Coastal habitat creation and water quality improvements to protect and enhance the Gold Coast Broadwater

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Introduction

The Gold Coast Broadwater estuary is a vital coastal resource within the Gold Coast and South East Queensland region for tourism, recreation and fisheries. Located in one of the fastest growing areas of Australia and South East Queensland, the Broadwater Parklands (the parklands) have been home to major events including the Gold Coast Marathon for over 20 years.

Redevelopment of the parklands was triggered through a momentous occasion celebrating 150 years of Queensland as an independent state from New South Wales under the Q150 Legacy Infrastructure Project (Q150 LIP); hereon the project. The project was undertaken through innovation and cooperation across all levels of government in planning for the future of our coastal assets, economic development and community capacity building.

At the fore of the project was coastal habitat creation and water quality improvements to protect and enhance the Gold Coast Broadwater. Considering parklands expansion required through reclamation, a balance between initial impacts on existing resources with environmental offsets for future enrichment were integral.

This paper presents the aims and objectives of the project goals to cater for people, the economy and coastal ecology. This review also explores the rationale for impacts, the collaborative outcomes for offsets, and the major capital investment required in planning for high growth and demand areas such as the Gold Coast Broadwater.

Background

Previously home to a large (740 space) asphalt car park, mostly devoid of trees and linked to the Southport Central Business District (CBD) by a narrow uninviting underpass, Gold Coast City Council (Council) recognised the potential for the Broadwater Parklands and applied for funding through the Q150 LIP for master planning and the first stage of construction.

Council received a significant allocation of State funding under the Q150 program matching $19M of State funds with $22.5M for Stage 1. Stage 2 was undertaken immediately afterwards in Councils response to the Global Financial Crisis (GFC) as part of a local economic stimulus package ($18M), with a total project cost for Stage 1 and 2 of $60M.

A major challenge for all levels of government is to balance the triple bottom line (TBL) and ensure intergenerational equity for future generations. This project provided a series of firsts for Council and the State, with the largest capital investment undertaken in social-recreational infrastructure on the Gold Coast Broadwater since construction of the Spit and Seaway in 1986 (primarily for navigation needs).

Project intent

Principal objectives of this project were to enhance the natural coastal assets and provide a world class recreational and event open space in the fastest growing region in the State, and Australia's sixth biggest city.

