve in Currumbin (Figure 22).This boardwalk runs 1km through mangrove community alongside the Currumbin Creek, proving scenic views and education of the surrounding area.

Figure 22 The Currumbin boardwalk that passes through the mangrove community (Walking the Gold Coast 2010)

A boardwalk can provide connectivity between the proposed green bridge and the botanic gardens, whilst ensuring the vegetation is unharmed. Incorporating a boardwalk that passes through the proposed vegetation on the site will provide aesthetic flow and generate a blue-green space network. It is also a more permeable option to a path and effectively preserves and maintains the riparian vegetation. The inclusion of a boardwalk within the Gold Coast Regional Botanic Gardens will ensure re-establishment of the pre-development conditions of the site.

4.6 GREEN GAZEBOS AND SPORT AND RECREATIONAL FIELD

The empty space near the proposed bridge in the Botanic Gardens is currently used as an off-the-leash dogs field. This will be transformed to incorporate shaded social spaces and a sport and recreational field whilst acting to mitigate flooding in high rainfall periods.

There will also be gazebos implemented throughout the area to provide shading and seating. These gazebos will have green roofs to minimise the impacts of climate change and heat waves upon the surrounding area. ‘A green roof system is an extension of the existing roof which involves, at a minimum, a drainage system, a filter, high-quality water-proofing, light-weight growing medium, root repellent system, and vegetation’ (Green Roofs for Healthy Cities 2017). Urban greening has long been promoted as an easy and effective strategy towards beautifying the natural environment (Green Roofs for Healthy Cities 2017). Green roofs offer many economic, environmental and social benefits, including:

- education opportunities (signage of their benefits, design and use);
- improvement of air quality, health and well-being (green roofs can act as community hubs and reduce pollution);
- increased amenity and biodiversity (green roofs can capture airborne pollutants and provide habitat for birds and migrating species);
- moderation of the urban heat island effect (able to cool cities due to daily dew and evaporation cycle); and
- stormwater management (green roofs can retain 70-90% of precipitation) (Green Roofs for Healthy Cities 2017).

The redesign of this area will attract more community involvement within the gardens and feature sustainable shading and seating designs.

4.7 EXTENSION TO LOT 616 + GREEN BRIDGE

The green bridge will link the Botanical Gardens to the empty lot on Nerang Broadbeach Road (Lot 610, 616 and 622). The lot will include green roof gazebos, biofilter strips, and gardens, which will add to filtration of the site as well as aesthetic beauty. A permeable pathway will be implemented through the lot connecting the green bridge to the current pathway along Nerang Broadbeach Road. This will allow pedestrians to meander through the Botanic Gardens to the opposite side of Clear

Island Lake, rather than walking along Ross Street/State Route 4, significantly increasing walkability of the area. This lot provides access to educational institutions and local services located near the Botanic Gardens (Figure 23) however, residents only have pedestrian access to the opposite side of Clear Island Lake by walking along Ross Street/State Route 4 (Figure 24). The concept of the site is illustrated in Figure 25. Appendix A attached shows Eco Solutions' Draft Concept Plan.

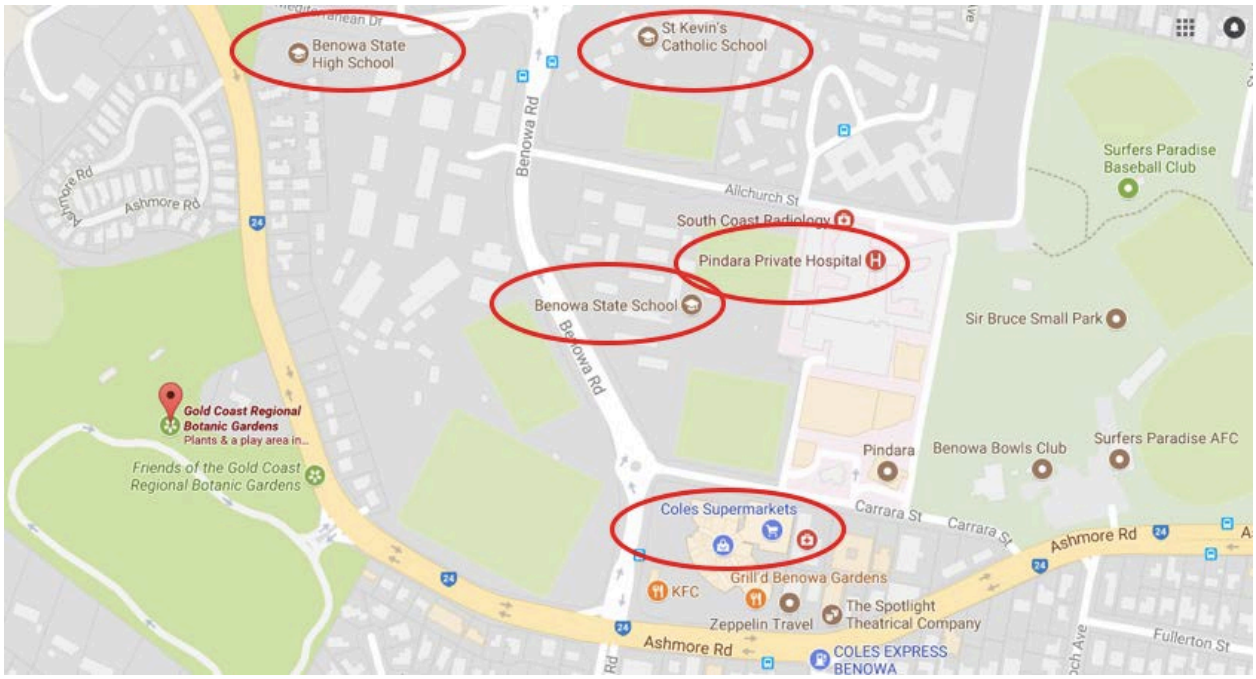


Figure 23 Local Education Institutions and Services (Google Maps 2017).

