Synopsis: This report presents the findings of a review of littoral processes and past beach management, and the development of a shoreline management plan for the Gold Coast beaches.

Keywords: Coastal erosion, stakeholder engagement, coastal process modelling, Gold Coast
CASE STUDIES:

- A way forward in managing the Gold Coast littoral environment - Getting beaches back on the agenda - A discussion paper

- Northern Gold Coast Beach Protection Strategy Environmental Monitoring Program: Summary of First 7 years of Narrowneck Reef

- Palm Beach Protection Strategy Update

- Kirra Wave Study

AMENDED COASTAL MANAGEMENT PLAN FOR THE GOLD COAST

INFORMATION SHEETS
Griffith Centre for Coastal Management

A WAY FORWARD IN MANAGING THE GOLD COAST LITTORAL ENVIRONMENT

Getting Beaches Back On the Agenda

A Discussion Paper

PREPARED BY
GREG STUART
Synopsis: The aim of this discussion paper is to act as a catalyst for a review of the understanding and management of the littoral environment on the Gold Coast. What is currently known, what additional knowledge is needed and how can this information be used to manage the environment?

Keywords: beach erosion, littoral environment, beach health, storm erosion, shoreline evolution
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1 **AIM**

The aim of this discussion paper is to act as a catalyst for a review of the understanding and management of the littoral environment on the Gold Coast. What is currently known, what additional knowledge is needed and how can this information be used to manage the environment?

2 **INTRODUCTION**

The beaches of the Gold Coast have achieved iconic status within the local, regional and national community. This can be a double-edged sword. The perception can be that because the beach is so important to the community, it is the responsibility of others. While it is true that many organisations and people are involved in managing the littoral environment on the Gold Coast, it could be argued that there is a lack of focus for all this activity.

3 **LITTORAL ENVIRONMENT**

There are many ways to define the coast. What is the meaning of the “Littoral Environment”?

“Littoral Zone. In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.” (IEAust, 1998)

For the purpose of this paper and the following review, the littoral environment is considered to be from the rear dune fence or boulder wall alignment to the offshore zone where sand deposits for beach nourishment may be. This takes in the active zone of littoral transport but also those areas outside the active zone that may act as sediment sources.

The planning timeframe for this review is the next 50 years until 2055.

4 **BACKGROUND**

The Queensland Government has a long history of involvement in planning for and managing the Gold Coast littoral environment. Storm events in 1936 and 1950 threatened buildings and roads. The Government invited the Delft Hydraulics Laboratory (DHL) to advise them on ways of minimising erosion problems. In 1965 a report was received detailing the data required for good management of erosion on beaches (DHL, 1965).

Following more cyclones in 1967 and the accumulation of a limited amount of data, a report (DHL, 1970) on sediment transport patterns and recommendations for coastal protection works was presented to the state government.

Gold Coast City Council and the Queensland Government have implemented many of the recommendations in the report. DHL and the Queensland Government have also updated the sediment transport calculation for the southern end of the Gold Coast based on an improved data set (DHL, 1992).
Source: Gourlay, 1996

The role of the state government in coastal management has changed over this period. Coastal planning has become a focus of the Environmental Protection Agency (EPA) since the introduction of the Coastal Protection and Management Act in 1995. Any management of Gold Coast Beaches must take the State Coastal Management Plan (SCMP) into consideration.

SCMP Vision

Queensland’s coast – the dynamic strip that straddles land and sea – is recognised as a precious part of our landscape, and government, industry and the community work together to understand its natural systems, protect and rehabilitate important areas and ensure that our activities and settlements are sustainable.

Seven out of the ten themes in the SCMP relate directly to the littoral review.

Themes
- Coastal Use and Development
- Physical Coastal Processes
- Public Access to the Coast
- Water Quality
- Indigenous Traditional Owner cultural resources
- Cultural Heritage
- Coastal Landscapes
- Conserving Nature
- Coordinated Management
- Research and Information

The SEQ Regional Coastal Management Plan is currently available for public consultation (EPA, 2004). This document lists the government’s key coastal management issues and outcomes for South East Queensland. It is interesting to note that none of the key issues or outcomes for the coastal zone relate to the littoral environment. The sandy beaches of the Gold and Sunshine coasts do not feature highly in this current version of the plan.

Section 2.2.3 of the plan states that Regional Coastal Management Plans will identify priority areas for erosion management but there is no mention of any priority areas for South East Queensland. There remains a significant threat to the tourism industry, livelihoods and lifestyles of the region from beach erosion.

To deal with the sandy beach environment it may be necessary to include a Shoreline Management Plan as part of the RCMP. Page 26 of the plan suggests that high-use recreational coasts require additional management to maintain or protect the coastal resources and their values. This plan supports the intensive management of activities on the Gold Coast beaches.

The current scheme of works or coastal management plan, prepared by the BPA in 1973, is the current shoreline management plan and it is expected to continue to be the relevant approval under the new RCMP. There does not appear to be anything within the RCMP that repeals the approvals and direction given in the original coastal management plan from 1973.
As the recommendations of the Delft Reports that make up this existing plan are now close to completion, it is considered timely to prepare a new shoreline management plan. The footnote of page 38 of the draft regional plan states:

“This document approved pursuant to section 38 of the repealed Beach Protection Act 1968, will be modified to be recognised as a scheme of coastal management works in accordance with section 31(2) (b) of the Coastal Act.”

There is no further discussion about what form this modified document would take or who would do such a task.

It is proposed that a partnership be formed between the EPA, Griffith Centre for Coastal Management and the Gold Coast City Council to undertake a review of the littoral environment on the Gold Coast. A major outcome of this review would be the development of a new shoreline management plan to guide coastal works for the next 50 years.

This partnership model will also help to achieve the principle of co-ordinated management as described in the State Coastal Management Plan.

5 CURRENT SITUATION

5.1 Beach Use

On average, the Gold Coast tourism region hosts over 75,000 visitors everyday. This figure includes international, domestic overnight and daytrip visitors, and represents approximately 16% of all people in the Gold Coast tourism region on any given day. (See Appendix 4 for more details)

For the year ending June 2004, the Gold Coast received a total of 4,285,000 tourists with 65% declaring the purpose of the visit was for holiday/leisure. Further research into nature-based tourism on the Gold Coast (GCCC, 2003) has shown that 56% of all overnight visitors and 30% of all day-trippers go to the beach during their stay on the Gold Coast.

This places a great deal of pressure on the beaches, which are our number one tourist asset. The Gold Coast Tourism Visioning Project (Faulkner, 2002) states:

*The coastal resort strip remains as the focus of commercial tourism accommodation, retailing, entertainment and restaurants, with world best practice surf beach management systems protecting, enhancing and presenting this key attribute of the destination.*

5.2 Beach Management

Gold Coast City Council is the authority that currently deals with the day-to-day management of the littoral system. Table 1 outlines some of the costs involved in this management during 2004-05.
Table 1. Some Beach Management costs in 2004/05

<table>
<thead>
<tr>
<th>GCCC Activity</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Coastal Protection Works</td>
<td>$3.63M</td>
</tr>
<tr>
<td>Beach Maintenance</td>
<td>$1.73M</td>
</tr>
<tr>
<td>Capital Works (primarily beach access projects)</td>
<td>$2.49M</td>
</tr>
<tr>
<td>Lifeguard Service</td>
<td>$4.20M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$12.05M</strong></td>
</tr>
</tbody>
</table>

Coastal projects undertaken by Council include major works such as the Palm Beach Protection Strategy, Tweed River Entrance Sand Bypassing Project and the Northern Gold Coast Beach Protection Strategy. Regular dredging and sand bypassing occurs at Tallebudgera and Currumbin Creeks. Major foreshore redevelopment projects providing access to and along the beach have occurred as part of the Gold Coast Oceanway project. Ongoing maintenance projects include, renewal of beach fencing, beach cleaning, and boardwalk and beach shower maintenance. Council also has a very strong commitment to providing safe, enjoyable beaches through the provision of a professional lifeguard service.

6 PROBLEMS

6.1 Beaches: The forgotten environment

“The beaches are a focal point for local residents of the City for the purposes of swimming, surfing, fishing and various other recreational activities. The beaches also provide an attraction and coastal recreational area for many tourists that visit the Gold Coast.” (GCCC, 2002)

A review of recent State of the Environment reporting across Australia has shown a lack of consideration of the beach as an environment. The 2002 Health of the Waterways report for the Gold Coast investigates the physico-chemical water quality indicators on the beaches. It does not look into other important environmental factors such as the volume of sand available to act as a buffer zone during stormy periods or the biological environment in the water and the sand.

Section 5.4 of this report (GCCC, 2002) talks about recommendations for managing Gold Coast Waterways and supports the need for the following activities (see Table 2 below). It should be noted that the recommendations in the left hand column come from the report. The author of this discussion paper has interpreted the relevance to the littoral environment in the right hand column.

Table 2. Recommendations for improving beach health.

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Relevance to Littoral environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment monitoring</td>
<td>Continue hydrographic surveys and increase number of parameters investigated</td>
</tr>
<tr>
<td>Biological monitoring</td>
<td>Undertake a large scale investigation into the biological littoral environment</td>
</tr>
<tr>
<td>Vegetation Surveys</td>
<td>Continue and expand dune vegetation assessments and restoration programs</td>
</tr>
<tr>
<td>Environmental Education Programs</td>
<td>Support and expand the CoastEd and BeachCare programs.</td>
</tr>
<tr>
<td>Environmental Values and</td>
<td>Develop a littoral environment catchment plan</td>
</tr>
</tbody>
</table>
Catchment studies and determine the environmental values that people wish to protect - integrating the coast with integrated catchment management.

The 2003 Queensland State of the Environment report (EPA, 2003) includes a substantial chapter on the coastal zone but with little reference to sandy beach environments. Examples are given about the impact of tourism on the Great Barrier Reef. Using the figures in the Qld SoER it is apparent that the Gold Coast received the same number of tourists in 2002 as the area of coast from Mackay to the Northern Territory border.

Table 6.26 of this report states that around 52% of the Queensland coastline is comprised of sand and 82% is comprised of sand or other mixed fines. As such a high percentage of the coast is made up of movable sediments it is surprising that there is not a stronger focus on the littoral environment. Information regarding the biota in this soft-bottomed habitat is available in the report for the Great Barrier Reef but not for other environments. There appears to be a need for further research in this area on the Gold Coast.

It is acknowledged that the report includes a section on coastal variability with a case study on the Tweed River Entrance Sand Bypassing Project. This section highlights the need to continue to be involved in managing the Gold Coast littoral environment. The largest wave heights listed in this section occurred in South East Queensland due to Tropical Cyclone Roger (Hmax = 13.1m). The number of cyclone crossings may be smaller in this region but the impact is likely to be more severe due to the much higher levels of development.

Other states also have reports on the beach environment that focus on issues such as water quality and littering (Vic EPA, 2003; DEC, 2004). While these reports are a step forward there appears to be a gap in the SoE reporting process. The beach should be treated as a holistic littoral environment.

### 6.2 Where do beaches fit?

Reviewing these reports has highlighted the question - *where do beaches fit into the scheme of natural resource management?* Is it more appropriate in South East Queensland to consider beaches as part of the urban environment?

The Draft South East Queensland Regional Plan (OUM, 2004) includes a principle for protecting the coast and waterways. The strategies listed below directly relate to and give urgency to the need for a littoral review.

**S1.7 – Future Urban, tourism and other economic development along the coast is consolidated within existing urban areas.**

This means that there will be increasing pressure on the littoral environment to support tourism industry and the lifestyle of Gold Coast residents.

**S1.8 – Land use planning, development assessment and management practices address potential impacts of natural hazards including flooding, storm tides and the climate change impacts of sea level rise**

This highlights the need for ongoing coastal protection works to prepare for and minimise the impacts of extreme events and sea level rise.
S1.9 – Planning design, construction and operation of infrastructure located within the coastal zone maintains geophysical and ecological functions.

To be able to maintain these functions, decision makers must have access to current and accurate information. Improvements are needed not only in the basic science but also in the decision support systems.

This draft plan provides strong support for a review of the littoral environment as described in this discussion paper.

6.3 Public Perceptions

Recent coastal protection works such as Palm Beach Protection Strategy (PBPS) and the Tweed River Entrance Sand Bypassing Project have highlighted a lack of understanding and acceptance of coastal works within the community. Concerns from the public include changed beach profiles, beach widths, surfing conditions and impacts on natural reef systems.

It has been shown through the consultation process of the PBPS that there is a lack of understanding of coastal processes and sediment transport in particular. This highlights the need to undertake a major community engagement process in conjunction with the littoral review. It is essential that the proposed options for managing our beach environment are socially acceptable as well as technically sound.

The larger aim of this engagement project should be to determine the environmental values that people currently attribute to the beach and determine what level of protection and management is needed.

**FUTURE OF COASTAL PROTECTION ON THE GOLD COAST**

Many traditional and innovative beach protection projects have been undertaken on the Gold Coast using the information and recommendations included in the Delft reports (Boak et al, 2001). As these recommendations are now close to being fully implemented it would appear to be an appropriate time to reflect on how the Coast has been managed.

- Are more coastal works needed?
- If so, what type of works and why?

7 COORDINATED APPROACH

How can the beaches be managed more effectively? The Coastal CRC has some good advice (Coastal CRC, 2004). The operating philosophy for managing coastal areas presented by the CRC contains the key elements listed below.

- Citizen Science – Community engagement
- Adaptive Management – A realistic approach to complex problems
- Decision frameworks
If these elements were to be adopted in relation to the management of the Gold Coast littoral environment, the managing authority would need to consider a number of themes.

There are many entities involved in managing the beaches on the Gold Coast including local government, state agencies (eg EPA, DPI&F NR&M), federally funded programs (eg NRM and Coastcare), research organisations (eg GCCM) and community groups. Each has different roles and responsibilities and the need for a co-ordinating body to act as the managing authority is apparent.

It is considered appropriate that the managing authority for the Gold Coast littoral environment be Gold Coast City Council. Currently the Council has a high level of coastal expertise within its various directorates and branches.

For the beaches to be managed in a sustainable manner there is a need to focus on the following coastal related topics and for co-ordination to take place across all these activity centres.
**Operations**
- Capital Works
- Maintenance
- Encroachment
- Clean Beaches
- Easy access
- Facilities such as showers, toilets, changing rooms

**Planning and Stakeholder Engagement**
- Community engagement
- Shared Vision
- Agreed objectives and environmental values
- Action plans to reach goals
- Involvement in regional planning
- Involvement in development assessment
- Educational programs
- Advocacy for Beaches
- Development of a marketing campaign for our beaches (eg Healthy Waterways: We’re all in the same boat; Our Great Barrier Reef: Let’s keep it great.)

**Coastal Knowledge and Research**
- Social Research
- Continuation and expansion of data collection
- Technical investigations

**Lifeguards and Beach Events**
- Lifeguard service
- Liaison with events such as schoolies, weddings, markets etc

**Agencies**
- Gold Coast City Council
- State govt eg EPA/DPI/NR&M
- Commonwealth govt eg NRM SEQ, Coastcare
- Community groups eg SLSC’s, volunteers, Surfrider

To keep these various groups on track and working towards the same goal it would be useful to have two reference groups for beach management. These would consist of a Technical Reference Group to guide the research, planning and works and a Community Reference Group, to improve communications and community ownership. The membership for these committees is suggested in Table 3 below

**Table 3. Suggested reference group membership.**

<table>
<thead>
<tr>
<th>Technical Reference Group</th>
<th>Community Reference Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach Management Coordinator</td>
<td>Beach Management Coordinator</td>
</tr>
<tr>
<td>Director Griffith Centre for Coastal Management</td>
<td>Councillor</td>
</tr>
<tr>
<td>Coastal CRC</td>
<td>Environment</td>
</tr>
<tr>
<td>Manager Beaches and Watercycle Infrastructure</td>
<td>Ratepayers</td>
</tr>
<tr>
<td>Engineer Coastal Management</td>
<td>Recreational Fishers</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>Commercial Fishers</td>
</tr>
<tr>
<td>Department of Primary Industries and Fisheries</td>
<td>Chamber of Commerce</td>
</tr>
<tr>
<td>Natural Resource Management SEQ</td>
<td>SLSC</td>
</tr>
<tr>
<td></td>
<td>Surfing</td>
</tr>
</tbody>
</table>

A diagram to explain the links between these different entities is included below (Figure 2).
Littoral Review Discussion Paper

2

Figure 2. Representation of the Gold Coast beach management system

8 TECHNICAL LITTORAL REVIEW

Littoral Review – what tasks need to be done to gain a better understanding of the littoral environment on the Gold Coast?

In summary the Gold Coast littoral environment can be described as a high-energy open coast. Large amounts of sediment are transported along the shore with a net annual transport rate of 500,000 m$^3$. In the 50-year planning period this system is basically in equilibrium with the major impact coming from the cross-shore movement of sand during large events such as cyclone.

Large amounts of development have occurred on the sand dunes of the Gold Coast, which limits the beach’s ability to cope with natural storm erosion events. Active involvement in managing the beach system is required. However, the community has begun to question the current activities undertaken to manage the beach and a review of the current approach is needed.