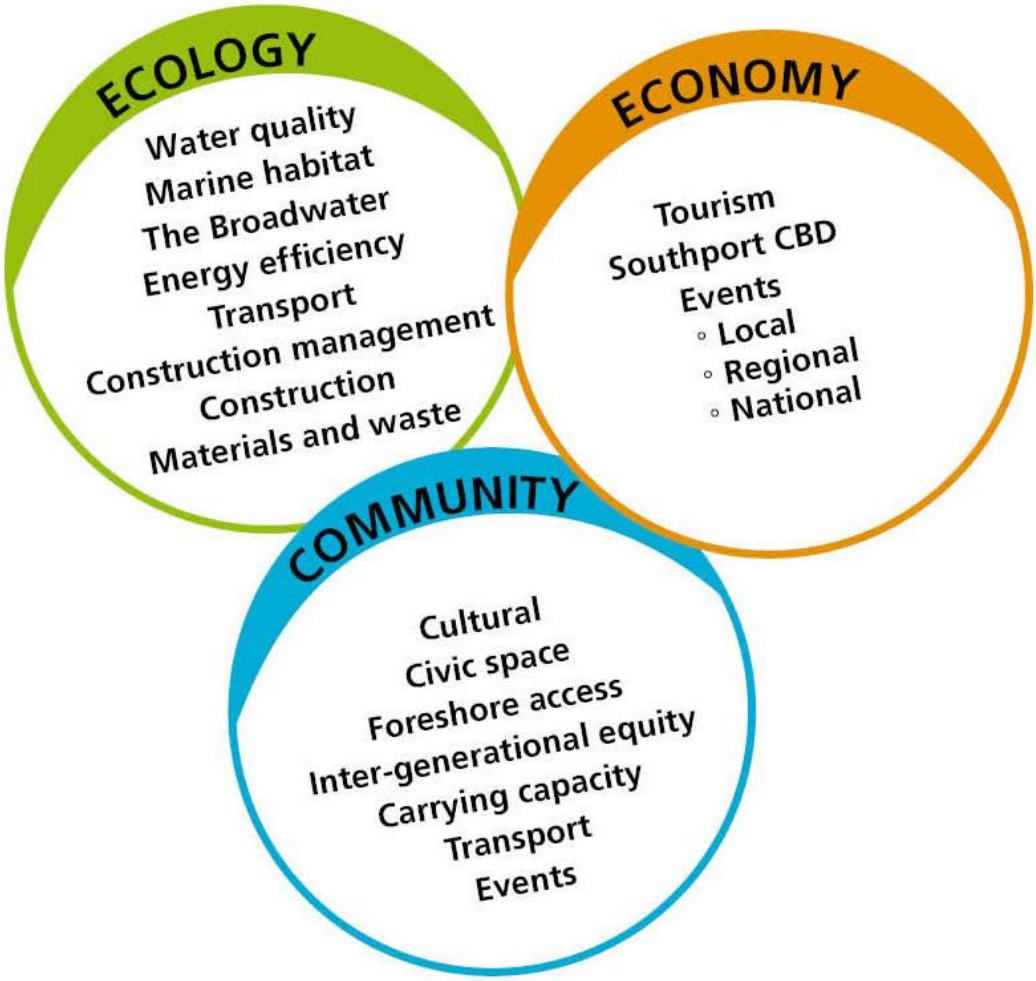
The aim of the Q150 grant was to redevelop the parklands in response to:

- Population growth and shortages in priority infrastructure; recreational space
- Economic growth for the region through:
    - Expansion of event space (to attract and retain events – Local, State, National and International)
    - Enhancement of the foreshore
    - Improving access to the coast

- Increasing tourism attraction of the region
- Deliver the above through ecologically sustainable development; balancing short term impacts offset by long term augmentation of the foreshore.

See Figure 1.0 for an overview of TBL initiatives and the balance of the 'three spheres of sustainability' as they related to project necessities.

Figure 1.0 –TBL Initiatives for the Southport Broadwater Parklands redevelopment



The Q150 project triggered local and regional community aspirations and needs, along with the impetus for progressing the world class tourist destination the Gold Coast is for Queensland. The scope of the project aimed at providing major infrastructure for the region and local community through best practices in open space development.

Balancing pressures of the three spheres of sustainability, the project incorporated parklands expansion through reclamation of tidal lands and offset environmental impacts through:

- Creation of a mangrove habitat at an existing degraded stormwater outfall
- Seagrass Translocation
- Water quality improvements
- Ongoing research into fish habitat and marine environs

Broadwater history

Historically the parklands have expanded through reclamation works from the 1960's to 1980's from a six hectare narrow shoreline park, to around 30 hectares in its current configuration. The estuary was altered most severely in the mid 1980's through construction of:

- Hinze Dam on the Nerang River
- Gold Coast Seaway
- Wave Break Island

Over the years the Broadwater and Broadwater Parklands recreational assets have been confronted by increasing pressure through population and visitation growth, with associated demand for quality recreational infrastructure along the foreshore.

With ambitious scope in redeveloping the foreshore as a world class events parklands, major capital investment and collaborative effort was required; including extensive community consultation. The pioneering aspect of the project draws distinct parallels to Council's Corporate Plan and Bold Futures key focus areas, along with State objectives under the Regional Plan 2021-2050.

Methods
The project was fast tracked over 27 months for Stage 1 and Stage 2 undertaken over 12-14 months. The planning process was undertaken in phases listed in Table 1.0 – Project Phases below.