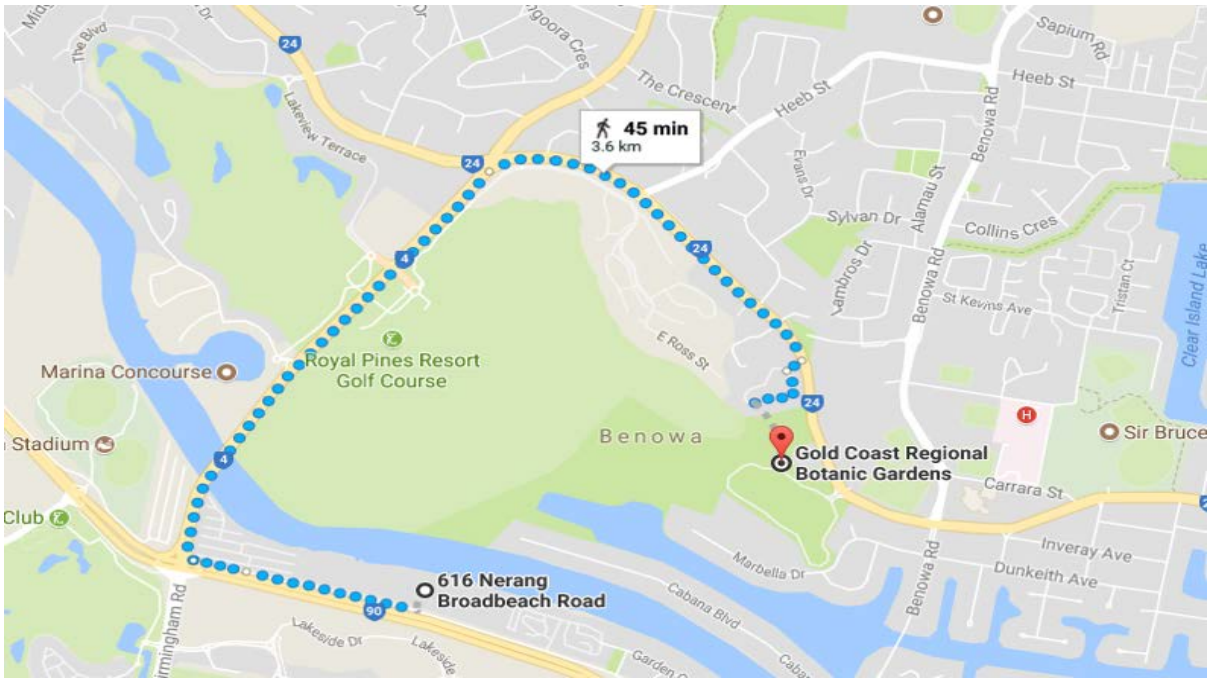


Figure 24 Access from Gold Coast Regional Botanic Gardens (Google Maps 2017).