Elements of the littoral review should include:
Data Collection Plan

- Natural physical coastal processes
- Biological coastal processes
- Improved knowledge of fauna and flora

Examine the concept of littoral recycling at the Gold Coast Seaway
Examine the potential impact of TRESBP sand will have on amenity
Examine the way coastal littoral sand interacts with Tallebudgera and Currumbin entrances
Examine potential future need and sources of littoral nourishment materials
Consideration of the removal of groynes from beaches throughout the city
Investigate the impacts of sea level rise and options to manage these impacts
Investigate future beach protection works
Investigate options for increasing the speed of boulder wall construction
Investigate the state of the biodiversity in the littoral zone
Investigate the best methods of dune vegetation protection and enhancement
Improve community engagement processes
Inform the counter disaster planning process
Establish socio-economic value of the beach – What is the total value of the beach to the community?
Develop Environmental Values that the public agrees are important
Develop conceptual models of sediment budgets, entrance interactions, and storm events
Develop a littoral environment catchment plan
Develop a littoral decision support system
Develop and commence of a system to document the littoral health of individual Gold Coast Beaches on a biannual basis

Some issues specific to the Palm Beach Community have been raised as part of the Palm Beach Protection Strategy community engagement process. The following issues have relevance for the whole of the Gold Coast and should also be included in the review.

- Whether a reef should form part of a future beach protection strategy for Palm Beach
- Increased environmental surveys (biological and hydrographic) of Palm Beach environments
- Vegetation protection strategies for Palm Beach
- Coastal access opportunities to Palm Beach
- Dredging programs for Tallebudgera and Currumbin Creeks

The first steps in such a review would include:

- Collate all current data collected
- Undertake a gap analysis.
- Determine which data is most appropriate and create a data collection plan
- Develop a web based data service for use by everyone
Table 4. Data collection required for responsible and sustainable beach management.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Agency Currently collecting data</th>
<th>Annual cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorology</td>
<td>BoM</td>
<td>?</td>
</tr>
<tr>
<td>Wave Data</td>
<td>EPA/GCCC</td>
<td></td>
</tr>
<tr>
<td>Hydrographic surveys</td>
<td>GCCC/TRESBP</td>
<td></td>
</tr>
<tr>
<td>Sediment characteristics</td>
<td>GCCC</td>
<td>?</td>
</tr>
<tr>
<td>ARGUS images</td>
<td>GCCC/TRESBP</td>
<td>$120,000 + (excluding TRESBP costs)</td>
</tr>
<tr>
<td>Aerial Photos</td>
<td>EPA/GCCC</td>
<td></td>
</tr>
<tr>
<td>Satellite Images</td>
<td>GCCC/?</td>
<td></td>
</tr>
<tr>
<td>GIS</td>
<td>GCCC</td>
<td></td>
</tr>
<tr>
<td>Beach use statistics</td>
<td>GCCC</td>
<td></td>
</tr>
<tr>
<td>Water temperatures</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Water quality</td>
<td>EPA/GCCC</td>
<td></td>
</tr>
<tr>
<td>Biological indicators of Water quality</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Reef ecology</td>
<td>GCCC/TRESBP</td>
<td></td>
</tr>
<tr>
<td>Benthic community data</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Pelagic community data</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Currents</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Tides</td>
<td>EPA/QT</td>
<td>?</td>
</tr>
<tr>
<td>Socio-economic data</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>

9 RESOURCES

What resources are needed and who should pay?
- For undertaking the review
- For proper management of the littoral environment

10 FEEDBACK

This discussion paper is designed to generate interest in the littoral environment and to put beaches back onto the agenda. Any support or help which can be offered will be greatly appreciated. It is important that information and ideas be obtained from as many different sources as possible to ensure that all relevant factors are considered.

Appendix 4 is a ‘Comment Form’ to help guide your feedback. Comments on this paper should be received by 31 January 2005.

Once the feedback has been analysed a series of workshops will be organised to determine the best way to move forward with a review of the littoral environment on the Gold Coast. At this stage it is anticipated that a partnership will be formed that will guide, direct and undertake a 3-year program to review the Gold Coast littoral environment.
Please send and comments regarding this paper to:

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g.donovan@griffith.edu.au
REFERENCES


DHL, 1992. Complete reference


APPENDIX 1

Ecologically Sustainable Development


In 1990 the Commonwealth Government suggested the following definition for ESD in Australia:

‘Using, conserving and enhancing the community’s resources so the ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.’

The Goal is:

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.

The Core Objectives are:

- To enhance individual and community well being and welfare by following a path of economic development that safeguards the welfare of future generations
- To provide for equity within and between generations
- To protect biological diversity and maintain essential ecological processes and life-support systems

The Guiding Principles are:

- Decision making processes should effectively integrate both long and short term economic, environmental, social and equity considerations
- Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- The global dimension of environmental impacts of actions and policies should be recognised and considered
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised
- The need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms
- Decisions and actions should provide for broad community involvement on issues which affect them

These guiding principles and core objectives need to be considered as a package. No objective or principle should predominate over the others. A balanced approach is required that takes into account all these objectives and principles to pursue the goal of ESD.
APPENDIX 2

Integrated Coastal Management

The elements of Integrated Coastal Management in the table below have been extracted from the following source.

Harvey, N. and Caton, B. 2003, Coastal Management in Australia, Oxford University Press.

This appendix gives some guidance as to how a review of the Gold Coast Littoral review will contribute to Integrated Coastal Management.

<table>
<thead>
<tr>
<th>Elements of ICM</th>
<th>Effect of Littoral Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term goal</td>
<td>Develop a vision for Gold Coast beaches and determine the values of this environment that the community care about</td>
</tr>
<tr>
<td>National Objectives/local plans</td>
<td>Better information for regional, state and national state of the environment reporting. The outcomes of this review will feed into the regional coastal management plan process.</td>
</tr>
<tr>
<td>Principles for Decision Making</td>
<td>Apart from defining the values of the littoral environment, the review will develop a decision making tool for coastal managers.</td>
</tr>
<tr>
<td>Policy agreement across agencies (horizontal integration)</td>
<td>Involvement of key stakeholders in the technical reference group and the development of the review.</td>
</tr>
<tr>
<td>Authority and Accountability</td>
<td>Clear lines of responsibility in the management of the littoral environment.</td>
</tr>
<tr>
<td>Use of performance indicators</td>
<td>Development of beach health indicators.</td>
</tr>
<tr>
<td>Commitment to implementation</td>
<td>Each level of government will provide resources to improve the management of the littoral environment on the Gold Coast.</td>
</tr>
<tr>
<td>Vertical integration between levels of government</td>
<td>Clear roles for each tier of government. New Beach Management Coordinator will improve communication.</td>
</tr>
<tr>
<td>Lead Agency</td>
<td>Gold Coast City Council is seen as the authority responsible for day to day management of the beach.</td>
</tr>
</tbody>
</table>
APPENDIX 3

Tourism Statistics for the Gold Coast


Statistics relating to tourism on the Gold Coast encompass the "Gold Coast tourism region." Under the jurisdiction of both the Gold Coast City Council and the Beaudesert Shire Council, the Gold Coast tourism region is bounded by the NSW - Qld state border, the East coast of Australia and the Brisbane tourism region.

On average, the Gold Coast tourism region hosts over 75,000 visitors everyday. This figure includes international, domestic overnight and daytrip visitors. With the resident population of the Gold Coast currently standing at 438,473 persons and the current resident population of Beaudesert standing at 55,612 (ABS, 2003), visitors will represent approximately 16% of all people in the Gold Coast tourism region on any given day. The average visitor population is roughly equivalent to the combined populations of the city’s four largest suburbs (Southport, Guanaba-Currumbin Valley, Nerang and Ashmore). If you were to consider tourists as a single population, they represent more than three times the current residential population of Southport, the City’s largest suburb.

The table below displays the most up-to-date visitor statistics for the Gold Coast region. The information has been obtained from the Bureau of Tourism Research’s National Visitor Survey (NVS) and the International Visitor Survey (IVS). More detailed information is available on the Tourism Branch’s Research and Statistics page.

<table>
<thead>
<tr>
<th>Gold Coast Visitor Numbers - (2003/04)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor Numbers (All overnight &amp; Daytrip visitors)</td>
</tr>
<tr>
<td>Visitor Numbers (Overnight visitors only)</td>
</tr>
<tr>
<td>Visitor Nights</td>
</tr>
<tr>
<td>Average Length of Stay (Overnight visitors only)</td>
</tr>
<tr>
<td>Number of visitors the Gold Coast hosts each day</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>International Visitors to the Gold Coast - (2003/04)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor Numbers</td>
</tr>
<tr>
<td>Visitor Nights</td>
</tr>
<tr>
<td>Average Length of Stay</td>
</tr>
<tr>
<td>Purpose of Travel (% of Visitor Numbers)</td>
</tr>
<tr>
<td>Holiday/Leisure</td>
</tr>
<tr>
<td>Visiting Friends &amp; Relatives</td>
</tr>
<tr>
<td>Business/Conference</td>
</tr>
</tbody>
</table>
### Domestic Overnight Visitors to the Gold Coast - (2003/04)

<table>
<thead>
<tr>
<th>Visitor Numbers</th>
<th>3 532 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Interstate</td>
<td>1 805 000</td>
</tr>
<tr>
<td>- Intrastate</td>
<td>1 727 000</td>
</tr>
<tr>
<td>- Brisbane</td>
<td>1 096 000</td>
</tr>
<tr>
<td>Visitor Nights</td>
<td>16 148 000</td>
</tr>
<tr>
<td>Average Length of Stay</td>
<td>4.6 Nights</td>
</tr>
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</table>

#### Purpose of Travel (% of Visitor Numbers)

<table>
<thead>
<tr>
<th>Purpose of Travel</th>
<th>% of Visitor Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holiday/Leisure</td>
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</tr>
<tr>
<td>Visiting Friends &amp; Relatives</td>
<td>28.5%</td>
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<tr>
<td>Business/Conference</td>
<td>9.1%</td>
</tr>
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### Daytrip Visitors to the Gold Coast - (2003/04)

<table>
<thead>
<tr>
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<th>6 322 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Interstate</td>
<td>585 000</td>
</tr>
<tr>
<td>- Intrastate</td>
<td>5 737 000</td>
</tr>
<tr>
<td>- Brisbane</td>
<td>4 382 000</td>
</tr>
</tbody>
</table>

#### Purpose of Travel (% of Visitor Numbers)

<table>
<thead>
<tr>
<th>Purpose of Travel</th>
<th>% of Visitor Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holiday/Leisure</td>
<td>65.0%</td>
</tr>
<tr>
<td>Visiting Friends &amp; Relatives</td>
<td>25.5%</td>
</tr>
<tr>
<td>Business/Conference</td>
<td>5.3%</td>
</tr>
</tbody>
</table>
APPENDIX 4

LITTORAL REVIEW DISCUSSION PAPER - FEEDBACK FORM

Q1  Do you agree there is a need for a review of the Gold Coast littoral environment? (Please tick)

Yes ☐
No ☐

Q2 Do you collect or know of anyone who collects coastal data on the Gold Coast? See table 3 on page 7. (Please tick)

Yes ☐
No ☐

If yes, please provide details below.

........................................................................................................................................................................
........................................................................................................................................................................

Q3 Are you prepared to provide that data to the Gold Coast community? (Please tick)

Yes ☐
No ☐

Q4 Do you know of any other data that should be collected that has been left out of Table 3? (Please tick)

Yes ☐
No ☐

If yes, please provide details below.

........................................................................................................................................................................
........................................................................................................................................................................

Q5 Do you agree with the Questions listed as part of the Littoral Review? See page 7. (Please tick)

Yes ☐
No ☐

Q6 Do you know of any other topics that should be included? (Please tick)

Yes ☐
No ☐
If yes, please provide details below.

Q7  Is your organisation currently involved with Gold Coast beaches? (Please tick)

Yes ☐
No ☐

Q8  Would you like to be involved with Gold Coast Beaches? (Please tick)

Yes ☐
No ☐

Q9  Are you interested in being part of a review of the Gold Coast littoral environment? (Please tick)

Yes ☐
No ☐

Q10 If you answered yes to Q9 in what capacity would like to be involved?

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Yes</th>
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</tr>
</thead>
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<tr>
<td>Attend Workshops</td>
<td>☐</td>
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</tr>
<tr>
<td>Review documents</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Undertake research</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Please provide details:

Thank you for taking the time to provide us with your feedback. Please provide your contact details if you would like us to follow up on your comments.

Name: ...................................................................................................................
Organisation: ...........................................................................................................
Role: .......................................................................................................................
Address: ................................................................................................................
Ph: ....................................................................................................................... 
Fax: ....................................................................................................................... 
Email: ....................................................................................................................
Northern Gold Coast Beach Protection Strategy

Environmental Monitoring Program

Baseline Data Assessment Volume 5: Summary of Narrowneck Reef Monitoring to May 2007

Griffith Centre for Coastal Management
Research Report No 63
June 2007

Prepared by:
Rodger Tomlinson
Angus Jackson and Bobbie Corbett
International Coastal Management

In partnership with

Griffith University
**Synopsis:**
This report provides a detailed assessment of the data obtained from routine monitoring of the Narrowneck Reef at Main Beach on the Gold Coast Australia. The report covers reef performance in terms of beach width, stability, durability marine ecology and surfing.

**Keywords:** Beaches, artificial reef, Gold Coast, marine ecology, surfing, geotextile
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1.0 BACKGROUND

The Gold Coast is a dynamic coastal environment where beaches experience high wave energy and a net northerly sand transport rate of ~500,000 m³/yr. The average wave height ($H_s$) is about 1.0m, with recorded storm waves ($H_m$) reaching over 13m. Tides are semi-diurnal with tide heights over 2m above LAT as follows (Qld. Transport tide tables – 2007):

- HAT 2.09m
- MHWS 1.63m
- MLWS 0.31m

In 1974 following an extended period of severe erosion, mainly due to cyclones in the 1950 and 60’s, the Northern Gold Coast beaches were nourished with about 1.5M m³ of sand. These works formed part of the implementation of the recommendations of the 1970 “Delft Report”. The artificially widened beach gradually narrowed, as was expected. Completion of the Nerang River training walls in 1985 (also part of the “Delft” recommendations) acted as a terminal groyne for the northern Gold Coast beaches, progressively realigning and widening the Spit. However, further southward (updrift) the beaches at Main Beach and Surfers Paradise continued to gradually narrow, and storms, such as cyclone Nancy in 1990, cut into the narrow dunes and exposed the boulder wall at Narrowneck. By the mid 1990’s, the boulder wall at Narrowneck was exposed to wave attack, with a no high tide beach on at least a yearly basis (Figure 1).

![Figure 1: Narrowneck looking southward to Surfers Paradise 1996](image)

As the wall juts some 20m seaward of the general boulder wall alignment, the adjacent beaches and dunes at Surfers Paradise and Main Beach were very narrow during such events. The increasing occurrences of beach erosion caused dangerous conditions for beach users accessing and using them, which in turn led to a negative impact on the city’s tourist image and economy. As a result, GCCC’s Coastal Engineers looked at ways to restore the northern Gold Coast beaches. A conceptual solution was proposed by GCCC (Jackson & McGrath, 1995):
“Beach widening to provide additional open space and an increased storm buffer is desirable for the Surfers Paradise area. Various schemes have been investigated. The preferred option is nourishment of the beach and dunal areas, stabilised by a low profile headland at Narrowneck (1.75km to the north of central Surfers Paradise). The headland is to be designed to enhance surfing conditions, be visually unobtrusive and cause no adverse impacts for the beaches to its north.”

To evaluate the state of the art, with respect to being able to incorporate surfing, consultants, AWACS, were commissioned by GCCC to do a comprehensive literature review (AWACS, 1996).

Following storm erosion in May 1996, GCCC resolved that consultants be commissioned to determine a sustainable long term strategy for the protection and improvement of northern Gold Coast beaches from Burleigh Heads to South Stradbroke Island, and to widen the beaches and dunes in the Surfers Paradise area by 30-50m initially as a high priority to accommodate storm erosion and improve the recreational amenity. The primary objective of this strategy was to widen the beach and dunes in the Surfers Paradise area to provide an increased storm buffer and additional open space. As it was considered likely that the works would involve construction of a control structure at Narrowneck, a secondary objective was to improve the surfing conditions at this popular location.

The preliminary concept plan developed by GCCC’s Coastal Engineers outlined the components of the strategy to be investigated.

### 1.1 NGCBPS Scheme of Works

International Coastal Management (ICM) was commissioned by Gold Coast City Council (GCCC) in October 1996 to act as Project Managers for the Northern Gold Coast Beach Protection Strategy (NGCBPS). The extensive study consisted of three stages:-

- **Stage One** - Data collection, determination of coastal processes, review of options, recommended strategy and preparation of an initial report with a Master Plan and Implementation Report (ICM, 1997)
- **Stage Two** - Impact Assessment and Design studies
- **Stage Three** – Preparation of construction specifications suitable for the tender documentation and final report in August 1998 (ICM, 1998)

The local coastal processes are complex and have been affected by significant coastal works. The assessment of coastal processes indicated that (Jackson, McGrath & Tomlinson, 1997):-

- The average long-shore transport in the study area is ~500,000m³/yr.
- As a result of the Seaway walls which act as a control point, ~1Mm³ has accreted on the Spit and the accretion is extending southward.
- ~4Mm³ of accretion occurred on the southern end of South Stradbroke Island between 1985 and 1992, but ~0.5Mm³ of erosion has occurred since 1992.
- ~2Mm³ has accreted on the ebb delta.
Back-passing directly from the bypassing pumps may not be a viable short term option if the erosion of South Stradbroke Island is a long term trend.