Table 1.0 – Project Phases

Project Phase	Timing	Key inclusions
Concept to Master Planning	April to December 2007	Community Consultation Engagement of a lead design consultancy Approvals process commenced
Schematic Design to Detailed Design	December 2007 to February 2008	Appointment of a managing contractor for construction delivery Design development Costing
Construction Design and Construction	February 2008 to August 2009	Approvals – June 2008 Reclamation and offsets works; July 2008 to July 2009 Completion of Stage 1
Completion – Stage 1	August 2009	Q150 Celebrations
Completion – Stage 2	December 2010	Planning, Design and construction commenced June 2009

An Ecologically Sustainable Development (ESD) report compiled by the lead consultancies detailed the philosophy and framework for the design initiatives for the project, with a major design integration of Water Sensitive Urban Design (WSUD) features throughout the parklands (ESD Report - AECOM, 2007).

By intending to undertake reclamation, Council understood the impacts and offset of the proposal, with community consultation integral to the decision making process. Consultation included engagement with the following key environmental and industry group along with consultation across the City:

- Loders Creek Catchment Group
- GECKO (Gold Coast Environmental Council)
- Marine Industries Association of Queensland
- Seafood Industries Association of Queensland
- Coastcare – Friends of Federation Walk
- Queensland Board Riders Association

Consultation encompassed part of the statutory approvals process triggered under the Coastal Act and associated legislation through the Department of Environment Resources and Mines (DERM – then EPA), along with the Fisheries Act and related policies through the Department of Employment and Economic Innovation (DEEDI) – Fisheries.

The following summary details the ESD initiatives for the project. Cost has been included to highlight the significant capital required to undertake such works.

Water quality initiatives – WSUD features
Water quality improvements are a key objective to reduce edge affects and enhance Seagrass colonisation (Connolly 2007, Lee 2007), especially pertinent at the parklands with predevelopment stormwater generally spilling untreated into the Broadwater. This project was a catalyst to retrofit the existing stormwater network to enhance the Broadwater environment.

Bioretention gardens – Stormwater Reconfiguration
Requiring major civil works to redirect stormwater lines and discharge points throughout the 6 hectare central Stage 1 area, bioretention gardens were constructed throughout the parklands including all car park areas (over 250 spaces), utilising wetlands species detailed in Table 2.0 – Species Used in Bioretention and Wetlands Areas.

- **Cost = $4.6M**

Constructed wetlands
A 2800m2 central wetland system was constructed comprising 3 sections (or cells) with a tiered weir system circulating water between each cell for treatment. Plants were selected for their capacity to survive in poor soils and water quality, plus the capacity for uptake of pollutants and metals, included in Table 2.0 – Species Used in Bioretention and Wetlands Areas. This system has a bore water supply and pump for extended dry periods as well.

Table 2.0 – Species Used in Bioretention and Wetlands Areas

Plant species	**Location/s**
Isolepsis nodosa (‘knobby club rush’)	Batters of wetlands and all bioretention gardens
Ghania sieberiana (‘Ghania’)	Batters of wetlands and all bioretention gardens
Schoenoplectus mucronatus (‘club rush’)	Standing water – constructed wetlands
Juncus usitatus (‘common rush’)	
Baumea rubiginosa (‘clumping sedge’)	

This feature captures 3.2 hectares of CBD runoff including basement car parks from adjoining high rises and the Australia Fair Shopping Centre, receiving rainfall from ‘Q2’ Average Recurrence Interval (ARI) intensity (‘average’) rainfall events. Built on existing sandy substrate, the cells are clay lined and further sealed with a geosynthetic layer impregnated with clay at the base. Coarse sandy media is used for the vegetation.

- **Cost = $1.2M**

Filtration and cleansing through the WSUD systems targets a reduction of mean annual loads of:

- 80% suspended solids
- 60% phosphorous
- 45% total nitrogen
- 90% gross pollutants

Ecological initiatives – Environmental impacts and offsets
To undertake reclamation for the social initiatives (see below), environmental offsets were necessitated due to initial environmental impacts, recovery and long term sustainability. Council undertook studies in existing floral and faunal assemblages and developed an offset program by engaging expert technical marine ecology advice from Griffith University (Connolly and Lee); along with marine and water quality specialist consultancies (Comley, and Leinster 2007).