4.8 CONCEPTUAL MAP

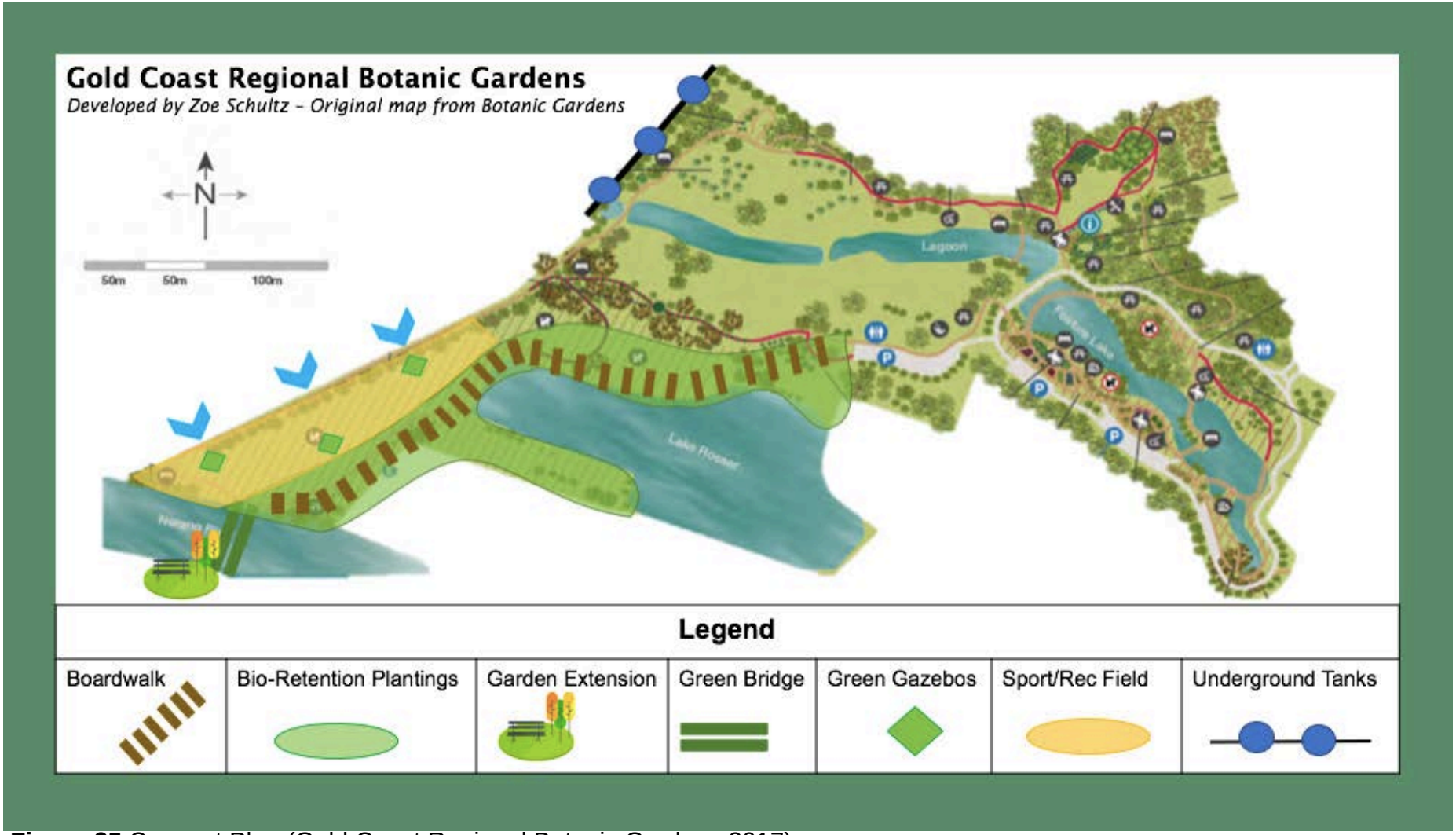
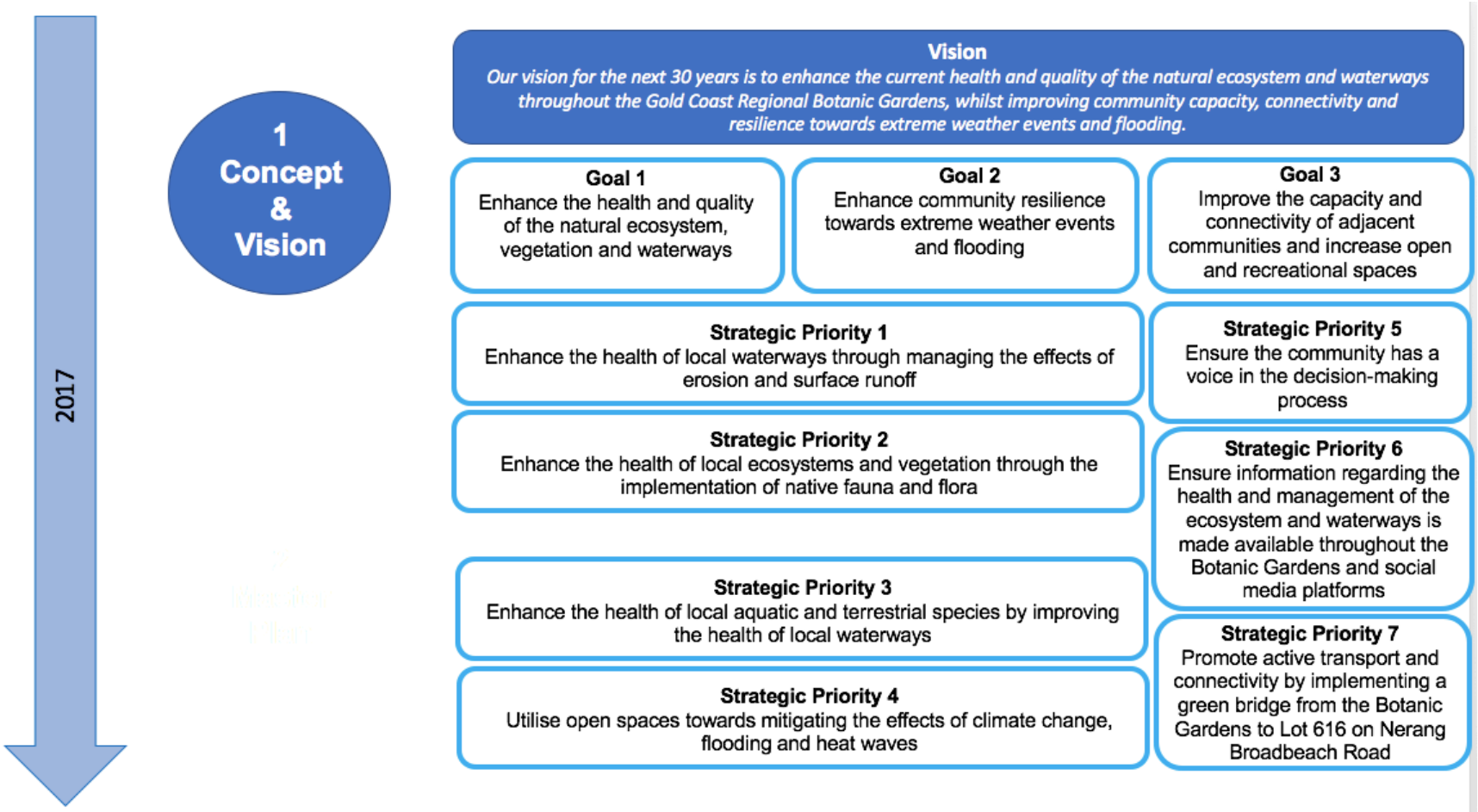
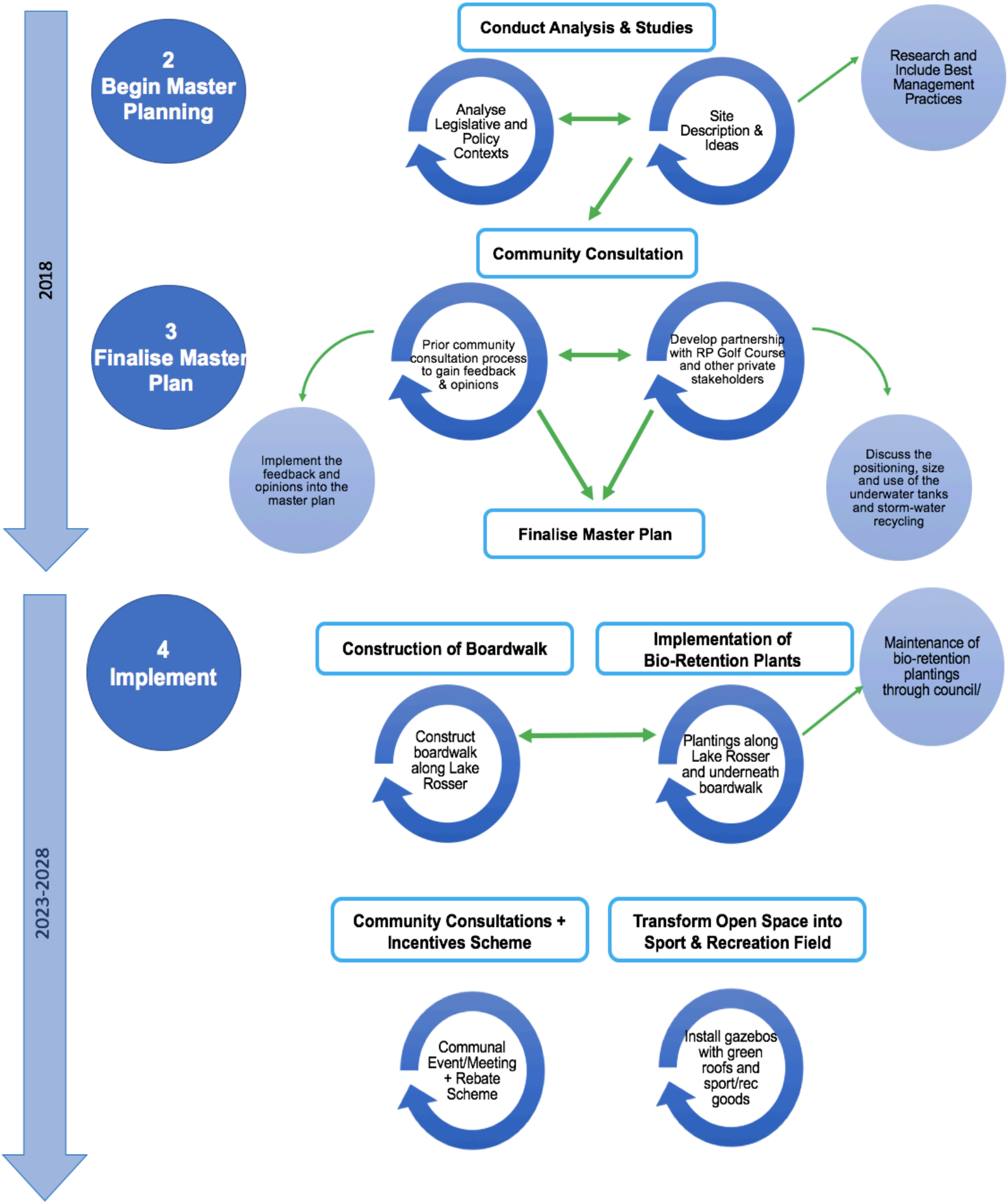