Beach widening of 30-50m will provide at least a 1 in 50 yr storm buffer.

For the Gold Coast wave climate surfing conditions (quality of ride and total surfable hrs/yr) can be improved by artificial reefs.

Sea level rise is a threat but can be compensated for by the addition of $6m^3/m/yr$. More than this quantity is presently being supplied at no cost to Council from developments within 500m of the seawall.

In light of these findings, a large number of conventional and non-conventional options were considered:-

- beach nourishment
- continuous beach feeding – back-passing
- artificial spit
- beach-face dewatering (& nourishment)
- groynes (& nourishment)
- artificial headland (& nourishment)
- offshore breakwater (& nourishment)
- artificial reef (& nourishment )
- artificial seaweed (& nourishment)

After reviewing all options, an integrated coastal management strategy was recommended (ICM, 1997). This proposed strategy was based on an “IENCE” (Infrastructure to Enhance the Natural Capacity of the Environment) type philosophy (Boak, McGrath & Jackson, 2000) and included the following key elements (Jackson, McGrath & Tomlinson, 1997):-

**Long Term**

1. **Widen and maintain all northern Gold Coast beaches (Burleigh Heads to The Seaway)** to a standard capable of withstanding at least a 1 in 50 year storm and sea level rise without exposing the seawall.

2. **Provide additional (soft/hard) control points and sand at suitable locations between Narrowneck and South Nobby (e.g. Kurrawa)** to widen the beaches, improve surfing conditions and allow sea level rise impacts to be mitigated.

3. **Complete construction of a continuous seawall** to the design standards to protect private and public beachfront assets.

**Short Term**

1. **Nourishment;** a minimum of $1.5Mm^3$ to be pumped from various sources to widen Surfers Paradise beach by 30-50m. Regular ongoing nourishment of at least $60,000m^3/yr$ is necessary to manage potential down-drift impacts. This quantity can at present be provided from maintenance dredging in the Broadwater and sand excavations from building sites. Back-passing from the Seaway bypass system is another potential source.

2. **Coastal Control Point;** the control point is to be an artificial reef designed to stabilize the nourishment and provide better and more consistent surfing conditions. The reef should be constructed of large sand bags to minimize the hazard to surfers and reduce construction impacts.
3. **Pipeline/Boosters;** a permanent buried pipeline is required from the Spit to Narrowneck to facilitate regular nourishment to the control structure to improve the beaches down-drift.

4. **Management Policies;** ongoing nourishment is required and operational procedures will need to be developed. Present policies should be continued to ensure completion of an adequate and continuous seawall and continued supply of additional sand from building sites to the beaches."

The strategy was summarized as per Figure 2.

Because of the nature of the site and the complexity of the integrated coastal management strategy which was to be “world best practice”, widespread expertise was used in the investigations and design. As part of the approval and detailed design stage, nine study briefs were prepared and carried out by specialist consultants, co-ordinated by the project consultants [ICM] with input from GCCC – there was a strong interaction and cross-flow of ideas, data and findings. The studies were as follows:-

### Table 1: Summary of studies undertaken during the detailed design stage

<table>
<thead>
<tr>
<th>GCCC Contract</th>
<th>Description</th>
<th>CONSULTANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>171/98/008Q</td>
<td>Physical Modelling –wave breaking characteristics and forces at reef</td>
<td>WRL [Unisearch – Uni of NSW]</td>
</tr>
<tr>
<td>171/98/009Q</td>
<td>Numerical Modelling –wave breaking characteristics &amp; sediment transport at reef</td>
<td>Uni of Waikato</td>
</tr>
<tr>
<td>171/98/010Q</td>
<td>Numerical Modelling – sediment movement and budget at Seaway</td>
<td>WRL / Griffith Uni</td>
</tr>
<tr>
<td>171/98/011Q</td>
<td>Numerical Modelling –estuarine hydrodynamics and sediment dynamics</td>
<td>WBM</td>
</tr>
<tr>
<td>171/98/012Q</td>
<td>Numerical Modelling –nourishment profiles/quantities and erosion due to storm &amp; sea level rise</td>
<td>WRL</td>
</tr>
<tr>
<td>171/98/013Q</td>
<td>Assessments of impacts of dredging &amp; nourishment on water quality and marine ecology in the Broadwater &amp; Narrowneck</td>
<td>Griffith Uni</td>
</tr>
<tr>
<td>171/98/018Q</td>
<td>Public information / Consultation Strategy</td>
<td>John Campbell Information and Marketing</td>
</tr>
<tr>
<td>171/98/019Q</td>
<td>Economic &amp; Social Impacts due to Changes in beach Amenity</td>
<td>GCCC / Griffith Uni</td>
</tr>
<tr>
<td>171/98/020Q</td>
<td>Land Tenure Investigations</td>
<td>Michel Survey Group</td>
</tr>
</tbody>
</table>

**UNIVERSITY/ STUDENT REPORTS**

Geotextile container design and behaviour

Griffith Uni
Figure 2: Scheme of Works
1.2 Design

1.2.1 Beach Nourishment

WRL (1998a) and GU carried out storm cut modeling using SBEACH and UNIBEST TC to confirm that a 30m widening would “provide protection for a single storm event of greater severity than 100yr ARI and adequate buffer for multiple storm events of similar severity to those of 1967”. To achieve the necessary 30m minimum beach widening, the volume of sand required was calculated to be 1.3Mm$^3$, slightly lower than the preliminary estimate. This was still a large volume however potential sources of sand were identified by ICM for the beach nourishment – offshore and within the Broadwater estuary. The preferred sand source involved cooperation between GCCC and Queensland Transport to extract dredged sand whilst widening and deepening the existing navigation channels in the Broadwater. With joint funding, this was the best option with the highest cost-benefit ratio. WBM (1998) undertook hydrodynamic modeling and impact assessment of these potential dredging works. No adverse impacts were predicted for dredging from the Broadwater and the Marine Stadium area.

The sustainability of the strategy relies on ongoing nourishment (ICM, 1998):

“Following the initial nourishment, to compensate for erosion due to sea level rise and ongoing accretion of the beaches to the south (updrift) of the coastal control structure, ongoing nourishment will be required. The predicted ongoing nourishment quantity will reduce progressively from approx. 80,000m$^3$/yr to approx 20,000 m$^3$/yr after about 10 years. Ongoing monitoring will enable the actual required quantities which are likely to be less to be determined.

After erosion events, natural recovery should be augmented with nourishment to restore the beaches as quickly as possible, not only to minimise the impact on beach users, but to reduce the risk due to multiple events. This strategy will help to reduce the significant adverse effects on tourist revenues identified in the impact assessment report by Griffith University on economic impacts. Two available suitable sources of nourishment were identified in the studies:

- sand from building excavations
- sand from channel maintenance and improvement dredging in the Broadwater by the Department of Transport.

From present trends, Option 1 is likely to provide in excess of the required quantities in the near future. As the initial nourishment will improve the channels south of Wave Break Is, little maintenance dredging by the Department of Transport is likely for several years. However, silting of the flood tide delta will continue and will necessitate maintenance dredging within a few years.

The proposed semi-permanent pipeline will facilitate pumping of sand dredged from the Broadwater and the bypassing system (back-passing) when sand is pumped from other sources to the southern end of South Stradbroke Is.”

1.2.2 Reef Control Point

The design criteria for the reef were (ICM, 1998):

- to act as a coastal control point to stabilise the nourished beaches to the south
- after the initial nourishment of 1.3Mm$^3$ the maximum annual trapping capacity be 100,000m$^3$/yr as this quantity of suitable sand can be provided from outside the active system
- the reef be shaped to provide improved surfing conditions
- the reef be constructed so as not to be hazardous to surfers

To ensure that these objectives were achieved, numerical and physical modelling was carried out.

Genesis modeling by WRL and GU confirmed that the seaway works were effectively realigning and widening the beaches back from the Seaway to about Narrowneck. This confirmed Narrowneck as a good location for the next control point. 2D numerical modeling using Genesis was also carried out to evaluate the beach widening that would be associated with various selected wave transmissions. This modeling indicated that only an average 30% reduction in the wave height (70% wave transmission) transmitted across the reef was required to move the average beach line 50m seaward and would trap ~100,000m³/yr initially in the vicinity of the reef.

The inclusion of “improved surfing” as a secondary design criterion increased the complexity and introduced an added community expectation and media focus on surfing amenity. The development of the reef shape and modelling of potential impacts was undertaken the University of Waikato, NZ (UW) using a number of 2D and quasi-3D numerical models (GENIUS, 3DD & POL 3DD). The models were calibrated using measurements taken in the surf zone (UW, 1998a) and run using idealized continuous crested monochromatic waves and a simplified bathymetry (flat pre-nourishment profile without the troughs and bars) to help ascertain the effectiveness and impacts of the reef. To achieve the surfing aims, the reef started as a “conventional” V shape. This shape caused high seaward velocities over the crest of the reef and this was considered an unacceptable safety issue by ICM who recommended a split V to reduce velocities and provide a longer shore parallel footprint for beach protection. A shoreward extension of the north arm was also requested to improve the submerged groyne effect. The final shape (UW, 1998a) was relatively complex (Figure 3). UW recommended a crest level of -1.0m AHD (approximately low tide level) and a large focusing area with a very smooth slope to increase wave height at the break point (UW, 1998b). Even with the split shape, the model results indicated that setup and currents in the vicinity of the reef remained significant with the shallow crest at low tide. For this shape, with the shallow crest height, a wide salient of 78m was predicted (UW, 1998c).

![Figure 3: Recommended Reef Levels – University of Waikato](image)

Physical modeling (basin and flume) was undertaken by WRL (1998b&c) with monochromatic waves and the results of this testing generally confirmed the numerical modeling for salient size, sediment transport and wave breaking.
The reef design and construction involved the development of innovative ideas. After detailed review of all of the modelling and impact assessment studies, for safety reasons and to avoid excessive sand retention, ICM / GCCC adopted a crest height of RL-1.5m AHD (-0.5m LAT) for the initial construction contract – it was considered preferable to construct, monitor and, if then required, to raise the crest in stages to minimise risk and exposure to litigation from surfers and boat users.

Constructability within the project budget was a key issue. Engineering construction drawings were prepared by ICM for approval and construction. Approvals were based on the final shape modelled by UW parameters including a very shallow crest, but this was considered as an envelope within which the reef could be constructed and maintained. The modified design was “replicated” using 408 very large sand filled geotextile “bags” that were 20m in length and ranged from 3 to 4.5m in diameter (See Section 1.3.2). For cost effectiveness, the nominated slopes were slightly truncated and more realistic slope tolerances were adopted. (Experience and modelling could not justify the +/- 300mm target for all sections of the reef nominated by UW).

The use of “sandbags” was strongly instrumental in gaining approvals, and the Queensland Government approval agencies showed, and are still showing, a strong preference where practical for structures that can be modified or even removed as necessary.

1.3 Construction

1.3.1 Beach Nourishment

Large-scale beach nourishment has been used widely on the Gold Coast since the mid-1970’s, and implementation of the $6.0M sand pumping contract was relatively easy using conventional equipment and techniques utilizing local dredging contractors, Neumann Contracting. The balance of the 1.1Mm³ of sand required was obtained from excavations for new buildings within 500m of the beach at no cost to Council as part of Council’s standard building requirements. Nourishment was commenced in February 1999 and completed in June 2000.

The improved navigation channels have provided increased amenity and safety for the recreational and commercial boat operators, although maintenance dredging is still required periodically in some areas. Accessibility to the marinas at Main Beach for private superyachts, large commercial whale watching vessels and private racing yachts (some now maxis) in organized races from Sydney etc. contributes greatly to the local economy – this data has not been collected and analyzed to date, but this could be done as a student project. The marine stadium is now a good deepwater temporary mooring area providing a suitable location for a wide range of marine events from outrigger canoe races to the local secondary school’s “Marine Olympics”.

The balance of the sand was provided by developers from building sites at no cost to Council. This source is providing an ongoing and significant source of sand. (Quantities are available from GCCC.) To date adequate sand has been provided from sand excavations and the permanent sand pipeline has not yet been constructed.
1.3.2 Narrowneck Artificial Reef

GCCC and local contractors had considerable experience with sand filled geotextile containers for coastal works. Filling containers underwater was considered but not adopted. As calm periods are very rare, it would have been more costly and was considered a high risk during construction. To allow efficient construction, it was proposed (ICM / GCCC) that pre-fabricated containers be filled within a split-hull hopper dredge prior to placement in the desired location (Figure 4).

Tenders were invited from the international construction community and the contract was awarded to experienced local marine contractors, McQuade Marine, with mega containers designed and fabricated on the Gold Coast by Soil Filters Australia (now Elco Solutions). The containers were filled with sand at the site and placed using the modified split hull hopper dredge, ‘Faucon’ (Figure 4), fitted with standard DGPS technology.

![Figure 4: Placement Procedure using a Split Hull Hopper Dredge, Faucon](image-url)
The lowered crest height had a significant cost benefit as well – a shallower crest was possible using the construction equipment proposed, but very shallow crest bags would have to be placed only at high tide in mild conditions, increasing the cost. Also, with the practical tolerances adopted, it was not necessary to anchor the dredge during the dropping procedure – this also had a significant cost advantage.

Reef construction commenced toward the end of the nourishment contract in August 1999, and was completed in mid December 2000 (Figure 5). The nourishment and large storms prior to reef construction had created a very large storm bar (over 1 m high over the back half of the reef). The bar would migrate shoreward with milder weather. As dredging to potential maximum scour depth, or a scour mattress, were not viable economic options, and as the construction materials allow for easy top-up, a sequenced construction schedule [at reduced cost] with top-up after initial settlement (as the large storm bar migrated shoreward) was undertaken. As recommended, regular maintenance has been carried out (Figure 5).

![Figure 5: Container placement numbers](image)

### 2.0 Monitoring Overview

This is the 5th GCCM Monitoring Report using ~7 years of data.

The NGCBPS Final Report (ICM, 1998) recommended that, “a monitoring plan be implemented with Griffith University as part of the works”. Griffith Centre for Coastal Management (GCCM) is co-ordinating an ongoing monitoring programme for the reef element – this has provided invaluable data not available elsewhere for refining the design and management of the Narrowneck reef. Data on beach width, reef stability, geotextile container durability, marine ecology and surfing amenity is being collected using:

- Video imaging
  - “ARGUS” using multiple cameras – WRL [contract with GCCC]
- Webcam – GCCM / Coastalwatch
- Hydrographic and beach surveys – GCCC
- Photography
  - aerial oblique – various
  - beach photographs – ICM
Surf & surf safety
- Observations – ICM, GCCC lifeguards, GCCM / Coastalwatch
- GPS surfing track plots – ICM, Brad Holmes Surf Coaching

Geotextile Containers
- Condition – ICM, McQuade Marine, Elco, GCCC
- Stability (pressure sensors in and on individual containers) – ICM, Elco

Ecological surveys – ICM, National Marine Science Centre, Ian Banks

The following parameters have been evaluated:
- Beach protection
  - beach width
  - shape
- Surfing amenity
  - surf frequency and quality
  - safety
- Marine ecology / fishing / diving
  - development
  - overall biodiversity
- Structural performance
  - construction aspects
  - container design
  - placement accuracy
  - stability
  - durability

Despite considerable interest worldwide, only 4 artificial reefs, including Narrowneck, have been completed to date, and the data from these plus data from the 2 reefs under construction in NZ, has been analyzed and benchmarked against Narrowneck (Jackson and Corbett, 2007) as summarized in Table 2. Only Narrowneck is designed as a multi-functional reef primarily for coastal protection.
Table 2: Comparison of reefs completed or under construction as at 1-5-07

<table>
<thead>
<tr>
<th>Reef</th>
<th>Bargara</th>
<th>Cables</th>
<th>Narrowneck</th>
<th>Pratte’s</th>
<th>Mt Maungani</th>
<th>Opanake</th>
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<tr>
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<td>Stated</td>
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<tr>
<td>Completed</td>
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<tr>
<td>Design - primary function</td>
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<td>Materials</td>
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<td>Volume (m³)</td>
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<tr>
<td>Performance - primary function</td>
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<tr>
<td>Approx Costs [A$/m³]</td>
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</table>

3.0 BEACH PROTECTION

3.1 Visual Observations of Beach Width

As per Section 1, the primary purpose of the NGCBPS (including the Narrowneck Artificial Reef) was to widen the existing beaches through creation of a salient in the lee of the structure and by acting as a coastal control point for the beaches to the south. Prior to implementation of the NGCBPS, erosion of the beaches was a recurring problem, particularly at Narrowneck where these events often exposed the boulder wall. A much wider beach has been created (Figure 6) and the boulder wall has not been exposed since implementation. (It is expected that in extreme events, the wall will be impacted, but recovery with the influence of the reef, will be in the order of months, not years).