As noted, a key issue facing seagrass colonisation is poor water quality especially in areas along the parklands where stormwater outfalls incur edge affects on seagrass; demonstrated by the sparse nature of pre-development seagrass beds along the foreshore (Connolly 2007, Comley 2007, Lienster 2007).

With past development building out the CBD, it was deemed appropriate to construct a marine habitat in a suitable location with a range of objectives to offset the impact on seagrass in the southern section used for reclamation.

Mangrove habitat creation
With a receiving catchment of over 7 hectares from the Southport CBD, runoff from stormwater pipes (4 x 1500mm and a 1 x 600mm) previously entered the Broadwater untreated.

The 1.2 hectare mangrove habitat area was created for water polishing and biofiltration to reduce edge effects and enhance seagrass colonisation in the surrounding area. Further, to increase habitat and species diversity, and species richness at this location of the Broadwater.

A primary objective is a reduction in fine sediment runoff into the Broadwater through deposition in the mangroves forest system and provide an intertidal fish habitat area, with increases in areas of bioturbation (Comley 2007, Leinster 2007, Connolly 2007, Lee, 2007).

This feature also represented a chance to put back a mangrove ecosystem, previously lost significantly through past reclamation projects for commercial-residential land up stream of the Broadwater estuary. These areas include Paradise Waters, Chevron Island and the Isle of Capri to name a few.

- **Cost = $1.2M**

Seagrass translocation
Considering the area to be impacted and in conjunction with advice from experts and cooperation with DEEDI, around 3-5% of the area to be impacted was translocated to the outside of the mangrove habitat area. The rationale for this was spores from the translocated stock (*Zostera capricorni* and *Halophila ovalis*) would take and provide increased colonisation in areas surrounding the mangrove habitat area; to benefit from a reduction in fines from the previously untreated stormwater outfall (Comley 2007, Leinster 2007, Connolly 2007, Lee 2007).

- **Cost $100,000**

Funding Urban Fish Habitat Management (UFHM) Research Program
Council is contributing $250,000 to the UFHM Research Program over 5 years. This program is administered through Griffith University Gold Coast, under DEEDI's program to integrate research projects about impacts (natural and human induced) on fish habitats in Queensland's urban areas (DEEDI http://www.dpi.qld.gov.au/28_9206.htm).

Total cost of water quality and marine habitat initiatives = $7.35M

Other Ecological Initiatives

Foreshore restoration
Included in the dredging program was nourishment to over 1 kilometre of previously eroding foreshore. Additional works included over 2 kilometres of dune restoration, utilising 20,000 dune plants.

- **Cost $155,000**

Energy efficiency
Located on the central 'spine' of the parklands including Nerang Street Pier, Council installed 266 Photovoltaic (PV) cells capable of generating up to 76,000 Kilowatts per annum. The power generation capacity for this feature is enough to power the demand created from Stage 1 works with LED lights throughout.

- **Cost $940,000**

Water efficiency
Water savings initiatives included stormwater harvesting for public amenities non-potable supply.

- **Cost $150,000**

Reticulation of future recycled water mains for non potable irrigation supply.

- **Cost $460,000**

Total cost = $1.75M

Major Related Social initiatives

Reclamation
Utilising material from the Southern Channel (seaway entrance) and South Wavebreak Channel in the Broadwater, over 110,000m3 of sand was dredged to create 3 hectares of land above Highest Astronomical Tide (HAT).

This parklands expansion has accommodated increased recreational facilities (bbq's, picinic facilities and amenity buildings), event space (Gold Coast Marathon, Triathlon, Gold Coast V8 600 Concert series).

- **Cost $4.2M**

Water play
Supplied by salt water from the Broadwater, a 130m x 35m water play, 'Rockpools' is a free family friendly attraction aimed at increasing visitors to the Parklands and the Gold Coast for overnight stays. Featuring sea creatures and 'tidal sequencing' the Rockpools ebb and flow along the course of the feature, providing a unique foreshore park experience.