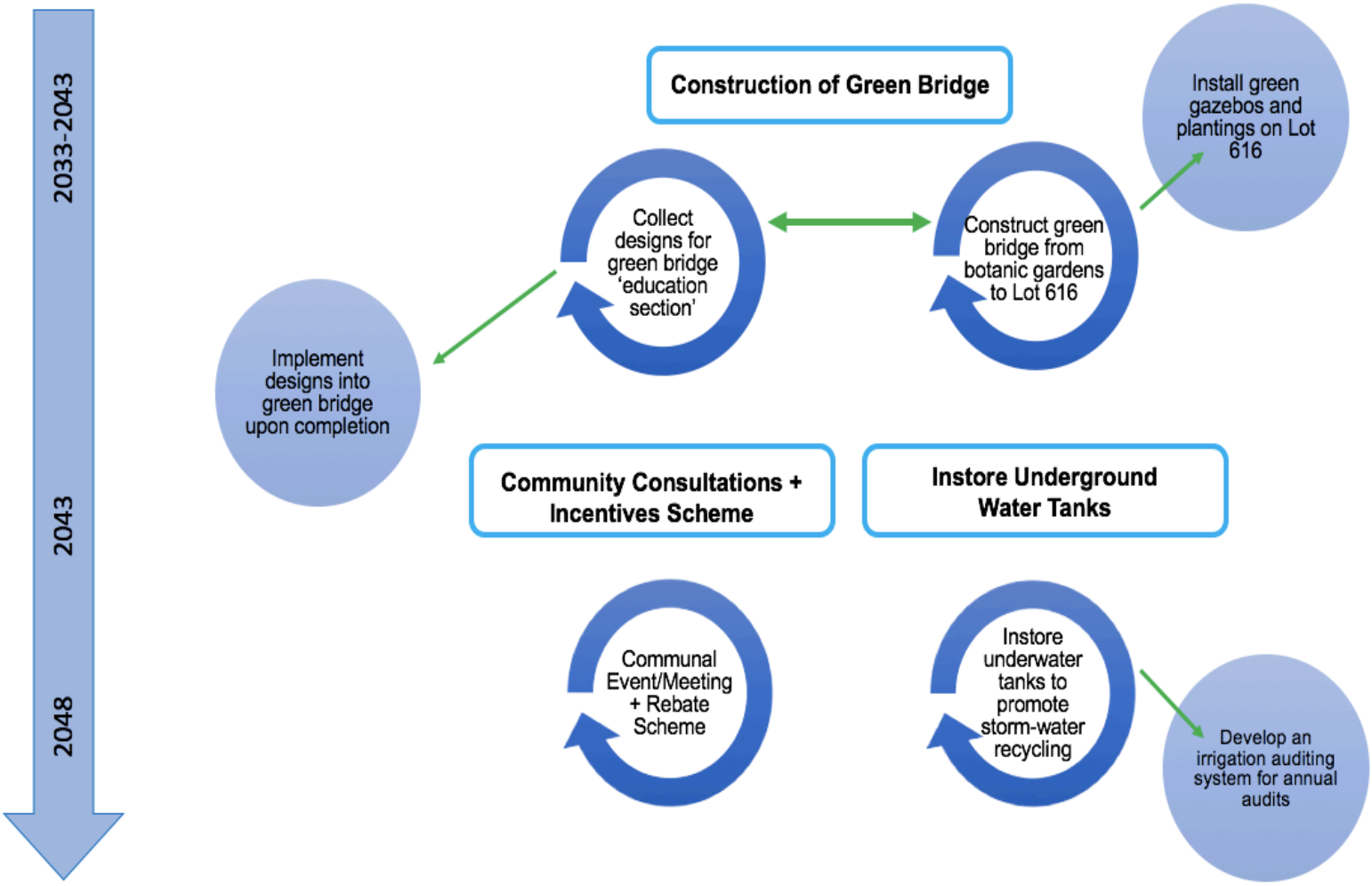
Figure 25 Concept Plan (Gold Coast Regional Botanic Gardens 2017).

5.0 STRATEGIC IMPLEMENTATION FRAMEWORK

A strategic framework that is resilient to future population growth and increased effects of climate change has been produced below. The strategic direction has been split into four sections: concept and vision, begin master planning, finalise master plan, and implementation. This is to be carried out between 2017 and 2048 (30-year vision) in accordance with the prescribed goals, strategic priorities and objectives.