A clear salient feature is often visible in the lee of the reef (Figure 7). This is not, however, always the case and there is often no obvious salient feature evident (Figure 8). Observation has shown the presence of a ‘double-salient’ feature (Figure 9) under certain wave conditions. This indicated that the “paddle” channel between north and south reef allows wave energy to leak through and erode the centre of the salient and does not provide an anchor or ‘toe’ for the base of the profile to prevent sand movement offshore. Two containers were placed to form a low weir between the arms in 2004. This weir is only 1.2m above seabed and only breaks waves in storm events and generally has no impact on the surf quality. Since then, no double salient features have been observed.
Figure 6: Comparison of beach width at Narrowneck
3.2 Storm Events

Conditions have been relatively “mild” but there have been a number of significant storms since start of the works with over 55 days with Hm > 5m. Major storm wave events that have occurred are as follows:-

- Mar 98
- April 02
- Mar 04 – early, Hs > 6m and Hm > 13m (and over 11m for 3 consecutive hours)
- Mar 04 – late
- Oct 04
- Mar 06 – early
- Mar 06 – late
- Aug 06
- Jan 07
- Feb 07
Observation of the most severe storm erosion events since the reef was completed, March 04, March 06, August 06 and January 07, showed that for a storm of these magnitudes storm erosion is easily being contained within the wider beaches. Beach widths of ~50m were still maintained after these events (Figure 10). Storm cut in the lee of the reef has also been less than the adjacent beaches. WRL (2004b) noted that recorded erosion of 30m was at the lower end of the 30-40m range experienced along the full length of the study area. This indicates that the reef is mitigating storm erosion in its lee.

Figure 10: Beach scraping post March 04 storms (beach width ~50m) (5/4/04)

The worst erosion [in the last 7 years] along the Northern Gold Coast beaches was Aug 06 (Figures 11 and 12) when extensive erosion affected most Gold Coast beaches. The protection and salient was very evident at Narrowneck. Note: as is often the case, this erosion event involved moderate wave conditions, but the storm duration was prolonged and waves were from the east. The recovery after this event was relatively rapid – several months – and the beach was in good shape for next storm waves in late January 2007. In May 07 the beaches are fully recovered and were used for a TV advertisement for Boots – get ready for summer campaign to be screened in the UK. With some 200 extras and associated catering etc, this use alone had significant financial benefits to the Gold Coast economy.

Figure 11: Post storm [12-8-06] looking north to reef from Q1 [ICM storm monitoring report]
3.3 Shoreline Analysis – ARGUS Data

3.3.1 The ARGUS System

Monitoring of the Narrowneck reef included installation of an ARGUS coastal imaging system in July 1999 by the Water Research Laboratory (WRL) at the University of NSW. The ARGUS system provides a very powerful monitoring tool. The automated image monitoring from four cameras (Figure 13) which, when combined, provide continuous coverage of 4.5 km of the coast (WRL, 2000a) gives semi continuous information on the shoreline and wave breaking changes due to all events, including storms when hydrographic survey is not practical. Digital image processing techniques are then applied on a routine basis to form a growing image database and allow the extraction of a range of quantitative information. (Figure 13 and web site

3.3.2 Regional Trends

Since nourishment was completed in mid-2000, the beaches of the northern Gold Coast have experienced periods of erosion and accretion corresponding to prevailing weather conditions. WRL (WRL 2004a), noted that:-

"the re-emergence of an annual erosion-recovery cycle indicates that the beaches of the northern Gold Coast are now in equilibrium with the sand nourishment that was placed on the beach during 1999-2000."

This new equilibrium position continues to experience the high variability in beach width that is typical of the high-energy Gold Coast beaches. Since nourishment, WRL (2007) estimate that the annual shoreline variability that can be attributed to the seasonal wave climate is ±20m (giving a total variability of ~40m for mid-tide conditions). WRL (2007) concludes that:-

"With the beaches of the Northern Gold Coast presently in a relatively healthy state, it is the shorter-term storm erosion rather than the underlying but longer-term erosion-accretion trends, which at the present time are of the primary importance to the ongoing planning and management of the Northern Gold Coast beaches."

WRL (2007) estimate that the longer-term net beach width change trends, to Jan 07, are:-

- South of Narrowneck +0.2m/yr
- at Narrowneck - 3.8m/yr
- North of Narrowneck -1.8m/yr

The trends correspond with a minor groyne effect of the reef as was part of the design. The trends are for the mid-tide position only and may be slightly downwardly displaced by the impact of the August 06 storm cut. As these trends do not take into account dune and sub
aerial bar volume growth, more accurate evaluation of long term trends should be evaluated by hydrographic surveys (Section 3.4).

3.3.3 Impact of the Narrowneck Reef

As the ARGUS system was implemented during nourishment works, there is no pre-nourishment baseline data. As such, assessment of the impact of the NGCBPS is limited to evaluating relative changes over this time period and cannot effectively quantify the impact of the works on total beach width.

To better determine the size of the salient and any ‘groyne’ effect Narrowneck was having updrift, WRL (2004c) undertook an Odd-Even Function Analysis of ARGUS output. This provided a means to distinguish between natural shoreline changes and those that are a result of engineered processes to allow the degree of coastal protection provided by the structure to be better quantified. They noted that the centre-line of the salient should be located down-drift of the structure centre-line. For Narrowneck, analysis showed that it was ~100m down-drift (i.e., north) of the reef centre-line. Results also showed that:-

“The even function calculated for this two-year period (2001-2003) shows a distinctive trend of up to 30m accretion at Narrowneck, consistent with symmetrical salient formation in the lee of the structure … The corresponding odd function for the same 2-year period continued to reveal a more subdued trend of asymmetrical accretion to the up-drift (south) of the reef and corresponding erosion to the down-drift (northern) side. This trend … indicated that the secondary ‘groyne’ effect at Narrowneck was relatively insignificant (~10m shoreline widening/retreat) and that the alongshore rate of transport at the site was only minimally impacted.”

This suggests that Narrowneck is effectively providing coastal protection in its lee, with the salient size of the order of that predicted. It also confirms that it is acting as a coastal control point for the updrift nourishment, as intended.

The most recent WRL report (WRL, 2007) noted that:-

‘As per the northern and southern sections, the cyclic variation of the beach width observed at Narrowneck (…..) for the six and a half year period, August 2000 to January 2007 is of the order of +.20m annually.”

This report (WRL, 2007) also noted that there had been a higher rate of recovery in the lee of the reef than adjacent beaches after the August storm cut and concluded that that:-

“The higher levels of accretion in the lee of the reef are expected to be a result of the decreased wave energy in this zone, caused by wave breaking and dissipation across the submerged reef structure.”

3.4 Shoreline Analysis – Hydrographic Survey Data

Gold Coast City Council has undertaken a number of surveys, both during construction and after construction for monitoring purposes. Typically, monitoring surveys extend from ETA 66.75 to ETA 68 with lines at 25m centres. Dates of monitoring surveys are as follows:

- 28th February 2001
- 1st March 2001
- 16th May 2001
- 17th September 2001
- 13th June 2002
The most recent survey [Figure 15] was undertaken approximately one month after the March 06 storms. Fitting a simple baseline to the contours shows a salient visible in the lee of the reef, as well as a sub-aerial salient. The fact that the salient appears to be almost directly in the lee of the reef [rather than 100m to the north as noted by WRL] could easily be the result of recently prevailing wave directions, particularly during the March storms.

Figure 15: GCCC survey May 2006 [post March storms] showing the salient
4.0 SURFING

The secondary objective of the Narrowneck artificial reef was to “improve surfing”.

4.1 Incidence of Wave Breaking

For surfing, waves need to break to be catchable. Waves break on both north and south reef (Figure 16) provided wave and tide conditions are favourable. Observations indicate incidence and initiation of wave breaking on the Narrowneck reef as per Figure 17.

Figure 16: Breaking initiated on North and South Reef at low tide – \( H_s = 0.8 \text{m} \) (16/5/04)

Figure 17: Incidence of wave breaking at Narrowneck Reef
In the most recent report, WRL (2007) notes that:-

“Wave breaking on the reef at Narrowneck continues to be commonly visible in images obtained by the coastal imaging system … “

This report also notes that since the additional crest containers were placed in 2002, that:-

“Since that time, it has been observed that waves break across the reef structure once the significant wave height exceeds around 1m.”

This report concluded that:-

“It is concluded that the reef continues to achieve the objective of enhancing potential surfing opportunities at Narrowneck.”

4.2 Frequency of Wave Breaking

To establish the frequency with which waves break on the reef, time-averaged and variance images from the WRL coastal imaging cameras (Figure 18) were analysed. The presence (or absence) of wave breaking on the reef was recorded for 7am each morning, regardless of tide and wave conditions (Figure 19). This showed that, after construction of the reef was complete, waves break on the reef an average of ~50% of the time at this time of the morning when the wind is most likely light or offshore.

![Figure 18: WRL image showing breaking on the Reef](image)

As expected, the frequency of wave breaking observed during the initial stages of construction (21%) is distinctly lower than the average frequency observed after construction was completed. This clearly demonstrates that crest height is important in the wave breaking process.

It is also evident from the variability in frequency that natural variability in wave conditions also has an impact on the presence of wave breaking, both seasonally and annually.
### Frequency of Wave Breaking on the Reef

#### 1999
- 21% Breaking

#### 2000
- 48% Breaking

#### 2001
- 61% Breaking

#### 2002
- 52% Breaking

#### 2003
- 62% Breaking

#### 2004
- 39% Breaking

#### 2005
- 41% Breaking

#### 2006
- 47% Breaking

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**Figure 19: Frequency of Wave Breaking on the Reef**
4.3 Type of Break

Formal observations of breaker characteristics were commenced initially after completion of the reef, but have not been continued. However, members of the project team regularly visit the site using different types of surf-craft (Figure 20), and observations are logged.

![Figure 20: Michel D’Agata (RIP) of GCCM Surfing the Reef](image)

4.3.1 Effect of Prevailing Conditions

In average conditions (1-1.5m), the waves tend to be more spilling than plunging (Figure 21). This is preferable for safety and more inexperienced surfers, or just for a relaxed ride. In larger swells with offshore wind conditions, the waves are typically hollow, plunging breakers (Figure 22) and the crest bags can “suck dry” even with the lowered crest level. In swell conditions >1m, particularly with a longer period, surf conditions can be very good and attract experienced surfers.

![Figure 21: Spilling Breakers in Smaller Conditions](image)
As with all reef breaks, tide level impacts on the breaker type as well as the incidence of breaking. At the top of the tide, waves tend to be more spilling, even in larger swell conditions (Figure 23). While offshore winds produce the best conditions, the reef often remains surfable for a time after the onshore winds kick in when the quality on the adjacent bars quickly deteriorate.
4.3.2 **Effect of Crest Height and Tolerances**

The reef and crest level were lowered as the 1999 storm bar migrated shoreward. The crest was subsequently topped up. The change in crest height has allowed the effect of crest height on wave breaking type to be evaluated. With the crest at or above the original design height of –0.5m LAT, a very hollow but hazardous wave develops that often sucks dry at the breakpoint even in small swell conditions. As swell height increases, this type of wave attracts only the expert body board and short board riders. With the crest lower than –1.5m LAT, waves tend to be spilling, attracting long boards and surf skis. The target crest height has been reduced to –1.5m LAT (RL –2.5m AHD) as a compromise between safety and surfing. Despite the lowered crest and acceptance of more practical tolerances from the original design, the reef still provides improved surfing conditions.

With the top ups and maintenance, the reef crest is not smooth. However, the wave breaking tends to be unaffected by the roughness of the reef, except where there is a localised high spot and small swell conditions. Figure 24 shows wave interactions causing wave confusion before the high “slightly” displaced bag moved into its hole. Localised low spots or even missing bags cause no significant adverse wave impacts.

4.4 **Ride Length**

In the early stages of monitoring, the length of the ride achieved was evaluated qualitatively, with simple observations regarding distance and time of ride. It was noted that the surf at Narrowneck was often providing much longer rides than anticipated as the reef break merged with the adjacent bar break in favourable conditions (Figure 25), resulting in a ride that started on the reef and finished close to the beach.
In late 2005, the monitoring program was extended to include recording and analysis of surf tracks from a wrist-mounted waterproof GPS unit (Figure 26). Local surf coach Brad Holmes was fitted with the GPS unit while surfing at Narrowneck. At present, data has been collected and analysed from six hours of surfing – some 22 separate rides. Breaker heights during the data collection were typically <2m.

Analysis of the data (Table 3 and Figure 27) shows that, while rides typically averaged 150 – 200m, recorded ride lengths reached up to 260 – 270m on both the north and south reefs. This confirmed earlier observations of long rides extending significantly shoreward of the reef and close to the beach. Similarly, the longest recorded ride reached over 60 seconds, although recorded ride times averaged ~30 seconds. Corresponding speeds (averaged over the length of the ride) varied between 3.7m/s and 7.4m/s.
Table 3: Narrowneck Surf Tracks – GPS Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Ride No.</th>
<th>Location</th>
<th>Ride Length</th>
<th>Ride Time</th>
<th>Average Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/08/05</td>
<td>1</td>
<td>South reef</td>
<td>268</td>
<td>55</td>
<td>4.87</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>South reef</td>
<td>134</td>
<td>28</td>
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<td>3</td>
<td>South reef</td>
<td>225</td>
<td>61</td>
<td>3.69</td>
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<tr>
<td>26/10/05</td>
<td>4</td>
<td>South reef</td>
<td>255</td>
<td>56</td>
<td>4.55</td>
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<tr>
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<td>43</td>
<td>6.05</td>
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<tr>
<td>03/02/06</td>
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<td>South reef</td>
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<td>31</td>
<td>4.87</td>
</tr>
<tr>
<td>16/02/06</td>
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<td></td>
<td>22</td>
<td>North reef</td>
<td>218</td>
<td>35</td>
<td>6.23</td>
</tr>
</tbody>
</table>

Figure 27: Plot of Recorded Surf Tracks
4.5 Range of Surf Craft

A review of the extensive literature on surfing and artificial surfing reefs was undertaken for GCCC by AWACS in 1996, prior to the design of the artificial reef at Narrowneck. The quantification of surfing quality appears simple in theory, as considerable research has been done to determine key parameters to define surf quality. All of this research, however, relates particularly to a single type of surfing – short-boards. Importantly, there are many other types of surf craft, and the “perfect” surf for one group of surfers may not be “perfect”, or even suitable, for another group of surfers. The sport of surfing encompasses a wide range of activities in the surf zone and many Australians consider themselves surfers.

The reef has provided significantly improved surfing conditions for a wide range of activities (Figure 28) including:-

- body surfing
- body boards (and mattresses)
- surf boards – short, medium and long ( norke)
- surf skis and paddle boards (Figure 28)
- surf kayaks and canoes
- sailboards & kite boards (Figure 29)
- tow-in surfing

![Figure 28: A range of surf craft at Narrowneck](image-url)
4.6 Surf Competitions

A number of regular major competitions, like the Clean Water Teams Challenge (Figure 30), and one-off events like the National Wave-jumping Titles, Queensland State Bodyboard Championships and the National Kite-board Championships (Figure 31) have been held at Narrowneck since the works were implemented.
Figure 31: National Kite Boarding Championships

Regular local competitions now are held at Narrowneck. The Narrowneck Long-board club and the Northend Boardriders cater for long-boards and short-boards respectively (Figures 32 and 33). While the competitions tend to find a quiet location not on the reef itself, the wide beach and adjacent breaks are key attractions. (The beach and surf amenity are complementary).

On days with good surf conditions or multiple surf competitions, car parking is inadequate.

Figure 32: Narrowneck Long-board Club Competition on Sunday 19-5-07

Figure 33: North-End Surfboard Club Competition on Sunday 19-5-07
4.7 Adjacent break

In small conditions, waves do not break on the reef. The bar formations around the salient, however, provide favorable conditions for the shore-break (Figure 34) and it is common to find significantly more surfers directly on the bar in the lee of the reef than on the shore-breaks on either side (Figure 35).

![Figure 34: Good surfing conditions at high tide directly inshore of Narrowneck Reef](image)

![Figure 35: ~25 Surfers directly inshore of reef](image)

It is also common for the flags to be set up directly in the lee of the reef, indicating that it produces a safer swimming environment than natural conditions on the adjacent beaches (Figure 36).

![Figure 36: Flags directly in the lee of Narrowneck Reef (14/3/04)](image)
4.8 Safety

With litigation so prevalent, safety is of particular importance. Surfing is inherently risky. Artificial reefs present a number of hazards for swimmers and surfers (Corbett & Tomlinson, 2002), including:

- impact with the reef when surfers dive / fall off their board (relevant for surfers only) - while surfers tend to ‘fall’ off their boards rather than diving, limiting potential for spinal damage, they also have a higher initial velocity than people who dive into a pool (and need 1.8m water depth for safety)
- impact with the reef due to turbulent wave action in shallow water

Whilst breaker height and type also impact on safety, the crest height of the structure is also critical. The original design (with crest at ~LAT) developed by the University of Waikato was intended to optimize surfing, particularly for short boards, over the entire tidal range with small waves. In 2002, the designers stated that the original Narrowneck design would have had a similar wave breaking intensity as Shark Island. As this is one of the most dangerous surf breaks in Australia, this was not desirable.

During the design process, safety was identified as a key issue. This was reflected in the lowering of the crest to -0.5m LAT and the use of user-friendly geotextile containers. Despite this, the reef produced a very hollow but hazardous wave that often sucked dry at the breakpoint (Figure 37). The break was suitable only for very experienced surfers, even in moderate swells.

After construction, the reef crest lowered as the pre-construction storm bar migrated shoreward. During the 2001 top-up, the design crest height was restricted to –1.0m LAT. Even at this level, the top of the crest bags is often shallow during the drawdown and has been observed to “suck dry” in larger wave heights at low tide.