- **Cost $3.4M**

ANZAC park
Re-located to the southern reclamation area, this is a purpose built park area for memorial services. Part of the dredging included a hill for the area to accommodate crowds and provide a view over services. This years first ANZAC services attracted over 3000 people.

- **Cost $380,000**

Nerang St pier
With links to the past and reconnecting the Southport CBD to the foreshore, a 105m pier was constructed along the foreshore for public recreation, fishing and future transport needs.

- **Cost $7.5M**

Total cost = $15.48M

Total cost for the three spheres of core environmental initiatives = $24.58M*

*The remaining $35.42M covers infrastructure such as buildings, electrical, stage, Close Circuit TV, Car Parks, pathways, artwork, picnic and bbq facilities, play facilities, hydraulics and more associated with creation of a world class parklands.

Results

Methodology

A statistically valid assessment detailing the constructed mangrove and marine vegetation community, associated biota assemblage and seagrass composition is currently underway. Methods for the evaluation of these communities has been evaluated and accepted by the DEEDI.

The following summary provides analysis of the works conducted since construction was completed in September 2009.

Mangrove Habitat Area

Council determined site specific survey parameters to determine the level of success from the project.

Relative site cover by mangroves and associated marine plants along the foreshore:

- Complete success 100%
- High 80 – 99%
- Moderate 60- 80%
- Moderate-low 40-60%

Eighteen months post-development in January 2011, the mangrove habitat area was assessed and considered to be at a Moderate (60-80%) level of success by Council. This evaluation underwent a cell-by-cell break down to detail relative site cover and associated marine plants along the foreshore.

However, since this assessment additional seed collection and planting has increased coverage across the site. Arguably this increased coverage flags a moderate to high level of success, with 3 years still remaining on conditioned reporting. It should be noted that Council and Griffith University will undertake further research into this feature after the five year reporting period.

The site has three distinct generations of manual propagule planting, throughout 2009, 2010 and 2011. All conducted during Mangrove seeding periods May to August. There has been an encouraging amount of natural recruitment through tidal inundation of the site, since development.

The 2009 planting (May to August) and the 2010 planting, planted over 2000 propagules in designated planting cells. In 2011, generation three was represented by planting of propagules and natural recruitment of *Avicennia marina* (Grey mangrove) which are the most abundant species on the site, See Figure 3.0 – Mangroves growth timeline.

In May 2010 these first recruits had produced an abundance of pneumatophores, establishing a good root stock which helped the plants move into their second faze of growth with lateral vegetation highly visible in the some cells. Grey mangroves had a high amount of propagules fruiting, with a large amount of propagules distributed throughout the larger Broadwater area in July 2010. This helped the GCCC in collection and planting out of the site.

Aegiceras corniculatum (River mangrove) are distributed relatively evenly across the mangrove habitat area, which is surprising considering most of the River mangrove are from natural recruitment. No manual propagule planting of this species was possible due to their

limited fruiting at the start of 2010. This made harvesting of propagules from native stock of River mangroves not recommended in 2010.

Interestingly two *Rhizophora stylosa* (Red mangrove) are on site from natural recruitment and have become of great interest, particularly for the marine biology department at the Griffith University, for their resilience and health in an area considered to be at the southern most distribution range for this species.

Figure 3.0 – Mangroves Growth Timeline

Substrate conditions

Preliminary analysis of substrate has concluded that major nutrients (TN, TP) and heavy metals (zinc, magnesium, iron etc) in the sediment have shown decreased nutrient levels as the water travels through the site. This may have been through the uptake from the mangrove vegetation (for growth) or the binding of these elements to the organic content in the sediments.

Samples taken at control sites in the receiving zone of the mangrove demonstrate nutrient reduction has occurred across all chemical parameters. (Figure 3.0 and 4.0 below). Further

monitoring to assess trends will be forthcoming future with two students from Griffith University working with Council to undertake studies over the next 12 months.