2018
2
Begin Master Planning
Conduct Analysis & Studies
Analyse Legislative and Policy Contexts
Site Description & Ideas
Research and Include Best Management Practices
Community Consultation
3
Finalise Master Plan
Prior community consultation process to gain feedback & opinions
Develop partnership with RP Golf Course and other private stakeholders
Implement the feedback and opinions into the master plan
Discuss the positioning, size and use of the underwater tanks and storm-water recycling
Finalise Master Plan
2023-2028
4
Implement
Construction of Boardwalk
Implementation of Bio-Retention Plants
Maintenance of bio-retention plantings through council/
Construct boardwalk along Lake Rosser
Plantings along Lake Rosser and underneath boardwalk
Community Consultations + Incentives Scheme
Transform Open Space into Sport & Recreation Field
Communal Event/Meeting + Rebate Scheme
Install gazebos with green roofs and sport/rec goods



5.1 TIMELINE

Figure 26 below shows the predicted timeline to implement the abovementioned ideas for the site.

Figure 26 Implementation Timeline (Created on Canva by Zoe Schultz 2017).

5.2 TURNING POINTS AND TRIGGER POINTS

Turning points are situations in which a socio-political threshold is reached - this relates to changes in the economic, environmental and social sectors, such as changes in climate change, changes in policies, and changes in the interests and preferences of society (Werners et al. 2013). Trigger points outline the necessary implementation time before a turning point is reached. As highlighted in the 'Site Description' section, the subject site currently triggers six overlays under the Gold Coast City Plan, including:

- Acid Sulfate Soils;
- Airport Environs;
- Coast Erosion Hazards;
- Environmental Significance;
- Flooding; and
- Landslide Management (PD Online 2017).

The following figure highlights the three key trigger points within the site, including: (1) Pesticide and storm water runoff; (2) Flooding; and (3) Climate change Figure 27.

Figure 27 The proposed local adaptation pathway, including key triggers affecting the site, their effects and their sequence (PD Online 2017).

5.3 START - ENGAGEMENT WITH THE LOCAL COMMUNITY AND STAKEHOLDERS

The proposed local adaptation pathway shows the key triggers affecting the site, their effects and their sequence. The pathway begins with the 'Start' Phase – this is directly linked to Strategic Priorities 5-7 (Figure 28).

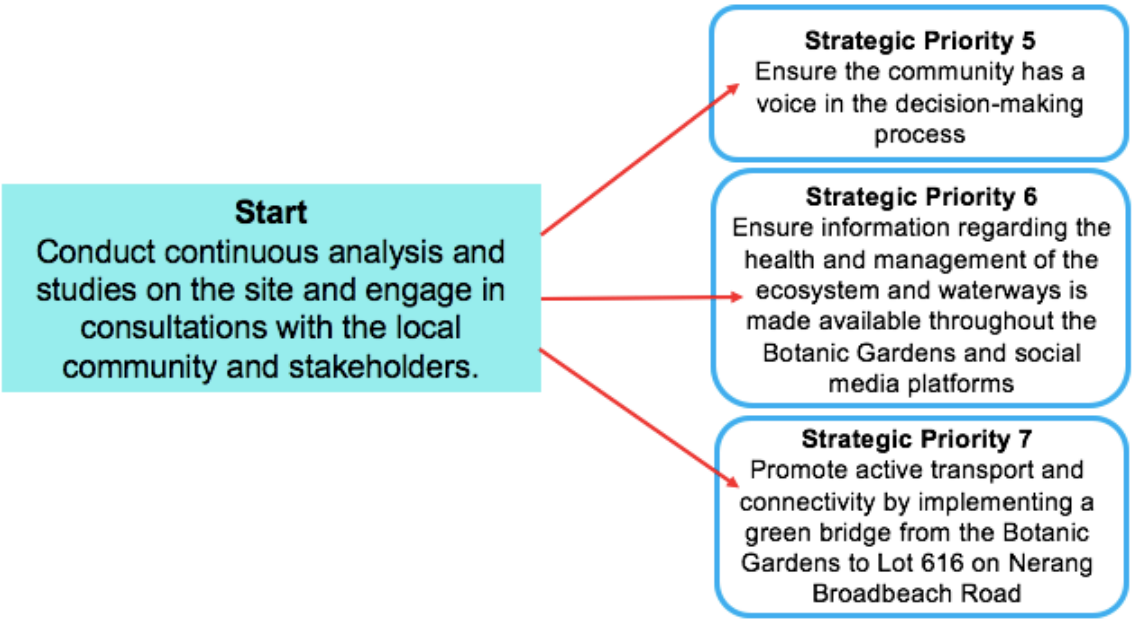


Figure 28 Start Trigger Related to Strategic Priorities 5-7.

Our team analysed and studied the current site, commenced a background study of SEQ's water resources attributes and challenges, and research into the following:

- Best management practice and innovative solutions and policies
- Blue-green space networks and their issues trends throughout SEQ
- Current land use and water management issues throughout SEQ
- Key issues within the Gold Coast Regional Botanic Gardens
- Relevant constraints and opportunities within the site

It is essential that the implementation of blue-green space networks is supported by both the local community and key stakeholders through community interaction, involvement and understanding (Thorne 2013). As the Gold Coast Botanic Gardens is an area used by both Gold Coast residents and tourists, it is advised to implement a prior public participation process, in order to increase awareness and public participation between all community groups. The term participation refers to the involvement of participants and residents within the decision-making process,

evaluation and implementation of a plan or project (Brown & Wyckoff-Baird 1992). In a study by Berkes (2009), it is highlighted that co-management involves an array of arrangements, with different degrees of power-sharing, for joint decision-making by communities and the state about a set of resources or a specific site. Essentially, those that are affected by management decisions should have a say in how those decisions are implemented. Therefore, our team needs to focus on the issues, needs and values of all affected parties, and build upon their capacity, knowledge and understanding of our natural assets and waterways through continuous community consultations and events. Thus, the community/stakeholder consultation process will comprise of the following phases.