During 2002, flume testing was undertaken at QGHL by GCCM and ICM for Noosa Council (Corbett & Tomlinson, 2002). The modelling confirmed the observations of water depth experienced at Narrowneck (~0.3m for crest heights of -1m LAT and ~1m for crest heights of -1.5m LAT – Figure 38).
As a result of these observations and testing, the design crest height has been reduced to -1.5m LAT (RL -2.5m AHD) as a compromise between safety and surfing. To date, there have been no reports of injuries on the reef.

4.9 Comparison with Modelling

Monitoring of the reef indicates that the reef needs long period, clean swell to replicate the modelling. The numerical and physical modelling was done with monochromatic long crested waves on a smooth (non-barred) seabed profile. In reality, the Gold Coast wave conditions are usually bi-modal and often short-crested. In the video monitoring, there have only been a few examples of the wave patterns replicating the modelling. The long period storm wave event below (Figure 40) is an example. A more typical wave breaking pattern is shown in Figure 41.

This emphasises the fact that, while modelling can be a powerful tool if used correctly, it is important to recognise that it provides information for a limited number of specific conditions while actual conditions are often highly variable. While modelling can be valuable, it is important model runs are representative of actual conditions and that results are interpreted appropriately based on independent data and past experience.
4.10 Public Perceptions

The Narrowneck Artificial Reef has undoubtedly improved surfing conditions and the reef does provide a quality surf wave in the right conditions. However, it has not gained a widespread reputation as a great surf spot. Part of the reason for this appears to be that it is surrounded by world-class surfing breaks – including Superbank – and typically these locations work in similar conditions as the reef.
The fact that the takeoff area is 300m offshore also seems to have had an impact. As with many surf spots, the majority of surfers tend to congregate closer in on the beach break, even when the reef is “pumping” in the sets. However, if one “brave” surfer heads further out to the reef and starts to catch good waves, some of the crowd generally follows. While having the reef closer to shore would undoubtedly be more attractive to surfers, it may not be better overall given that distance offshore also has a significant impact on erosion protection and local currents. Press statements damning the reef even before construction was completed gave a very negative community perception which has been lasting (Figure 42).

![Image](Image)

**Figure 42: News article 10-4-01**

### 5.0 Marine Ecology

Prior to construction, the School of Environmental and Applied Science at Griffith University (1998) undertook an impact assessment of the proposed NGCBPS. It was found that the existing nearshore beach zone was dominated by polychaete worms, molluscs, crustaceans, surf clams and predatory snails. The impact assessment stated that Narrowneck reef:-

“Although it will certainly be colonised by a range of small invertebrates and marine plants, the low relief and lack of structure (holes and crevices) are expected to limit the abundance of marine life. Some attraction of fish to the area is expected, but the lack of abundant prey items is also likely to limit fish abundance.”

During inspections, it was quickly observed that growth of marine vegetation on the bags occurred rapidly after placement. As construction continued, it soon became evident that the extent and diversity of the marine habitat had been underestimated. Since completion, the reef has provided significant ecological and recreational benefits. The ingress of sand into the structure of the geotextile and the growth of marine vegetation has also provided an additional benefit in the form of protection to the geotextile (both mechanical and UV).
5.1 Observed Species

Visual observations as well as photo and video identification (Figure 43) by ICM, National Marine Science Center (NMSC) and the Reef CRC has provided a comprehensive list of the diverse marine species found on the reef (Table 4).

![Video recording of marine growth](image)

Table 4: Benthos and Fish Species identified at Narrowneck

<table>
<thead>
<tr>
<th>Benthos (Live on the sea bed)</th>
<th>Figure 44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abalone (Haliotis sp)</td>
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<tr>
<td>Algae / Seaweed, Brown (Dictyopteris acrostichoides)</td>
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<tr>
<td>Algae / Seaweed, Brown (Dilophus intermedius)</td>
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<tr>
<td>Algae / Seaweed, Brown (Sargassum biserrula)</td>
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<tr>
<td>Algae / Seaweed, Brown (Family: Ecklonia)</td>
<td>Figure 45</td>
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<tr>
<td>Algae / Seaweed, Red (Gracilaria blodgettii)</td>
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<tr>
<td>Algae / Seaweed, Red (Family: Coralline algae)</td>
<td>Figure 46</td>
</tr>
<tr>
<td>Anenome, Sea (Anthozoa)</td>
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<tr>
<td>Ascidian (Family: Ascidiiidae)</td>
<td>Figure 47</td>
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<tr>
<td>Barnacles (Cirripedia)</td>
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<tr>
<td>Clam, Razor (Siliqua pathula)</td>
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<tr>
<td>Coral, Soft (Octocorallia)</td>
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<tr>
<td>Crinoid (Feather star) (Comanthina schlegeli)</td>
<td>Figure 49</td>
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<tr>
<td>Cunjevoi (Pyura stolonifera)</td>
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<tr>
<td>Hydroids</td>
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<tr>
<td>Kelp, Broad Leaf (Laminaria sp)</td>
<td>Figure 52</td>
</tr>
<tr>
<td>Polychaete, Tube-Building (Family: Diopatra)</td>
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<tr>
<td>Sponges, Sub-Massive</td>
<td>Figure 53</td>
</tr>
<tr>
<td>Urchin, Sea (Class: Echinoidea)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Nekton (Organisms that swim in the ocean freely) – Fish</th>
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<tbody>
<tr>
<td>Bannerfish, Longfin (Heniochus acuminatus)</td>
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<tr>
<td>Batfish, Tall-fin (Platax teira)</td>
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<tr>
<td>Batfish, Humped (Platax batavianus)</td>
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<tr>
<td>Batfish, Silver (Monodactylus argentius)</td>
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<tr>
<td>Blenny sp. (Family: Blennidae)</td>
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<tr>
<td>Boxfish, Eastern Smooth (Anoplocapros inermis)</td>
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<tr>
<td>Bream, Butter (Monodactylus argenteus)</td>
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<tr>
<td>Bream, Silver (Acanthopagrus australis)</td>
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<tr>
<td>Cardinal fish, Five-Line (Cheilodipterus quinquelineatus)</td>
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<tr>
<td>Catfish, Estuary (Chidoglanis macrocephalus)</td>
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<tr>
<td>Cod (small groper) (Epinephelus sp.)</td>
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<tr>
<td>Coris, Pink-Lined (Coris dorsomaculata)</td>
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<tr>
<td>Dottyback, Brown (Pseudochromis fuscus)</td>
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<tr>
<td>Fish Name</td>
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<tr>
<td>Flathead</td>
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<tr>
<td>Fortesque</td>
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<tr>
<td>Goaffish, Blackspot</td>
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<tr>
<td>Hawkfish, Blotched</td>
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<tr>
<td>Kelpfish</td>
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<tr>
<td>Leatherjacket, Large-scale</td>
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<tr>
<td>Mado</td>
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<tr>
<td>Morwong, Red</td>
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<tr>
<td>Parma, Girdled</td>
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<tr>
<td>Parrotfish</td>
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<tr>
<td>Perch, Moses</td>
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<tr>
<td>Pike, Striped Sea</td>
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<tr>
<td>Pineapple fish</td>
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<tr>
<td>Porcupine fish, Three-Bar</td>
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<tr>
<td>Puffer fish</td>
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<tr>
<td>Scad, Southern Yellowtail</td>
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<tr>
<td>Soapfish, Barred</td>
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<tr>
<td>Stripey</td>
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<tr>
<td>Suckerfish, Slender</td>
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<tr>
<td>Sweep, Silver</td>
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<tr>
<td>Sweetlip, Gold-Spotted</td>
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<tr>
<td>Tailor</td>
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<tr>
<td>Tang</td>
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<tr>
<td>Toadfish, Stars and Stripes</td>
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<tr>
<td>Trevally, Golden</td>
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<tr>
<td>Triggerfish</td>
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<tr>
<td>Trumpet fish</td>
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<tr>
<td>Whiting</td>
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<tr>
<td>Wrasse, Blue-Streak Cleaner</td>
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<tr>
<td>Wrasse, Crimson-Banded</td>
</tr>
<tr>
<td>Wrasse, Gunther’s</td>
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<tr>
<td>Wrasse sp.</td>
</tr>
<tr>
<td>Nekton (Organisms that swim in the ocean freely) – Other</td>
</tr>
<tr>
<td>Crab, Red Spot / Three Spot</td>
</tr>
<tr>
<td>Dolphin, Bottlenose</td>
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<tr>
<td>Eel, Giant Moray</td>
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<tr>
<td>Lobster, Southern Rock</td>
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<tr>
<td>Lobster, Tropical Rock</td>
</tr>
<tr>
<td>Octopus sp.</td>
</tr>
<tr>
<td>Prawns, Juvenile</td>
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<tr>
<td>Ray, Bull</td>
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<tr>
<td>Ray, Common Sting</td>
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<tr>
<td>Ray, Spotted Eagle</td>
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<tr>
<td>Seahorse</td>
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<tr>
<td>Seasnake</td>
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<tr>
<td>Shark, Blind</td>
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<tr>
<td>Shark, Leopard</td>
</tr>
<tr>
<td>Shark, Shovelnose</td>
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<tr>
<td>Shrimp, Coral-Banded</td>
</tr>
<tr>
<td>Wobbegong, Spotted</td>
</tr>
</tbody>
</table>
Figure 44: Abalone

Figure 45: Brown Algae

Figure 46: Red Algae

Figure 47: Ascidian
Figure 48: Soft coral

Figure 49: Feather star

Figure 50: Cunjevoi
Figure 51: Kelp

Figure 52: Tube-building Polychaete

Figure 53: Sponge
Figure 54: Estuary Catfish

Figure 55: Blotched Hawkfish

Figure 56: Pufferfish

Figure 57: Yellowtail scad
Figure 58: Stripeys

Figure 59: Slender Suckerfish (Remora)

Figure 60: Bottle-nose dolphin

Figure 61: Lobster

Figure 62: Spotted eagle ray
5.2 Development

The early stages of development of marine growth on the containers have been well observed during underwater construction inspections undertaken by ICM. While development times and the type of growth differ slightly between containers depending on various factors (including type of material, water temperature after placement, depth of water etc.), it is generally similar in the preliminary stages. After placement, suspended sand and shell migrates into the structure of the geotextile fabric. Generally, within several days to a week, a brownish algae covers the surface of the geotextile, attracting small fish and birds (Figure 66). Seagrasses then colonise and develop on the exposed sections of the containers. After a year, a broader range of benthos is evident, particularly on the undersides of the container and protected areas.
Monitoring of the 2004 top-up allowed the staged development of marine life to be better examined, particularly in light of the cooler water temperatures (~19°) in which the early stages of the development took place.
Day 1: No growth evident

Day 5: Weed is caught in the material

Day 7: Continued weed being caught

Figure 67: 1 day after placement

Figure 68: 5 days after placement

Figure 69: 7 days after placement
Day 8: Initial development of algae results in discolouration bag

Day 24: Further development of algae to form a short ‘fur’ covering the majority of the container

1 month: Algae further develops to form a dense mat some 2-3cm in length, covering the majority of the container

Figure 70: 8 days after placement

Figure 71: 24 days after placement

Figure 72: 1 month after placement
7 months: Seagrasses (~10cm in length) completely cover the container.

![Figure 73: 7 months after placement](image)

16 months: Good coverage of seagrasses interspersed with a broader range of growth. Adjacent photo shows red seagrasses and sponges, although this depends on the individual container.

![Figure 74: 7 months after placement](image)

![Figure 75: 16 months after placement](image)
5.3 Overall Biodiversity

Additional research has been undertaken by NMSC for Soil Filters Australia (now ELCO Solutions) in the form of an honours thesis by Rhys Edwards (NMSC, 2003). It compared the ecology of Narrowneck Reef with other natural reefs in similar depths nearby (Palm Beach, Kirra and Cook Island). This was achieved using four randomly placed 25m video transects along which ecological surveys were undertaken.

5.3.1 Benthic Transects

NMSC (2003) found that nine of the benthic categories were found at Narrowneck – including macroalgae, coralline algae, sponges (sub-massive), hydroids, echinoderms (crinoids), echinoids, ascidians, MSA (mixed sessile assemblage – algae and invertebrates) and sand. Of these, macroalgae (seagrasses) accounted for almost 70 percent reef coverage.

In summary, NMSC (2003) observed that:

“Narrowneck benthic assemblages were largely dominated by macroalgae and crinoids, ... was less diverse than natural reefs, and also showed higher within-reef variability. Although benthic assemblages were shown to be highly discrete for all survey reefs, NAR (Narrowneck Artificial Reef) still appeared to be unrepresentative of natural reefs in the region, and was probably more similar to the temperate reef assemblages typical of higher latitudes.”

Although also postulated that:

“As the reef at Narrowneck has been completed for less than five years, it is possible that the algal-dominated community may represent an early or ‘pioneer’ development phase. Given sufficient time and suitable conditions for development, the structure of this community might be expected to become more diverse as other benthic organisms begin to outcompete these large macrophytes.”

Supporting this, it observed that:

“The age of NAR (Narrowneck Artificial Reef) is similar to that of recently emergent reef substrata at Kirra, ... (This) may explain the distinctly high presence of macroalgae at both NAR and Kirra. In addition, hard corals were conspicuously absent from both Narrowneck and Kirra reefs.”

Temporal replication of the ecological surveys, which could verify this, has not been undertaken to date.

5.3.2 Fish Assemblages

Of the total 6,633 fish observed during the surveys conducted by NMSC (2003), 2,086 were recorded at Narrowneck. Of the fish observed at Narrowneck, the vast majority (94.5%) were pelagic, predominantly yellow-tail scad.

“The abundance of pelagic fish at Narrowneck Reef ... (was) the highest of all reefs surveyed ... (with) a high degree of similarity between NAR and two of the three natural sub-tidal reefs surveyed in this study. ... Pelagic fish are likely to follow diurnal, seasonal or annual migration patterns, with schools often occurring...
at reefs in close proximity to each other at or around the same time. ... The size of NAR may account for the presence of pelagic fish in high abundance.”

Conversely, while 1,667 (25%) of the total were demersal fish, only 114 (5.5%) of the fish observed at Narrowneck were demersal. NMSC (2003) observed that:-

“The benthic / demersal fish community at Narrowneck was relatively species poor, and of a much lower abundance than displayed by natural examples”

although it was also noted that:-

“Benthic and demersal reef fish communities tend to develop over time, and are largely dependent upon the supply of larvae or immigrant juveniles and adults.”

5.4 Production / Attraction

There is much debate over whether artificial reefs function by attraction or production. As a result of their analysis, NMSC (2004) believe that:-

“The biological communities associated with Narrowneck Artificial Reef appear to enhance biodiversity and productivity at a local scale, and may also contribute to overall regional productivity.”

5.5 Impact of Complexity

Analysis of survey data by NMSC (2003) also investigated the relationship between the complexity of the reef and the corresponding biodiversity. Reef complexity was measured as the ratio between the 25m straight line transect and the actual distance following the bottom contours. It was found that Narrowneck reef had a significantly lower complexity than the adjacent natural reefs. The complexity provided by Narrowneck is generally limited to the vertical sides, crevasses, caves and overhangs that occur between individual containers due to slight inaccuracies in placement.

5.5.1 Benthos

During monitoring dives, it has been observed that, while the dominant macroalgae attaches to the entire container, it is the locations of greater complexity that generally support the more unusual species. Particularly, it has been observed that sponges typically develop on the more protected undersides of containers (Figure 76).
This suggests that increased complexity does result in increased biodiversity. This is supported by NMSC (2003) that states that:-

“The linear regression equation for macroalgae produced a negative coefficient (slope), indicating that the cover of macroalgae is inversely affected by an increase in complexity. The relationship between sponge cover and complexity was shown to be positive, i.e. an increase in complexity produced a corresponding increase in the cover of sponges.”

5.5.2 Fish Assemblages

As could be anticipated, habitat complexity has a very different influence on pelagic fish compared with demersal fish. Analysis by NMSC (2003) showed no clear relationship between complexity and pelagic fish populations, stating that:-

“Regression analysis between univariate indices for pelagic fish populations, and reef complexity revealed that neither a strong, nor significant, relationship exists between these biological and physical factors, in agreement with BIOENV results.”

During monitoring dives, however, it has regularly been observed that crevasses provide shelter for some species of demersal fish and it is not surprising that NMSC (2003) states that:-

“… Regression analysis between univariate measures and complexity … coefficients for both of these measures were positive, indicating that an increase in complexity caused an increase in both the number of individuals and the number of benthic/demersal fish species.”

In this study, reef complexity accounted for ~30% of the variability in the number of benthic/demersal species, with an increase in complexity resulting in an increase in species numbers. Despite this finding, however, no relationship was detected between species diversity and substratum heterogeneity.

5.5.3 Overall

NMSC (2003) concluded that:-

“By increasing the complexity of an artificial reef, it may, therefore, be possible to increase the diversity of benthic assemblages, whilst enhancing microhabitat complexity.”

This could potentially be achieved, particularly in the deeper sections of the reef, by random or scattered placement of additional units. Additionally, these units could be of different sizes and shapes to better provide the holes and crevasses that contribute to complexity.
5.6 Impact of Water Depth

The reef covers a large area, with water depths at low tide ranging from 1.5m on the crest out to about 10m at the seaward edge. In the shallower sections, growth is predominantly short (Figure 77) and longer vegetation that can develop in calmer weather is often stripped during larger conditions. In the mid depths (~3m-8m), below most of the severe wave action, the vegetation is mainly dense seagrasses with a length of ~100-200mm and cunjevoi, with other organisms found in sheltered locations (Figure 78). In the deeper depths, longer algae and kelp up to 400-500mm predominate (Figure 79).