Figure 4.0- Sediment sampling results for 2009-2011 of Total Nitrogen (TN)

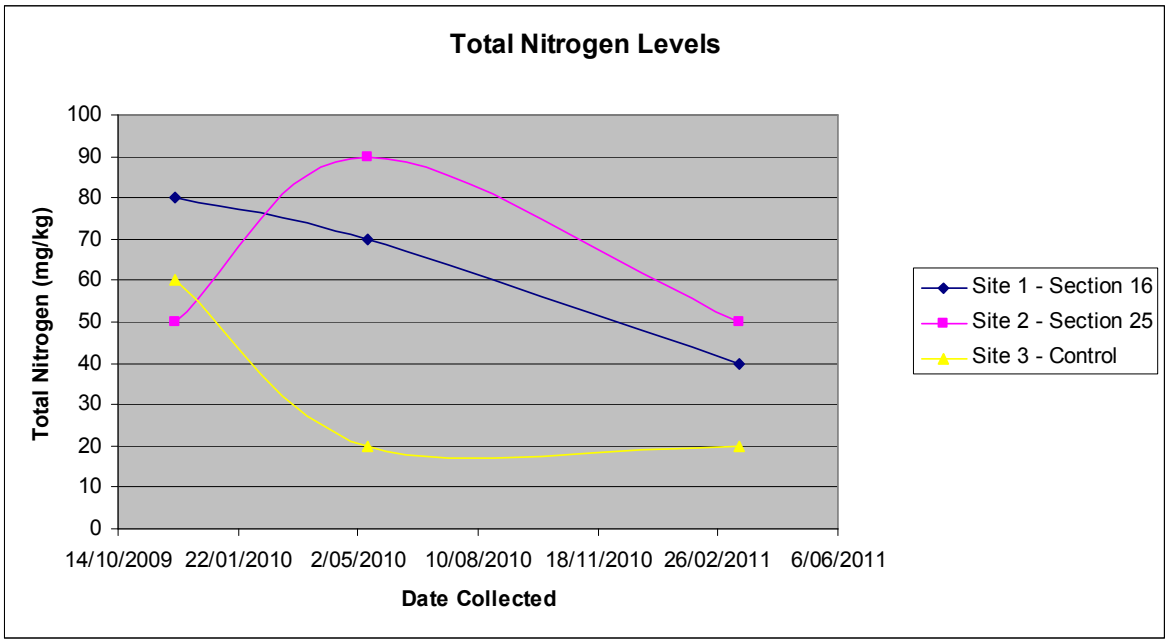
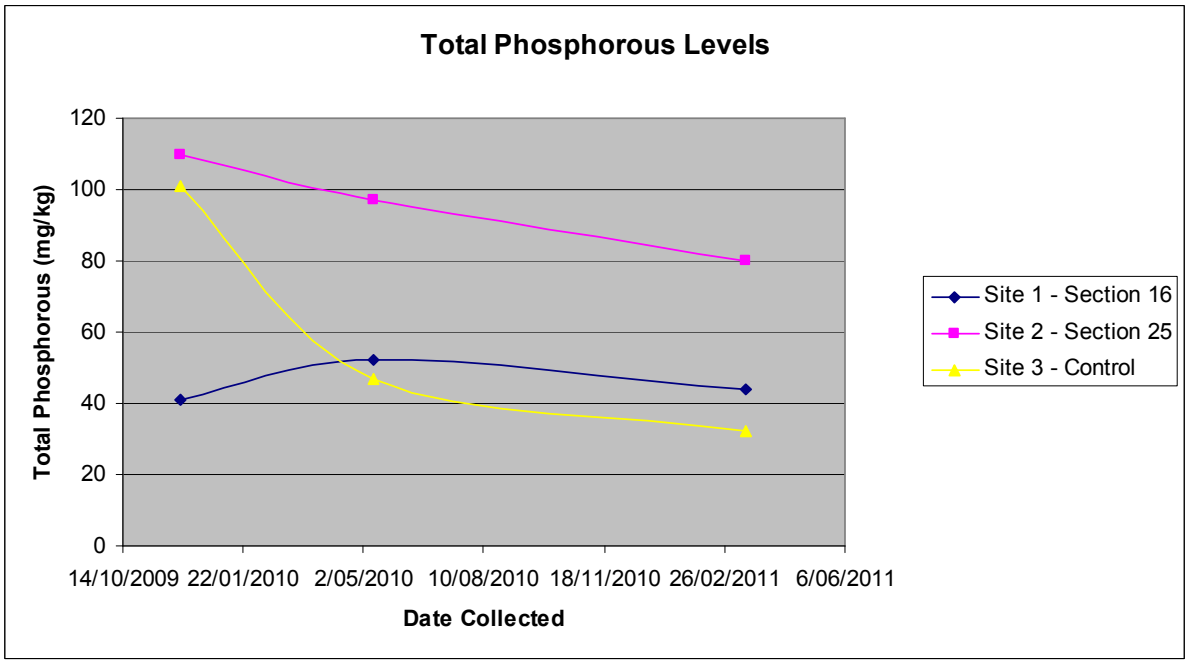