5.3.1 PHASE 1: PRIOR CONSULTATION PROCESS

The first phase will commence prior to any upgrades, and will allow the community to give their feedback and opinions of the proposal through both an open day and social media platforms. It has become evident that an array of 'demographics are increasingly using social media as a primary source of communication in society' (Fredericks, 2013, p. 246). The Gold Coast Botanic Gardens currently promote their events through the City of Gold Coast website and various Twitter accounts including: GC Tourist Parks, Gold Coast Together, More Gold Coast, MyGC, and other promotional accounts. The Botanic Gardens recently held a 'Gold Coast Botanic Gardens Open Day' which involved recreational and sporting activities. However, although this is a great initiative towards community engagement and involvement, there was not enough awareness around this open day event. By promoting another open day event through Facebook, Instagram and Twitter, this can attract, educate and inform residents on the importance of managing and protecting our natural assets and waterways. Our team are planning to promote our ideas for the site on this open day, and to gain feedback from the public through on-site surveys and social media platforms.

5.3.2. PHASE 2: FEEDBACK OPPORTUNITIES AND FOCUS GROUPS

The second phase involves educating the local community on the importance of blue-green infrastructure and the inclusion of more vegetation and WSUD in their private properties, in order to align with our overall vision and improve the health of local

waterways. This will be addressed through community forums and meetings, and will also be provided through brochures and pamphlets. The local community will also be able to give feedback on the progression of the site through these focus group sessions.

5.3.3. PHASE 3: ANNUAL REPORTS

The third phase involves outlining the progress of the project through an annual report. This report will include the achievements to date, any implemented ideas relevant to the goals and the overall vision of the project site, as well as further recommendations for progressing towards the 30-year vision.

5.3.4 PHASE 4: COMMUNITY WORKSHOPS

The fourth phase involves community workshops that builds upon the focus groups and inputs the knowledge gained from the focus groups (on blue-green infrastructure and WSUD), and inputs this knowledge into real-world solutions. The community workshops will provide the local community with guidance and incentives on how to effectively integrate more vegetation and WSUD within their private properties.

5.3.5 PHASE 5: EDUCATION THROUGH INFRASTRUCTURE

The fifth phase involves the ‘education section’ on the green bridge - this will increase the community’s knowledge and understanding of Gold Coast waterways through the artistic flow map of the Gold Coast waterways that shows the importance of blue-green infrastructure in conjunction with waterways. By including an interactive pathway of the Gold Coast waterways, this can guide people through the importance of our natural assets and waterways, and how they can individually contribute, manage and protect our natural assets and waterways. In conjunction with these four key phases, there will be continuous community engagement through community events held at the Gold Coast Botanic Gardens.

Our team will work closely with a number of private stakeholders to achieve our ideas for the site and to further implement blue-green infrastructure and WSUD throughout the SEQ Region. By operating with the SEQ NRM organisation, our team aims to create the prospect of private organisations using our designs and projects to offset

their corporate social responsibilities (SEQ Plan 2016). Companies that are already involved in providing positive ecological projects throughout SEQ includes:

- Energex;
- Powerlink;
- Queensland Urban Utilities; and
- Utility Water.

The companies listed have all been involved in the delivery of rehabilitation, restoration and revegetation programs, and have created cost-effective and innovative solutions towards managing waste water. Our team aims to include private stakeholder investment to achieve the most innovative blue-green infrastructure goals.

5.4 FUNDING OPTIONS

This project will be implemented over a 30-year period and the funding will be primarily from the local and state governments – potential sources of funding within these governing bodies includes:

- ✓ City of Gold Coast Council
- ✓ Department of Environment and Heritage Protection
- ✓ Queensland Government – Get Paying Plus Program (Queensland Government 2016)
- ✓ SEQ Catchments

Funding will also be sourced from rates paid by local residents, as they will be using the botanic gardens, the green bridge, as well as other facilities within the vicinity. These local residents will be offered incentives towards their individual responsibility and role in the improvement of the Gold Coast Botanic Gardens and the surrounding vicinity. These incentives will be explained further in the 'Recommendations' section. Additionally, funding for the green bridge may be granted through the Australian Government's National Cycling Strategy 2011-2016 – the Australian Government invests in cycling and pedestrian infrastructure as part of this program, and the

implementation of the green bridge will increase accessibility, active transport and cycling.

5.5 STEP 1 & TRIGGER 1

The local adaptation pathway continues on to 'Step 1' – this is directly linked to Strategic Priorities 5-7 (Figure 29). This step is linked to 'Trigger 1: An estimate of 5-10% of pesticide and storm-water runoff from the adjacent golf course leading to the damaged health of vegetation and waterways' (Freeman 2008).

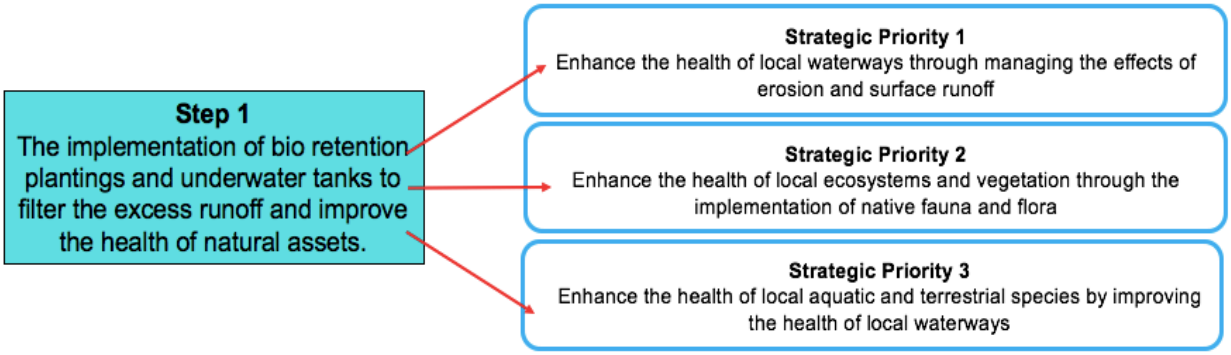


Figure 29 Step 1 Related to Strategic Priorities 1-3.