Figure 77: Short Growth in Shallow Water

Figure 78: Growth in mid-depths

Figure 79: Growth in deeper sections
5.7 Impact of Substrate Type

The type of geotextile influences the nature and abundance of growth which develops on the geotextile. This has been well established independently since the construction of the Narrowneck reef, with a wide variety of geotextile samples being deployed in a number of locations worldwide.

The type of geotextile used at Narrowneck (non-woven needle-punched geotextile) provides a good attachment for marine vegetation. Monitoring of the impact of geotextile type is limited to general observations during monitoring dives. While the (discontinued) polyurethane material developed harder growths (e.g., barnacles) similar to woven geotextile, the 1200R (standard) and 1209RP (composite) materials encouraged the development of typically “soft” growths (e.g., algae). These softer growths are beneficial in terms of surfer safety, particularly on the upper sections of the reef where surfers could come into contact with the reef itself. Differences in the type of growth between the standard and composite geotextile have been observed in the early stages of development (Figure 80), however this has not been well documented to date.

![Figure 80: Growth on ½ RP container](image)

5.8 Additional Recreation

The increased biodiversity experienced on the reef has resulted in Narrowneck becoming a popular location for diving (Figure 81), snorkelling (Figure 82), spearfishing (Figure 83) and fishing (Figure 84) in calmer conditions.
Figure 81: Diver

Figure 82: Snorkellers

Figure 83: Spearfisherman
The popularity of the reef for fishing introduces a number of problems. Firstly, fishing can create a hazard for other recreational users. While surfers are generally not surfing the reef in these calmer conditions, those who are diving, snorkelling and spearfishing could be threatened. Vessels that anchor on the reef also have the potential to damage the reef itself, particularly if the vessel uses a winch and a reef anchor. Anchoring also presents a safety hazard for the vessel as sudden shoaling of larger waves over the reef could capsize a smaller vessel.

On 29/11/2002, the reef was designated a “no anchoring” zone by Queensland Transport and buoys were placed around the reef (Figure 85). Loss of the “no anchoring” buoys during large wave events typically results in an increasing number of boats anchoring on the reef, so it is important that they are maintained or replaced as necessary. The present “spar” buoys seem able to cope with storm waves, and with the smaller anchors can be serviced easily and inexpensively with Queensland transport’s Gold Coast vessel. The larger buoys needed the large vessel out of Brisbane.
6.0 GEOTEXTILE CONTAINER PERFORMANCE

6.1 Container Material

The geotextile material has been improved considerably during the last 7 years due to the monitoring at Narrowneck. The locally produced geotextile used at Narrowneck has been used in all subsequent reefs.

The containers are subjected to:

- high forces due to filling, dropping and impact with the seabed
- high forces associated with storm waves
- ultra-violet exposure
- surfboard impact (Figure 86)
- vessel impact (Figure 87)
- propeller cuts (Figure 88)
- anchor damage (Figure 89)
- damage from fishing hooks (Figure 90)
- damage from spear heads (Figure 91)
- vandalism (Figure 92)
- wear/fatigue failure from cyclic movement of any loose material [e.g. the initial trunk covers, identification tags or wide seams, often exacerbated by presence of marine growth] (Figure 93)

![Figure 86: Fin impact mark on RP container – no damage](image1)

![Figure 87: Result of Vessel Impact – no damage](image2)
Figure 88: Large Propeller Cuts - repaired

Figure 89: Anchor wedged tightly between containers – no damage

Figure 90: Hook caught in standard container – no damage
As the Narrowneck reef was considered to be a prototype, container material and design were refined during the course of the works. Three different geotextile materials were used for fabrication of containers: –

- 1200R “Terrafix” non woven geotextile (Figure 94)
- 1200R “Terrafix” non woven geotextile with a sprayed urethane coating (Figure 95)
- Composite 1209RP “Terrafix” non woven geotextile (1200R Terrafix with an outer “hairy” wear layer bonded onto it) (Figure 96)

Figure 94: 1200R “Terrafix” non woven geotextile

Figure 95: 1200R “Terrafix” with polyurethane coating

Figure 96: 1209RP “Terrafix” non woven geotextile

Terrafix 1200R

The standard un-reinforced 1200R geotextile has proven adequate to withstand construction and environmental forces. Trapping of sand between the outer fibres and attachment of marine vegetation appears to provide good protection from ultra-violet radiation (Figure 97). Monitoring by divers shows that observed instances of surfboard or vessel impact has generally not resulted in damage, although the geotextile remains vulnerable to damage by propellers, anchors and spears, as well as vandalism using knives. Of these, large anchors from vessels with winches seem to be the main problem in deeper areas, with a number of containers being punctured and deflated. Whilst wear can potentially result in container failure, the sources of wear (loose material, failed trunk covers, identification tags and wide seams) can be effectively controlled through design, or repaired as necessary.
The establishment of softer marine growths, rather than harder growths such as barnacles, is also beneficial in terms of improving surfer safety.

1200R with urethane coating
While this geotextile is capable of withstanding the forces associated with construction, the use of urethane coating was discontinued after monitoring showed that it experienced localised stress cracking, resulting in deflation of the container (Figure 98). Of the 30 trial coated containers, at least 50% have cracked and partially or fully deflated, although some are still in perfect condition. As the urethane coating is slippery and experiences little marine growth, it is generally exposed to ultra-violet. What little growth is evident tends to be hard (e.g. barnacles) which is not desirable, particularly in shallow areas where it is possible for surfers and swimmers to come in contact with the geotextile. Monitoring indicates that the urethane is vulnerable to spear heads and vandalism, although its resistance to anchor damage, propeller cuts, and vessel and surfboard impacts appears reasonable but has not been established. While wear could potentially result in container failure alone, the problem is usually compounded by cracking in the urethane coating.
Composite 1209RP
Developed in 2000 during the final stages of the works after failures of the urethane coating occurred, the 1209RP is highly durable. Typically used in the shallow sections, it has withstood loading associated with construction. With enhanced sand ingress between the outer fibres and attachment of marine vegetation, it appears to provide very good protection from ultra-violet. Designed for higher durability, the geotextile is more resistant to damage from impacts, spearheads, anchors and vandalism. It is still, however, vulnerable to damage from propellers of large vessels.

To improve the robustness of the container while minimising the associated cost, a number of shallow containers were fabricated using standard 1200R geotextile for the bottom half and the composite 1209RP for the exposed top half (Figure 99).

**Figure 99: ½ RP container before filling**

6.2 Container Design

A number of design issues have been addressed making the containers far more robust. These issues include:-

- rounded corners
- improved stitching
- improved inlet and outlet trunks
- shorter tags to eliminate wear

6.3 Repairs

A number of maintenance procedures have been trialed on Narrowneck and implemented at no cost to GCCC. They have proven to be effective and can be carried out in an underwater environment with acceptably low wave activity. The details are documented in ICM R&D report 07-1.

6.4 Stability

Sand filled structures tend to form an elliptical shape with the base moulded to the shape of the seafloor. As such, they are extremely difficult to roll, and so are very stable, despite having a lower SG than rock or concrete. The permeability of the sand filled containers also helps absorb wave forces and contributes to the stability of sand filled structures.

The reef and individual components needed to be stable for offshore wave heights ($H_{max}$) in excess of 12m. The stability of the individual 100t – 300t sand filled geotextile containers was not considered likely to be a problem, as in these conditions concrete blocks of ~25t
would generally be adequate and blocks of this size were successfully used for the seaward ends of the seaway training walls.

Since initial construction, there have been over 55 storm events with wave heights ($H_{\text{max}}$) in excess of 5m, including a storm event in March 2004 for which recorded wave heights reached about 11m for over 3 hours with corresponding periods of up to 13 seconds (Figure 100).

![Wave Data](image)

**Figure 100: Wave Data (from EPA/GCCC wave buoy near site)**

As a result of these storms, a small number of containers were washed up on adjacent beaches. Inspection of these indicated that the containers were most likely damaged prior to the storm and the higher wave activity merely resulted in their removal from the reef. This was confirmed when dive inspections revealed that there was negligible movement on the reef as a result of the storm activity, including those containers with elevated crest levels. As such, it may be considered that mega-containers of the size utilized at Narrowneck are stable in at least 11m wave conditions.
7.0 SUMMARY AND RECOMMENDATIONS

7.1 Beach Protection

The reef is achieving the beach protection objectives and the beach has been wide enough to contain all storms to date. While the weather has been relatively mild, the beaches have withstood several significant erosion events.

The ARGUS camera system is showing an erosion trend inshore and north of the reef. While the rate is low, and may have been exacerbated by the August 06 storms, hydrographic survey should be undertaken and analysed to more comprehensively understand any trends. If there is an erosion trend, it can be reduced by future nourishment from channel maintenance dredging. Sand deposition rates from building sites should be quantified. The bypassing rates and opportunities to back-pass should also be investigated.

For beach protection, future maintenance need only concentrate on maintaining the reef sections above about RL -6 and completing the low weir between the arms.

7.2 Surfing

The Narrowneck Artificial Reef has achieved the secondary objective of improved surfing. In hindsight, this objective was appropriate, but needed to be more precisely defined. Promotion by the media prior to construction led to unrealistically high surfer expectations. As has been experienced with all of the artificial reefs worldwide (four completed, one partially completed), there was a belief that an artificial reef “created” surf waves and that it would perform reliably regardless of conditions.

Further improvements designed specifically to improve surfing are not considered warranted.

7.3 Marine ecology, Fishing and Diving

The ecological benefits and associated fishing and diving amenity created have exceeded expectations. While the deeper sections of the reef, deeper than about 6m, need not be maintained for beach protection, this area should be, at least, maintained for fishing and diving. The deeper area is subject to anchor damage. To reduce this, the following is recommended:-

- Move the existing no anchoring buoys closer to the reef.
- Top up the deeper section where bags are missing with concrete modules which will not be damaged by anchors and will:-
  - provide attachment for corals and other “hard” benthos.
  - Provide holes for larger fish to hide.

7.4 Reef Structure Performance

The improvements in the container design and materials have improved the durability of the reef. Maintenance will be required but this will now be decreased. Any maintenance above about -6m should use the geotextile mega sand filled containers. Any maintenance deeper than about -6m should use concrete [or other hard] material.
8.0 CONCLUSIONS

- Monitoring should be continued to ensure that adequate maintenance is carried out to maintain the levels as per Figure 101.
- Maintenance
  - above about -6m should use the geotextile mega sand filled containers
  - between about -6m and -8m should use either geotextile mega sand filled containers or concrete [or other hard] material
  - below about -8m should use concrete [or other hard] material
- The erosion trends need to be better quantified with accurate hydrographic survey.
- The practicality of increasing car parking by nose in parking should be considered. (This also needs to consider Indy).

![Figure 101: Maintenance Levels](image-url)
9.0 REFERENCES


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Gold Coast Shoreline Management Plan
Update on Recommendations for Palm Beach Protection Strategy

Griffith Centre for Coastal Management Research Report No. 69
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The report presents an update on the Palm Beach Protection Strategy with particular reference to the need for a coastal control structure in association with the beach nourishment.

Keywords: beach nourishment, coastal processes, Palm Beach, artificial reef

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EXECUTIVE SUMMARY

Palm Beach remains vulnerable to complete loss of beaches and severe property damage as a result of severe short term storm erosion. Erosion events in 1996 and 2000 exposed the oceanfront boulder wall along sections of Palm Beach. Over time, climate change will only increase this risk. The TRESBP will ensure that the littoral supply to Palm Beach is maintained, however it will not act as a source of new sand for Palm Beach that is above and beyond natural supply rates for the whole Gold Coast [despite there being some popular public opinion to the contrary]. A “do nothing” approach will not be adequate if it is expected that a beach be maintained during large storm events.

The presently adopted strategy of beach nourishment has not been notably successful in the past [despite ongoing nourishment since 1974]. Comprehensive monitoring of the most recent large-scale nearshore nourishment [involving placement of some 385,000m$^3$ between 2004 and 2006] shows that there is some short-term benefit provided, however the rapid migration of this material northward results in the works providing no long-term benefit to the beach. At present, Palm Beach is no wider than it was in 2004, prior to nourishment.

As ongoing large-scale nourishment is not sustainable given the inadequate availability of sand resources, nourishment alone cannot successfully provide a long-term solution. Some form of control structure is required to stabilise the nourishment and ensure a change to the equilibrium beach alignment along the Palm Beach embayment. This was recommended as part of the Palm Beach Protection Strategy [PBPS] master plan originally adopted by GCCC in 2003 and it was endorsed in the independent peer review undertaken by Prof Colin Apelt in 2004.

There are many different types of control structures and a full review of these options was undertaken as part of the PBPS. A submerged berm remains the preferred option due to this type of technology having been proven to be effective at Narrowneck and, unlike other control structures, offshore submerged structures are typically low impact [both visually and on the amenity of the beach]. They also have the potential to provide additional recreational and ecological benefits [such as surfing and diving].

The outcomes of this report are consistent with the original recommendations – that a control structure is needed at Palm Beach and that the proposed design of the structure will effectively meet the GCCC design requirements. In light of community concerns, perhaps a staged approach to construction [as recommended by GCCM in 2004] could be considered. With comprehensive monitoring, this will provide site-specific data of how the system responds to the structure prior to completion.

The other important issues identified for re-evaluation include environmental issues, dune vegetation, coastal access, and the dredging programs for Tallebudgera andCurrumbin Creeks. The community particularly expressed concern over the natural reefs at Palm Beach and an assessment was made in 2005. It is recommended that this be repeated to assess the impact of the nourishment. A review of Council dune vegetation policy and practices is recommended with active implementation of vegetation management at Palm Beach. The PBPS set out a proposal for a long term study of socio-economic factors, and it is recommended that this be undertaken as a mean of examining the issues surrounding coastal access. Since the original PBPS report, a research program was established known as the Currumbin Entrance Research Program (CERP). This has not been fully implemented since, and it has
been reviewed in this report. It is recommended that CERP be implemented to provide a framework in which issues related to the dredging of the creeks, and the impact on Palm Beach, can be addressed.
1 BACKGROUND

1.1 Palm Beach Protection Strategy

There has been continuing concern that the Palm Beach section of the coastline does not have a sufficient storm buffer to prevent loss of beach and property damage in the event of a major storm in the future. As a result Council resolved to develop a strategy for the protection of the Palm Beach foreshore areas. In collaboration with Council, the Griffith Centre for Coastal Management [GCCM] began the preparation of the Palm Beach Protection Strategy [PBPS]. This was undertaken in three stages:

- **Stage One** – Scoping study, Master Plan Report and Implementation Plan
- **Stage Two** – Impact Assessment, design of components and securing of necessary approvals
- **Stage Three** – Implementation

1.1.1 Stage 1 – Scoping Study, Master Plan Report and Implementation Plan

In order to improve understanding of the area, GCCM prepared a scoping study, reviewing local coastal processes [GCCM, 2000]. A number of options for coastal protection were then generated and evaluated.

The objectives of the strategy were as follows:

- To protect and, if practical, enhance the beach amenity for the community
- To reduce the vulnerability of the beach and beachfront developments to storm damage
- To be a sustainable, cost effective and integrated scheme in accordance with “world best practice”
- To avoid adverse environmental and social impacts

The physical design parameters for the management strategy and any works were:-

- Any beach replenishment work between Currumbin Creek and Tallebudgera Creek be undertaken to achieve conditions providing for the DELFT recommended pre-cyclone buffer of 400m$^3$/m.
- Any structures be able to withstand at least a 1 in 50 year storm event
- Be able to accommodate or be able to be modified to accommodate the expected changes such as sea level rise due to the “Greenhouse” effect over the next 50yrs
- To be designed and managed as an integrated project so as to provide maximum benefits and not to cause adverse impacts on tides, surfing conditions, dredge and deposition areas, sediment transport or the surrounding environment as a whole, both within the study area and within adjacent areas

A short-term and long-term strategy was then recommended [Figure 1]. The strategy proposed is as follows:
Short Term

- Implement programs to upgrade sub-standard public and private boulder walls
- Continue dredging from Currumbin and Tallebudgera creeks.
- Increase regular hydrographic surveys of Palm Beach to provide data for detailed design
- Construct a single reef [with nourishment] in the vicinity of 19th Ave. Palm Beach SLSC to provide increased protection to the beach and properties in this area.
- Undertake detailed studies to:
  - Optimise the Currumbin and Tallebudgera dredging program
  - Identify nourishment sand reserves [offshore and land-based]
  - Design the reef structure and associated nourishment
  - Determine the socio-economic framework for the implementation of a long-term foreshore improvement scheme and associated coastal protection

Long Term

- Prepare plans and preliminary estimates of practical foreshore improvement schemes for public comment and input.
- After adoption of a foreshore improvement scheme, prepare designs and estimates for implementation of:-
  - Foreshore landscaping
  - Coastal protection [such as 3 reefs plus nourishment]

The final master plan proposed by GCCM was adopted by GCCC on 14th December 2001.
Stage 2 – Impact Assessment & Approvals

This stage involved the preparation of a number of very comprehensive reports:

- Detailed impact assessment studies including public consultation for the short-term strategy
- Specific coastal process studies to assess sand reserves and maintenance dredging programs
- Modelling for detailed design of short-term coastal protection
- Determination of monitoring program
- Obtaining necessary Statutory Approvals
- Finalisation of estimates and funding sources
1.1.3 Stage 3 – Strategy Implementation

Once approvals had been obtained, tender documents for beach nourishment and construction of the control structures [to prevent loss of the widened beach] were prepared. Tenders were advertised on 9/8/03. Tenders were received from eight different contractors and the contract was awarded on merit to McQuade Marine on 12th December 2003.