Figure 5.0 – Sediment sampling results for 2009-2011 of Total Phosphorous (TP)



Although in its early stage of establishment, there are promising signs of the mangrove habitat area's capacity to uptake nutrients and for sediment deposition receiving fines as intended.

Seagrass

Evaluation of seagrass success was assessed across the entire 2ha area with evaluation looking for improved and rigorous growth patterns from the original site (pre-construction).

Rating is as follows:

- Complete success .75ha

- Moderate .2-.75ha
- Low .05-.2ha
- Failure Nil colonisation of seagrass 1 – 5 years

Seagrass rehabilitation was assessed on 8 September 2010 with the conclusion that overall seagrass cover is approximately 0.2 hectares of the (2ha) site, with a mean seagrass cover of 17%.

Considering this, a moderate (0.2-0.75ha cover) level of success has been documented for the site at this point in time. Natural seagrass recruitment from seeds has been noticed within the mangrove habitat area and in the seagrass zone areas through tidal dispersed processes.

However, additional site observations and further analysis reveal additional increases in spread and density between January 2010; see Figure 6.0 - Comparative Seagrass Images (January 2010 and July 2011). Council is undertaking further survey and reporting in the coming months, as well as the next 3-5 years.

General ecology
Benthic community (macro-invertebrates) composition and abundance is yet to be assessed. Observations of the site have shown that predation on benthic organisms by various fish species and the family *Dasyatidae* (stingrays) has been happening since October 2009.

All dunes are in good health and stabilized along the foreshore the dunes, two seagrass species and three mangrove species are present on site at this point in time also.

General observations of faunal presence is that the site is becoming used by a full suite of species from yabbies, snail, and flat sand worms to mullet, flat head and other fish species, with bird species trawling the water edge to feed. More extensive marine ecological studies will be produced in following years when the habitat matures.

UFHM Research Program
Over $130,000 has been paid to date as with the following Table 3.0– Broadwater Parklands UFHM Research Program Contributions, detailing programs aligned with Councils contributions as a result of this project.

Table 3.0 – Broadwater Parklands UFHM Research Program Contributions

Research Program		Funding
1	Created mangrove wetland for urban stormwater purification	$40,000
2	Value of small patches of seagrass to juvenile nekton: a physical perspective	$40,000
3	Impact of urbanisation on the trophodynamics of estuarine sandflats	$40,000
4	Artificial waterways as nurseries for juvenile estuarine nekton	$40,000
5	Remnant aquatic vegetation as fish habitat in artificial waterways	$40,000
Total		**$250,000**

Funding paid to date has contributed to include:
- 1 Phd
- 2 Masters
- 1 Honours
- 2 Industry Affiliate Students reports - currently working with Council

Figure 6.0 – Comparative Seagrass Images

January 2010 – Seagrass colonies adjacent to shoreline and north east diagonal

July 2011 – Seagrass colonies adjacent to shoreline and north east diagonal; note increased density.