The bio-retention plantings are able to absorb pollutants and sediments and hold them within the soil whilst they are broken down by microorganisms. These plantings act as a filter, by allowing the runoff to infiltrate, rather than enter the waterways (Freeman 2008).

By developing a partnership with the Royal Pines Resort Golf Course (RPRGC), our team and the RPRGC can form a knowledge partnership by discussing the positioning, responsibility and shared use of the underground water tanks. This is essentially a form of social learning, both for the co-operation of partners and the outcome of the co-operation of partners (Berkes 2009). Social learning is efficient through joint problem solving and reflection - through this process of learning and problem solving, learning networks can incorporate different levels of knowledge to manage and resolve issues at increasingly larger scales, leading to the transition from co-management arrangements to adaptive management arrangements (Berkes 2009). Adaptive management is essentially 'natural resource management conducted in a manner that purposely increases knowledge and decreases uncertainty' (Rist et al.

2012). This form of management allows for best practice environmental management to be implemented as technologies develop over time (Department of Environment and Heritage Protection 2013).

In this situation, the outcome of this partnership will be decreased storm water runoff through the collection of excess storm water in the underground water tanks. The degree of pesticide and storm water runoff from the RPRGC to the Botanic Gardens can have a detrimental effect upon the gardens itself, as well as the surrounding waterways. By positioning the underground water tanks on the border of the Botanic Gardens and the RPRGC, this allows both properties to utilise this wastewater by controlling the quality and quantity of storm water runoff from the RPRGC to the Botanic Gardens.

An example of a successful partnership is the Byron Bay Golf Course the Byron Resort and Spa. The golf course has recently partnered with the adjacent five-star resort, leading to the upgrade of the infrastructure and irrigation system which is part of a self-sufficient water initiative master plan. The transformation was initiated in 2004, when the resort developer enquired into offloading treated water from the resort's treatment plant onto the golf course. However, as the Byron Bay Shire Council (BBSC) Sewage Treatment Plant (STP) already supplied irrigation water to the golf course, the council and the resort's developer decided to reuse the water in native garden sections (Australian Turf Grass Management 2017).

5.6 STEP 2 & TRIGGER 2

The local adaptation pathway continues on to 'Step 2' – this is directly linked to Strategic Priorities 2 and 3 (Figure 30). This step is linked to 'Trigger 2: An increased intensity of extreme rainfall events by 10-20% throughout Australia, leading to increased inundation of the Botanic Gardens and adjacent area during extreme flooding events'.

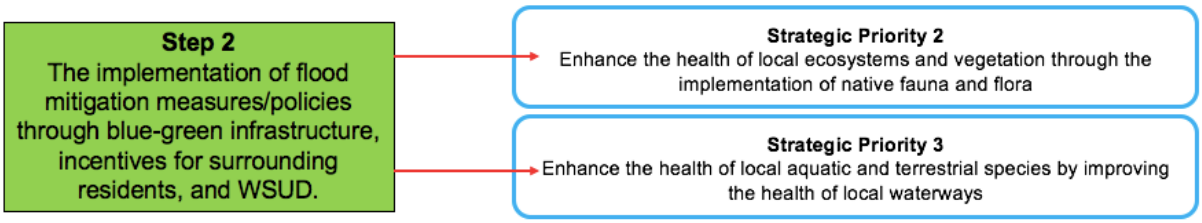


Figure 30 Step 2 Related to Strategic Priorities 2 & 3.

'The Gold Coast is subject to existing, future and residual flood risks, and comprehensive flood studies have shown that several thousand properties across the city will experience over-floor flooding during a one in 100-year flood event' (City of Gold Coast 2017). The City Plan Interactive Mapping tool identifies at-risk areas that are subject to flooding - this tool is useful for knowledge purposes; however, the implementation and promotion of WSUD in new developments and sites is essential towards managing and minimising flood risks. The correct implementation of WSUD is dependent upon the City of the Gold Coast, developers, and residents all playing their part. Therefore, our team has implemented incentives for surrounding residents to include more vegetation and WSUD in their private properties, in order to align with the overall vision and improve the health of local waterways. These incentives will be explained further in the 'Recommendations' section.

5.7 STEP 3 & TRIGGER 3

The local adaptation pathway continues on to 'Step 3' – this is directly linked to Strategic Priority 4 (Figure 31). This step is linked to 'Trigger 3: An annual average warming of 0.4 to 1.3°C throughout Australia, leading to increased droughts and heat waves (UIHE) due to climate change'. According to Commonwealth Scientific and Industrial Research Organisation (CSIRO), 'extreme temperatures are projected to increase annually by 0.4 to 1.3°C across Australia - this includes a significant increase in the duration, frequency and temperature of hot days'.

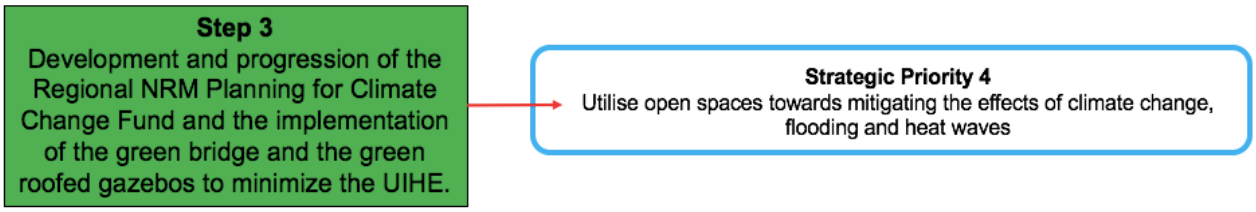


Figure 31 Step 3 Related to Strategic Priority 4.

The Regional Natural Resource Management (NRM) Planning for Climate Change Fund helps NRM organisations plan for climate change by building their capacity to implement climate change information by operating with climate scientists (Department of Environment and Energy 2016). This enhances the relationship between NRM planners and researchers; however, the success of this partnership is also dependent upon future generations and their willingness to contribute towards climate change adaptation and mitigation measures.