1.2 Community Reactions

A series of community awareness campaigns and documents regarding the details of the works formed an integral part of the PBPS. It was not until after the announcement of start of construction that the first opposition to the project became evident. The community opposition was generated by local surfers and was bolstered by significant press involvement as well as a well-funded “no reef” campaign.

Save Our Surf Incorporated commissioned New Zealand-based consultants ASR Ltd to review the design [ASR, 2004]. Their report was strongly critical of the proposed strategy. Their study was undertaken quickly and was based heavily on output from numerical models developed by ASR. Since this time, their modelling has been replicated by GCCC using the well-respected and widely used numerical model DELFT 3D [DELFT Hydraulic, Netherlands] using GCCC survey data from 2002 to create the bathymetry. Comparison between these results and the ASR Ltd report revealed that ASR Ltd included significant inaccuracies and assumptions, including:

- The ASR modelling was based on incorrect bathymetry and the control structure configurations used in their modelling were not the same as those presented in the Stage 2 PBPS Design report.
- Figure 5.3 in the ASR [2004] review [currents analysis] shows rip currents of more than 1 m/s at <20m centres. This is physically incoherent and is likely the result of a model default.
- Figure 5.4 in the ASR [2004] review [wave breaking analysis] is based on the same model and is therefore also incorrect
- Only a small range of conditions were considered

It has been concluded that the work done by ASR Ltd was narrowly focussed on one aspect of the overall PBPS strategy and was of little value in terms of providing an objective and scientifically robust assessment of the proposed coastal control structure design and its impacts.

1.3 PBPS Consultative Committee

In February 2004, GCCC decided to form a consultative committee to resolve community concerns. The recommendations made by the PBPS Consultative Committee on 19th August 2004 are below:

1. Implement programs to upgrade substandard public and private boulder walls. This should be given the highest priority. Consideration should be given to incorporating public footpath access along the length of Palm Beach.
2. Continue dredging from Currumbin and Tallebudgera creeks, continue associated beach nourishment proposal and review funding levels.
3. Increase environmental study and hydrographic surveys of Palm Beach and complete littoral review and biodiversity study.

4. Implement vegetation protection strategies.

5. Pass resolution through Council to delete the submerged coastal control structure [artificial reef] in its present form from the current PBPS.

6. Continue consultation through a consultative committee, particularly in view of Council entering into long-term contracts for PBPS.

1.4 Independent Peer Review

As a result of the community reaction to the project, GCCC also commissioned Prof Colin Apelt [BE, DPhil(Oxon), FIEAust, CPEng, RPEQ] in February 2004 to undertake a detailed review of the planning and design activities undertaken by GCCM relative to the Palm Beach Artificial Reef.

This review was completed on 20/7/04 and determined that:

- “GCCM [had] expended a very large effort on community consultation, with a limited budget and as directed by GCCC, and that it had done a careful and thorough job.” It was considered unfortunate that making contact with potentially problematic stakeholders was difficult if not unachievable.

- “The strategy objectives and design criteria developed in stage 1 are considered satisfactory” although it was “recommended that GCCC … [specify] the desired/designed minimum profile.”

- Regarding the effects of the Tweed River Training Walls, “it is recognised that it will be a considerable time, of the order of 20 years, before Palm Beach receives significant benefit from the Tweed Entrance Bypass. Therefore, a decision is required concerning what protection would be provided to Palm Beach in the short term”

- With regard to the strategy by GCCM, Prof Apelt commented as follows:
  - Upgrade rock walls “endorsed without reservation”
  - Continue creek dredging “endorsed without reservation”
  - Increase surveys “endorsed without reservation”
  - Beach nourishment “endorsed without reservation”
  - Control Structure “endorsed”

- Control Structure – general comment
  - Prof Apelt stipulated that there is a “need for some type of control structure in conjunction with beach nourishment if a widening of the beach is to be sustained” and “in the light of the success of the Narrowneck reef in widening the beach there, it is reasonable to consider use of a submerged control structure to achieve a similar objective at Palm Beach.”

- Control Structure – Salient size
  - “variables … such as reef geometry, wave climate and its variability, littoral drift patterns and sand supply … may cause reality to differ in a particular case from the simple relationship used for estimation of the salient.”
  - “The designers’ extensive experience, especially that derived from Narrowneck reef, is acknowledged … however it is not clear to what
extent the experience with the essentially shore-normal reef at Narrowneck applies to the proposed shore-parallel reef at Palm Beach.”

- Control Structure – Surfing
  - “What is the quality of the surf at Palm Beach?”
  - “Can surf quality be defined in such a way that it can be measured? Or must it always be essentially a matter of opinion?”
  - “Can intensity of wave breaking be defined in such a way that it can be used as a measure of surf safety without ambiguity?”
  - “What, if any, change to that surf would be acceptable to the surfing interests represented on the PBPS Consultative Committee?”
  - “What is the measure of surfing enhancement?”

- Control Structure - Crest height and safety
  - “Concern has been expressed about safety aspects of the design of the reef and about its impact on surfing.”
  - “in considerations of safety, it seems reasonable to expect, as a norm, that surfers will be sufficiently safety conscious to avoid very dangerous conditions. But what would be the situation if a surfer were injured at a structure built for GCCC in circumstances that he/she should have avoided? The reviewer has no expertise in this matter but raises the question whether the GCCC would be at risk from liability claims in such circumstances?”
  - With regard to GCCM suggestion to undertake construction with crest levels lowered by 1m initially, it was “considered to be a reasonable proposal”.

- Multiple control structures
  - “the unstated assumptions are that each reef will create its own separate salient, that there will be no interaction between the reefs and that the effect of each of the three reefs will simply overlap that of the others. These assumptions imply a simple linearity that is thought to be unlikely. The question is whether the wave climate will ‘see’ the reefs as individual reefs or as one long ‘leaky’ reef?”

- Control Structure - construction materials
  - endorsed use of geotextile containers

- Control Structure – staged construction
  - “the spectrum of options for Stage 2, ranging from completing the reef as designed to leaving the base only as a low berm, indicate that the proposed Palm Beach reef is seen as an R&D project, the outcomes for which cannot be fully guaranteed in advance.”

- Numerical models
  - “Their purpose and correct use is to be an aid to judgement, not to provide a description of reality.”
  - “The reviewer is not aware of the existence of data that would enable any of the models to be calibrated for application to the Palm Beach reef. Without calibration, the results produced by any model must be treated with caution; they cannot be relied on to give accurate detailed results.”
“Within these constraints, the numerical modelling … appears to have been done competently and with awareness of its inherent limitations.”

The reviewer identified two options for advancing the construction of a submerged control structure if this is to proceed:

1. Proceed with construction following the staged approach with extensive monitoring recommended by GCCM and setting maximum crest levels 1m lower than original levels, as recently proposed by GCCM.

2. Use a physical hydraulic model to check the effectiveness of the control structure for beach protection and to assess its impact on surfing amenity.

### 1.5 Council Resolution

On the 22nd November 2004, Council resolved [CI04.1104.007] to do the following:

1. That the 19th Avenue reef in its current form be deleted from the Palm Beach Protection Strategy Master Plan.

2. That the current works program (Contract LG314/254/04-076) to deliver 150,000 m³ of sand nourishment to Palm Beach be completed and that no further nourishment be undertaken until after future consideration by Council.

3. That a report be prepared into options for accelerating the completion of both public and private oceanfront seawalls throughout the City.

4. That the Chief Executive Officer write to the Environmental Protection Agency requesting that the following issues are included as part of the Gold Coast littoral environment review:
   a. Whether a reef should form part of a future beach protection strategy for Palm Beach.
   b. Increased environmental (biodiversity and hydrographic) survey of Palm Beach Environments.
   c. Vegetation protection strategies for Palm Beach.
   d. Coastal access opportunities to Palm Beach.
   e. Dredging programs for Tallebudgera and Currumbin Creeks.

5. That Prof Apelt and the members of the Palm Beach Protection Strategy Consultation Committee be thanked for their contribution to the review of the Palm Beach Protection Strategy.

This report is prepared as part of the development of the Gold Coast Shoreline Management Plan to address resolution 4, with particular emphasis being given to resolution 4a. The remainder of this report is structured as follows:

- **Section 2** Coastal Control Structure
- **Section 3** Environmental Issues
- **Section 4** Vegetation Protection Strategy
- **Section 5** Coastal Access
- **Section 6** Currumbin and Tallebudgera Dredging Programs
- **Section 7** Recommendations
2 COASTAL CONTROL STRUCTURES

This section deals with Council Resolution 4a as set out in Section 1.5 of this report.

2.1 Present Behaviour of Palm Beach

2.1.1 Physical Environment and Processes – Tides

The tidal cycle for the Gold Coast beaches is semi-diurnal [Table 1]

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<tr>
<td>MHWS</td>
<td>+1.63m</td>
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<tr>
<td>AHD</td>
<td>+0.98m</td>
</tr>
<tr>
<td>MLWS</td>
<td>+0.31m</td>
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</table>

2.1.2 Waves

The normal condition is a swell direction varying between northeast and southeast sectors with a mean significant wave height of approximately 1m. The area is, however, often exposed to energetic swells during the year.

Three swell regimes can be considered dominant on the Gold Coast dynamic shoreline:

- SE [110°]: South to Southeast swells in winter and spring, generated by intense low pressure systems off the New South Wales coast. These contribute the main component of the northerly littoral drift and are most common.

- ENE [60° - shore perpendicular]: East Coast Lows. These are fairly common, often resulting in strong wind gusts, high waves and storm surges.

- NE [20°]: Tropical cyclones. These are not responsible for the majority of the high wave events on the Gold Coast; however they have the highest potential for destruction, with significant wave heights up to 8m.
2.1.3 Littoral Drift

Longshore currents are generated as a result of waves breaking at an angle to the shoreline. The amount of longshore sand transported is dependant upon the wave energy, angle of incidence, slope of beach, ripple height and the mean particle size. Sand in the Gold Coast tends to be transported in and near the surf zone in a depth of water generally less than 15m. The DELFT report [1970] established that the longshore drift results in a net northerly littoral transport approximately 500,000m³ on the Gold Coast.

2.1.4 Offshore-Onshore Transport

The onshore-offshore transport at Palm Beach is not equivalent along the entire length of the beach. The beach is principally made of sand and rocky reefs. It is located between two relatively close headlands with two estuaries at each extremity. Two different compartments may be identified [Figure 2]:

- The north part of the beach behaves similar to a straight sandy beach, building a storm bar with sand stirred up from the berm.
- The south part of the beach, an external delta is observed. This accreted sand volume acts as a continuation of the headland contour and causes wave refraction. Because of its location downdrift of the headland and the reverse current circulation, removing the sand from this platform [external delta] would create a sink in the littoral transport and downdrift erosion on Palm Beach and Currumbin Creek Spit. [GCCM, 2001]

Figure 2: Accretion and erosion of sediment on Palm Beach
2.1.5 Past Coastal Protection Works

Over the last century, Palm Beach has been severely eroded several times. Training works have been built to stabilize Currumbin and Tallebudgera Creeks, although dredging campaigns are still necessary to avoid infilling of the two entrances. Seawalls and groynes have been implemented on the beach and the growth of the dune now provides a real protection for the private properties located at either end of Palm Beach. While several beach nourishment campaigns have widened the beach for a limited period, a sustainable solution needs to be implemented. A summary has been provided in Table 2.

Table 2: Summary of Dredging & Other Works

<table>
<thead>
<tr>
<th>Year</th>
<th>Currumbin Dredging, m³</th>
<th>Offshore Dredging, m³</th>
<th>Other works</th>
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<tr>
<td>1968 - 1972</td>
<td>0</td>
<td>0</td>
<td>Private rock walls</td>
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<tr>
<td>1972</td>
<td>0</td>
<td>0</td>
<td>Currumbin Ck Groyne (stage 1)</td>
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<td>1973</td>
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<td>1974</td>
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<td>1976</td>
<td>111,325</td>
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<td>Tallebudgera Ck groyne (Stage 1)</td>
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<td>1979</td>
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<td>Tallebudgera Ck training wall (Stage 2)</td>
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<td>Palm Beach Mini Groynes</td>
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<td>2001</td>
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<td>2002</td>
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<td>2003</td>
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<td>Tender for PBPS awarded to McQuade Marine</td>
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<td>2004</td>
<td>29,946</td>
<td>145,446</td>
<td>Proposed control structure deleted from strategy after community consultation</td>
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<td>2005</td>
<td>38,086</td>
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<tr>
<td>2006</td>
<td>37,274</td>
<td>101,147</td>
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2.2 Numerical Modelling

Numerical modelling was undertaken during the development and design of the PBPS. It was recognised that numerical models were a useful tool, but had inherent limitations, particularly when it came to replicating the behaviour of submerged structures. As such, two different models - REF/DIF-1 and DELFT3D-SWAN - were utilised in the analysis of the proposed structures. While the individual results seemed to be acceptable, there were significant differences between the wave fields predicted leeward of the structure by the two models.

To provide additional information regarding the interaction with the previously proposed structures for the review process, further numerical modelling has been undertaken, as detailed below.

2.2.1 Model Selection

Modelling has been undertaken using the DELFT3D package developed by DELFT Hydraulics. DELFT3D is a software package which consists of several modules coupled together to provide a complete picture of three-dimensional flow, surface waves, water quality, sediment transport and bottom morphology in complex coastal areas. The modules to be used in the study are WAVE and FLOW [including sediment transport]. DELFT3D has been used extensively world-wide for coastal process studies and is well suited for beach and tidal inlet morphodynamics and hydrodynamics.

2.2.2 Model Setup

The bathymetric data of Palm Beach was derived from a GCCC survey from 2002 that provided accurate data for the beach and nearshore region, the natural offshore reef and the Currumbin and Tallebudgera Creeks. This provided the existing bathymetry file.

The design of the proposed control structures [Figure 3] was overlaid onto the existing bathymetry to create a new bathymetry file [Figure 4].

Figure 3: Idealized design of proposed control structures
2.2.3 Existing Behaviour

Model runs of velocity fluctuations under existing conditions were tested under different swell directions. Results [Figure 5] show that velocities range from 0 to 0.4 m/s. As expected, flow directions range from a generally southerly flow in northerly conditions to strongly northerly flow associated with the more common south-easterly swell [and northerly littoral drift]. In the case of a more easterly swell direction, currents converge on central Palm Beach [in this case around 11th Ave] and create a seaward current. This is expected as, in these conditions, rips would be common.

a) Swell direction :

20° - NE

Almost constant downdrift along the beach and aroundCurrumbin Rock.
b) Swell direction:
60° - ENE

Light currents from the north and the south converge around 11th Ave and Thrower Dv. These currents escape seaward.

c) Swell direction:
110° - ESE

Almost constant updrift along the beach and around Burleigh Head.

Figure 5: Velocity Fluctuations under Existing Conditions

[H = 2m; T = 10s; WL = MSL; swell direction = a) 20°, b) 60° & c) 110°]

In order to make some evaluation of the impact of the natural offshore reef, models were also undertaken with the natural offshore reef deleted from the bathymetry. Results [Figure 6] indicated that there was little change in wave direction [likely due to the depth of the reef], although the reef did influence wave shoaling. In larger conditions, it is likely that the effect of the reef on wave conditions would be greater.
a) Natural reef: deleted

Waves are focused on the headlands and in the middle of the beach. The refraction phenomenon is acting as a horseshoe bay.

b) Natural reef: present

Wave shoaling is present, but wave direction does not change. This can be explained by the depth of the reef. [10 to 20m]

Figure 6: Wave heights a) without and b) with the natural offshore reef
[H = 2m; T = 10s; WL = MSL; swell direction = 60°]

2.2.4 Behaviour with Proposed Control Structure

Dissipation in storm conditions
The model was run for storm conditions with $H_s$ of 5m to evaluate the performance of the structure. This is approximately equivalent to a 1996 event which is deemed to have had a return period of 1 in 5 – 10 years. Wave height plots [Figure 7] show that wave heights in the lee of the structures is 30 – 50% lower than incident wave height.
a) Swell direction:
20° - NE

Wave breaking occurs just shoreward of the control structure and links with the storm bar.

b) Swell direction:
60° - ENE

Wave breaking occurs just shoreward of the control structure and links with the storm bar.

c) Swell direction:
110° - ESE

Wave breaking occurs just shoreward of the control structure and links with the storm bar.

Figure 7: Wave height
[H = 5m ; T = 14s ; WL = MSL ; swell direction = a) 20°, b) 60° & c) 110°]
This is supported by plots of energy dissipation [Figure 8], which show significant dissipation [up to 2000 - 3000N/ms] on the control structure during these larger wave heights.

This is consistent with wave breaking on or just shoreward of the control structure, possibly merging with a milder break on the adjacent storm bar during these larger conditions, as intended in the design. It should be noted, however, that this level of dissipation [and associated wave height reduction] does not occur with more typical wave conditions.