Discussion

The natural beauty of the Broadwater is a key attraction for visitors and events, and immensely popular as a diverse family friendly destination. Throughout the design process in redeveloping the parklands, a strong emphasis was placed on preservation and enhancement of the Broadwater natural assets, balanced with offsetting impacts.

With Council's role to improve carrying capacity, event expansion for the region and amenity of the site, reclamation of tidal lands was seen as a viable option provided a balance could be struck between impact and offsets.

Council and the State have addressed regional needs across the three spheres of sustainability by ESD initiatives undertaken throughout the parklands redevelopment involving:

- Stormwater treatment
- Foreshore and marine works
- Social equity
- Water conservation
- Energy efficiency
- Beach nourishment
- Reclamation of tidal lands (3 hectares), with:
    - Environmental offsets including;
        - Seagrass translocation
        - Mangrove habitat creation
        - Financial contributions to the Urban Fish Habitat Management (UFHM) Research Program

The parklands have produced a range of firsts in creating a mangrove habitat area in a sandy substrate, undertaking seagrass translocation, and incurring a high capital cost in reconstructing a foreshore stormwater network. The new stormwater network represents best practice for water quality treatment. This required a strong partnership with the State Government providing one-third of the project cost, and diligent inter-government support during the process.

Since establishment, these features are now developing into the next phase of consolidating early growth and function. They also provide a substantial educational asset by engaging school groups and Coast Ed programs, along with visitors to the parklands with environmental interpretive elements at each point. Coast Ed now utilises the sites for it's regular program, including planting days during early construction and ongoing.

Through the juxtaposition of the mangrove habitat creation, seagrass initiatives and water quality improvements, Council is confident they will meet the objectives in increasing habitat and species diversity in this location, with improvements in seagrass colony spread and density. The next phase in the project evolution is one of a commitment to survey and monitor the site, drawing on Council resources and interaction with the community across all levels of education.

Conclusion

This milestone and pioneering foreshore project required significant capital investment and support across government and the community. The initiatives of the project combine with the needs of public recreation and tourism to create a productive landscape of vibrant community spaces. The objectives to enhance the Broadwater ecology through marine habitat creation and diverse water quality improvements is on track.

The scope of reclamation and offsets signified a level of works not previously undertaken on the Gold Coast nor Queensland for social infrastructure, ecological planning and development along a high profile regional foreshore location.

The design response to the parks often harsh natural environment reflects a commitment to ecosystem preservation, and world class social infrastructure to propel the Gold Coast into the next evolution of sustainable design for recreational space. Since project inception, the project has provided a timely social and economic investment in city wide public open space, creating greater appeal for major events for the City and region.

Redevelopment of the Broadwater Parklands has created a unique and fun, family friendly destination along the Gold Coast Broadwater, and it is hoped it won't take another 150 years to plan our future for the Broadwater considering sustainability initiatives now in place.

Take home messages

⇒ Constructed mangrove habitats at stormwater outfalls provide a good buffer zone to seagrass colonies by reducing edge affects from urban runoff, and we will learn more from features such as this at the Broadwater Parklands.

⇒ To improve water quality and fish habitat in a highly urbanised areas requires a balance between using tidal and non-tidal lands, capital investment and cooperation across all levels of government; especially to implement changes that are 'out of the ordinary'.

⇒ It shouldn't take another momentous celebration for Local and State Government to undertake such initiatives, with the scale and significance of the project not necessitated by tens of millions of dollars, these works can be more affordable.

⇒ We have the knowledge and capacity, therefore should be the smart state and plan for broad changes in urban runoff and fish habitat management with similar collaboration.

Acknowledgements

Department of Employment and Economic Innovation, Fisheries Queensland
Department of Energy Resources and Mines, (Land Department)
Department of Energy Resources and Mines, (Environmental Protection Agency)
Department of Transport and Main Roads
Associate Professor Rod Connolly, Griffith University 2007
Professor Joe Lee, Griffith University, 2007

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