The empty field in the Botanic Gardens is currently used as an off-the-leash dogs field; however, this will be transformed to incorporate shaded social spaces and a sport and recreational field. There will also be gazebos implemented throughout the empty field in the Botanic Gardens, as well as gazebos positioned throughout Lot 616. These gazebos will also have green roofs to minimise the impacts of climate change and heat waves upon the local community. The implementation of a green bridge from the Botanic Gardens to Lot 616 on Nerang-Broadbeach Road will allow employees, residents and students to actively commute to local schools, services and public spaces. This green bridge will eventually feature plantings and vegetation that will also contribute towards the minimisation of climate change and heat waves upon the local community. Therefore, the implementation of the green bridge and the green-roofed gazebos will mitigate the effects of extreme droughts and heat waves by the daily dew and evaporation cycle.

6.0 CONCLUSION & RECOMMENDATIONS

This report has highlighted that blue-green space networks are essential towards the mitigation of flooding and the improvement of water quality following extreme weather events from the emerging threat of climate change. Our company Eco Solutions endeavours to create liveable communities that are economically, socially and environmentally sustainable. To combat the challenges that have been outlined in this report, several recommendations have been suggested.

To begin with, it is evident that many of the NRM plans throughout Australia use an adaptive management approach which is extremely science-based and focuses on monitoring, evaluating, reporting and improvement. This approach is aspirational and is a normative concept in conservation. Rist et al. (2012, p.1) highlights that adaptive management is, “natural resource management conducted in a manner that purposely and explicitly increases knowledge and reduces uncertainty”. Moreover, it enables wider stakeholder interaction and reverses the traditional approach to management based on centralised planning, control and top-down decision making. However, the biggest criticism to an adaptive management approach is that there is a lot of planning and engagement, but little monitoring once a strategy is implemented. This approach does not consider the dynamics of nature and often does not include multiple forms of knowledge. Mistakes are inevitable within adaptive management due to the fact that this approach assumes and predicts scenarios in the future.

It is recommended that an adaptive co-management approach be implemented as an alternative. This approach highlights the social context of an adaptive management approach and encourages horizontal interaction among stakeholders and vertical interaction among communities (Rist et al. 2012). Furthermore, it is a process where institutional arrangements and ecological knowledge are tested and revised in a dynamic process of learning by doing (Rist et al. 2012). This approach uses other forms of knowledge (apart from science) such as indigenous ‘storytelling’ and local community knowledge to make decisions (Christie 2005).

This approach is similar to the grassroots development approach, where non-governmental organisations and the community have power over governmental

organisations (Willis 2005). A ‘bottom-up’ development approach is suggested for the SEQ NRM region to improve communication and collaboration between the community, key stakeholders, and federal, state and local government in order to encourage blue-green space infrastructure. Further, a grassroots development approach may offer a solution to the many institutional gaps between federal and state policies when they are implemented at a local level. This will allow for improved management of catchments and surrounding low-lying areas during extreme weather events (i.e. flooding).

It is finally recommended that residents within one kilometre of the Gold Coast Regional Botanic Gardens site receive incentives to incorporate blue and green infrastructure in their backyards. It is suggested that residents receive lower rates and rebates if their property contains WSUD features. It is further suggested that private and public stakeholders provide grants to specific houses in order to encourage them to include blue-green infrastructure in their backyard. Investors may also provide infrastructure discounts for the implementation of WSUD features in each backyard. Finally, another incentive recommended is expedited approval for blue-green development. This means that households awaiting approval for development within their backyard may be able to ‘fast track’ through the process.

Overall, this report has analysed the Gold Coast Regional Botanic Gardens site located at 230 Ashmore Road, Benowa with key findings as follows:

- blue-green space networks are essential to combatting the negative effects of climate change and subsequent extreme weather events (i.e. flooding and poor water quality). The pros of blue-green space networks include; improving land and water quality, mitigating against climate change, creating space for recreational and social activities, and enhancing the attractiveness of a city. The cons of blue-green spaces which have been outlined in the report include; doubt surrounding the hydraulic performance of drainage systems, the inability to effectively manage the community’s reaction to the shift in environmental policies and frameworks, and the economic cost;
- there is a vast array of legislation and planning frameworks surrounding catchment management within SEQ. Federal and state policies are poorly

reflected in local plans; therefore, it has been recommended that goals and policies outlined within each institutional arrangement at different government levels be better integrated;

- the subject site is located in the centre of Benowa, beside a private golf course that produces a large amount of sediment runoff that is detrimental to the quality of water in nearby catchments. The Botanic Gardens is located in an area that is easily accessible for many visitors and nearby residents to enjoy;
- as highlighted by the Gold Coast City Plan, there are many overlays within the site including; acid sulphate soils, airport environs, coastal erosion hazard, landslide hazard, environmental significance – wetlands and watercourse, and flooding. These overlays have been considered and managed accordingly when proposing ideas for the site;
- specific blue and green infrastructure that has been recommended for the site includes; recycling stormwater runoff from the golf course through underground stormwater tanks, additional bio filtration plantings, native and riparian vegetation, construction of a green active transport bridge with local educational art work, a boardwalk, and a sporting/ recreational field. These ideas for the site aim to connect blue and green spaces in order to reduce flooding impacts on nearby roads and residential areas;
- the abovementioned recommendations are to be implemented over a 30-year period as to ensure economic sustainability. The proposed timeline of implementation measures includes three trigger points, relating to pesticide runoff, increased intensity of rainfall events and increased global warming leading to droughts and heat waves; and
- private and public stakeholders shall be engaged throughout all stages of the strategic framework and the project shall be funded initially through local and state governments. Eventually, we propose that the federal government partially invest in cycling and pedestrian infrastructure on the Gold Coast as part of a more integrated active transport strategy.

Eco Solutions has proposed an innovative, holistic and sustainable design that encompasses characteristics of a blue-green space network. It is essential to keep the subject site as an Open Space Zone with zero provisions for development. The

site is utilised for flood management as to minimise flooding impacts on surrounding residential streets. Therefore, the abovementioned recommendations for the site will better integrate water management throughout Benowa, and eventually throughout all of SEQ.

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8.0 APPENDIX

APPENDIX A – DRAFT CONCEPT PLAN (SCHULTZ 2017)

APPENDIX B – FINAL POSTER DESIGN (SCHULTZ, BITZIOS, BELL, IRVINE & MERCER 2017)