**Rip Systems**

To evaluate currents, the model was run for wave heights of 2m. These conditions are high for the average swimmer and provide an indication of maximum current strength while the beach is usable by the general public. Results [Figure 9] indicate that velocities ranged from 0 to 1 m/s. Maximum currents recorded were alongshore and not directly in the lee of the control structures. Seaward rip currents that developed between the reefs were generally fairly mild [up to ~0.4m/s] and similar to those experienced in existing conditions.

In storm conditions \([H_s = 5m, T = 14s]\), results [Figure 10] indicate that currents can reach up to 1.5m/s between the structures and up to 1.5 - 2m/s over the crest of the structure in places. In these conditions, however, it is unlikely that this will be an issue in terms of swimmer safety. Similar to existing conditions, rip currents were maximum and more complex when the wave direction was shore-perpendicular.

The model indicates that the control structures should effectively stabilise the formation of the rip currents and make them behave in a more predictable manner, generally improving surf safety.

**Sediment Transport and Salient Formation**

To provide a preliminary indication, the morphological model was run with average wave conditions \([H = 1m \text{ from ESE}]\) for a period of one month with a morphological coefficient accelerator of 24 [i.e. for one simulated month, the beach morphology changes the equivalent of 24 months or two years]. As the simulation only incorporates one type of swell and the boundaries are not fully calibrated, it cannot be used to provide an accurate prediction of salient development or size. It does, however, provide an indication of how the beach could respond to the proposed control structures in typical conditions.

The results showed that the existing beach [Figure 11] evolved to create a new bathymetry [Figure 12] with a wider beach and distinct salient features associated with each control structure. It is noted that the salients formed north of the associated control structure, although this is likely due to the orientation of the incident waves, which do not allow for averaging of variable wave conditions over time.
a) Swell direction:

20° - NE

Significant dissipation occurs on the control structures [up to ~5 times more than the beach].

b) Swell direction:

60° - ENE

Significant dissipation occurs on the control structures [up to ~5 times more than the beach].

c) Swell direction:

110° - ESE

Significant dissipation occurs on the control structures [up to ~5 times more than the beach].

Figure 8: Dissipation [from 0 to 3000 N/ms] at mid-tide for different swell directions

[H = 5m; T = 14s; WL = MSL; swell direction = a) 20°, b) 60° & c) 110°]
a) Swell direction:

20° - NE

The wave energy is strongly focused by the natural reef in a north easterly swell. The control structures reduce this energy, offering protection to the beach.

b) Swell direction:

60° - ENE

The easterly swell is also focused by the natural reef, although this is substantially reduced by the control structures.

c) Swell direction:

110° - ESE

Currumbin rock provides protection to the southern beaches with southerly swell and the control structures continue this protection on the more northern sections.

Figure 9: Energy [W/m

\[H = 1.5m ; T = 8s ; WL = MSL ; \text{swell direction} = \text{a) 20°, b) 60° & c) 110°}\]
Figure 10: Velocity Fluctuations

[H = 2m; T = 8s; WL = MSL; swell direction = a) 20°, b) 60° & c) 110°]

a) Swell direction: 20° - NE
Little rip currents are visible between the control structures, but are not dangerous (1 km/h). Longshore current near the beach seems to be decreasing in the lee of the control structures.

b) Swell direction: 60° - ENE
Small rip currents between the control structures. Weak, disorganized currents in the lee of the control structures.

c) Swell direction: 110° - ESE
Weak rip currents between the control structures. Longshore current is attenuated in the lee of the control structures.
a) Swell direction: 20° - NE

Significant southerly current along the beach is deviated offshore between the control structures. Before Currimbin Rock the current turns eastward along the shoreline.

b) Swell direction: 60° - ENE

Strong currents coming from the north and south are meeting each other in the lee of the two southern control structures. Here the current dissipates, creating a series of circulation cells before escaping seaward.

c) Swell direction: 110° - ESE

Strong northerly current along the beach is deviated offshore by the control structures.

Figure 11: Velocity Fluctuations

[H = 5m; T = 14s; WL = MSL; swell direction = a) 20°, b) 60° & c) 110°]
2.2.5 Alternate Configurations

There are numerous possible design combinations. As part of this study, further design options have been investigated.

**Lowered Crest [Staged Construction]**

It has been suggested that initial construction could be limited to the first layer of the control structure [Figure 13]. This would provide an indication of its affect and provide some measure of protection in larger storm events.
The results [Figure 14] show a light effect can be observed on waves as a result of the control structure with the lowered crest. This demonstrates that placement of the first layer can successfully provide an indication of the effect of the structure.
**Altered Spacing between Control Structures**

The spacing between the reefs has an impact on the currents experienced between the reefs. The reefs were modelled and the results [Figure 15] show that with a spacing of some 600m [as opposed to the design spacing of 320m], the rip cells are less defined.

![Figure 15: Velocities with spacing increased to 600m](image)

[\text{H = 1.0m ; T = 8s ; WL = MSL ; swell direction = 110°}]

It is noted, however, that rip currents are a normal feature on Gold Coast beaches and the modelled velocities were typical of the natural conditions and were generally within a range considered to be safe for swimmers.

**Extended Length of Control Structure**

The effect of linking two of the control structures was also investigated. This scenario was considered as a community view was expressed that the individual reefs were not long enough to provide any meaningful protection. Results [Figure 16] show that linking the two control structures did not result in enhanced coastal protection. While there were no seaward currents, the longshore current remained with an oblique swell. There appears to be no significant benefit associated with replacing the three structures with a single elongated structure.
a) $H_s$ [m]

Waves break on the structure. Waves are generally smaller in the lee of the control structure.

b) Energy transport [W/m].

Energy is dissipated on the control structure and reduced in its lee.

c) Current [m/s]

A significant current is observed on the north wing. The current on the lee of the control structure is attenuated.

Figure 16: Elongated control structure
– results of a) wave height b) energy and c) current [$H = 2.0$ m; $T = 8$ s; $WL = MSL$; swell direction = $110^\circ$]
**Shape of Control Structure Similar to Narrowneck Artificial Reef**

The shape of the Palm Beach reefs is a result of an evolution of the original Narrowneck design - modified for the site conditions, lessons learnt from other preliminary designs, objectives and requirements at Palm Beach. Particularly, the design reflects the reduced focus on surfing and the need to reduce the overall cost [and volume] of the structure.

For comparison, the bathymetry of the Narrowneck artificial reef has been overlaid onto the existing Palm Beach bathymetry [Figure 17]. As there are obviously differences in the beach profile between Narrowneck and Palm Beach, to have a coherent bathymetry the Narrowneck artificial reef has been placed slightly closer to the shore just inshore of the natural offshore reef.

![Figure 17: Palm Beach bathymetry overlaid with Narrowneck artificial reef.](image)

While results of modelling indicate that it has the potential to dissipate wave energy, [Figure 18 & Figure 19] sediment transport is unpredictable [Figure 21] and it is possible that it would result in erosion in its lee. This is likely due to the fact that it is closer to the shore.

This type of structure is well-suited to refract waves and dissipate energy and has the potential to provide improved surfing, although this would need to be more fully investigated. Safety would also need to be more fully considered and it is likely that, similar to Narrowneck, the crest height would need to be lowered to a more suitable level. This is confirmed by the high currents experienced on the reef [Figure 20].
a) Swell direction:

20° - NE

Waves are focused on the artificial reef because it is just in the lee of the natural reef. Waves are breaking on the reef.

b) Swell direction:

60° - ENE

Waves are significant all along the beach with a front swell. They are breaking also on the artificial reef.

c) Swell direction:

110° - ESE

There is attenuation behind Currumbin rock with a southern swell.

Figure 18: Wave Heights

[H = 2.0m ; T = 8s ; WL = MSL ; swell direction = a) 20°, b) 60° & c) 110°]
a) Swell direction:
20° - NE

The energy is attracted by the headland and the artificial reef. To the north of the reef energy is reduced.

b) Swell direction:
60° - ENE

Wave energy is significant along the beach, except for an area south of the artificial reef.

c) Swell direction:
110° - ESE

Wave energy is focused on the shallow crests of the artificial reef. From Currumbin Rock to the reef, the energy is weak near shore, but further north it increases.

Without the artificial reef, models show weak energy all along Palm Beach.

Figure 19: Energy Transport

[H = 2.0m ; T = 8s ; WL = MSL ; swell direction = a) 20°, b) 60° & c) 110°]
a) Swell direction: 20° - NE

There is a strong longshore drift of around 3 m/s in the lee of the reef, indicating the reef is located too close to the beach.

b) Swell direction: 60° - ENE

The main currents are located near the headlands. Currents are weak in the middle of the beach.

c) Swell direction: 110° - ESE

The velocity south of the reef is mild while the current is accelerated northward of the reef.

Figure 20: Currents

[H = 2.0m ; T = 8s ; WL = MSL ; swell direction = a) 20°, b) 60° & c) 110°]
Figure 21: Sediment Transport

\[ H = 2.0 \text{m} ; T = 8 \text{s} ; \text{WL} = \text{MSL} ; \text{swell direction} = 110^\circ \]

### 2.3 Recent Knowledge Gained

Since the Council resolution, additional information has been obtained about the site and the effectiveness of other elements of the PBPS as well as general advances in the field of reef design and construction.

#### 2.3.1 Additional Information for Peer Review

During the independent peer review, an addendum to the Stage 1 and 2 reports was prepared by GCCM [2004] to provide further detail regarding areas that had been queried during the community consultation process. This included the effect of the Tweed bypassing, adequacy of survey data, coastline evolution and storm cut. It also included greater detail on the options considered and the performance of the submerged control structure in terms of salient size, safety and the effect on surfing. Key findings from the addendum are as follows.

**Tweed Bypassing**

Previous detailed analyses of the sediment budget of the southern Gold Coast beaches has been undertaken by the BPA, NSW PWD, DELFT [on behalf of BPA] and independently by GCCC in partnership with UNSW. These analyses have been based on beach profile survey data. Shoreline evolution modelling has not been carried out to date except for isolated projects, such as the N-Line [US Army CERC] modelling undertaken for the first nearshore nourishment at North Kirra in 1985.

A conceptual model of the gross sediment dynamics between Fingal Head and North Kirra was developed in the late 1980s [Figure 212] and detailed sediment volume changes and inferred longshore transport rates calculated by the BPA [1984] and DELFT [1992] as given in [ ]
Figure 23 &

Figure 24]
Since the inception of the Tweed River Entrance Sand Bypassing Project [TRESBP] in the late 1990s regular surveys and beach profile analysis has re-commenced. Although this work is backed up by significant budgets and graphical outputs, the focus is on the contractual issues associated with the dredging and sand pumping. No overview analysis or extension of the DELFT work has been published.
Figure 23: Tweed Erosion Wave 1963-1983

Figure 24: DELFT [1992] Sediment Budget Analysis
From the available data a conceptual broad scale model of the sediment budget of the Fingal Head to Currumbin coastline has been developed as a basis for an assessment of sediment supply to the Palm Beach compartment in the past and of the impact of the TRESBP in the future. This was not undertaken at the time of the preparation of the PBPS Stage 1 report, but supports the expert opinion expressed in that report.

It should be noted that the following assessment is based on reliable surveyed volume changes and sand pumping rates as well as assumptions based on knowledge of the coastal processes in this region.

**Conceptual Model for Tweed Bypassing**
A conceptual model of overall sediment volume changes is shown in Figure 25 based on the DELFT data and earlier work. The model assumes an average longshore transport rate of 500,000m$^3$/year, although the recent TRESBP data suggests a higher rate in recent years [~670,000m$^3$/year].

For the years 1963 to 1989, the transport rates and volume changes are based on surveyed profile analysis. The resulting transport rate leaving the compartment is inferred to be a little less than the input at Fingal Head. It is clear that in the absence of the commencement of the offshore nourishment there would have been considerable more exposure of rock walls in the Kirra – Currumbin region.

Given the presence of fully established beach profiles in the northern end of the compartment (Bilinga-Tugun area), it is reasonable to assume that the longshore
transport potential is satisfied by the available sand. Hence there should have been no “trapping” of sand south ofCurrumbin, and consequently, Palm Beach was receiving a full longshore supply.

For the period 1989 to 2003, the model relies on available TRESBP data for Fingal Head to Tweed covering 2000 to 2003 and for Tweed to Currumbin for 1994 to 2003. As there has not been any available detailed analysis from 1989 to 1994, assumptions have been made to extend the model for this period.

The assumed conditions for 1989 to 2003 result in an inferred transport rate at Currumbin in excess of the input at Fingal, but this is consistent with the DELFT data for 1983 to 1989. There has also been a recovery of the Point Danger to Currumbin compartment mainly due to the offshore nourishment. The sand pumping and Tweed Entrance dredging data shows, however, that the TRESBP program has hardly kept up with the natural longshore transport rate.

In Figure 26, a combined assessment is given for the period from 1963 to 2003, from which it can be inferred that the impacts of the 1962-64 extension of the Tweed training walls have been confined to the Fingal-Currumbin compartments. It is also clear that the recent TRESBP activities can only – as planned - replace the natural bypassing of Point Danger. The system has of course been over-pumping in an attempt to rapidly overcome the deficit on Gold Coast beaches remaining after the nourishment from offshore. This deficit has still not been fully met and from Figure 27 it is assessed that at least another 2.5 million m³ is needed primarily to fill in the erosion deficit in the Bilinga – Tugun area.
Figure 27: Future TRESBP Requirements

Overall it would appear that in the absence of the offshore nourishment in the late 1980s and 1990s, the erosion shadow would have been extended significantly further to the north and possible well into the Palm Beach compartment. Indeed the TRESBP detailed data shows that the section of coast from Bilinga to Flat Rock atCurrumbin has been consistently eroding from 1994. [Figure 28]
Survey Data
It is noted that, while there is not full and regular comprehensive surveys of the entirety of Palm Beach, and more was desirable for the numerical modelling, this data and other data [such as aerial photographs] is more than adequate for shoreline evolution modelling. This data is more comprehensive than that typically undertaken on many coastal engineering investigations. The aerial photographs of Palm Beach undertaken by BPA since 1956 are numerous and were included in Appendix I of the Technical Report. Additionally, there is much qualitative data derived from direct observations of Palm Beach over the past several decades, particularly on occasions where large wave conditions resulted in exposure of the boulder wall [as occurred in 1959, 1967, 1969, 1972, 1973, 1974, 1976, 1978 and 1982].

Coastline Evolution
The Stage 1 report concluded that the Palm Beach compartment was most likely to have been impacted by the Tweed erosion wave in the short term, but that overall the compartment shoreline has been stable for over 40 years. The artificial re-establishment of longshore transport past Point Danger with the TRESBP program will ensure that this long term stability in longshore sand availability continues.

While there is presently an oversupply of sand into the Coolangatta embayment, there is no mechanism for this to provide additional sand into the system in the long-term. It is possible, however, that the short term oversupply from TRESBP onto the upper beach profile between Point Danger and North Kirra may work its way northward as a dispersing slug and provide a short term oversupply to Palm Beach at some stage over the next two decades.

Claims by the community during consultation in 2004 that the TRESBP sand had reached Currumbin Creek several years previously and had resulted in the blocking of the entrance is not supported by any of the available data, which showed continuing erosion from Bilinga to Currumbin since 1994 [Figure 28]. A more realistic explanation may be that more energetic swell conditions resulted in the release of a mini-slug past Currumbin Rock or that a slug originating in an earlier nourishment [1985 or later] may have reached the area.

Shoreline modelling using GENESIS was carried out using the methods developed by WRL and GU for modelling the effects of Narrowneck reef, however the results were not relied upon as results replicating existing shoreline conditions and known interactions with reef-type control structures were inaccurate.

Shoreline evolution was undertaken using analysis of shorelines extracted from a comprehensive series of aerial photographs taken by the BPA since 1956 [Appendix I of the Technical Report]. While there is some uncertainty with regard to tidal level at the time of the photos, they provide valuable long-term data on shoreline evolution and trends, including response to storm conditions, previous nourishment works and groyne construction.

Overlays of shorelines for the past 40 years show that the construction of the training walls at Tallebudgera Creek [1976 – 1979] and Currumbin Creek [1980] has resulted in a substantial realignment at the north and south ends. The Tallebudgera Creek training wall acts as a groyne and analysis shows that the post-groyne realignment was well developed by 1982 [Figure 29]. The mini-groynes have had only minor impacts and even with over 2 decades of “mild” weather, the central section of Palm Beach has remained relatively narrow and variable [Figure 30].
Analysis of beach width at the 19th Ave SLSC over the last 10 years [post Tallebudgera Creek training wall realignment] shows that there has been ~80m of natural shoreline variability [Figure 31]. With a more comprehensive dataset, this figure could be even higher. Thus, there is presently an inadequate buffer zone to accommodate normal variations, even without significant storm events.

Figure 29: Evolution of Palm Beach
On the Gold Coast, the wave climate and coastal processes are highly variable and sand transport rates [alongshore and x-shore] and storm cut volumes are high.
Storm surge, local rip cells etc complicate sand transport and storm cut calculations. As found by WRL in their storm cut analysis for the Northern Gold Coast Beach Protection Strategy [NGCBPS], the cumulative erosion effects of multiple storms are significant and difficult to model with any useful accuracy [WRL, 1998]. Deft [1970] had similar problems and used a volume of about 400m³/m for 1967 erosion events. The 1967 cumulative storms and cyclones are considered to be anywhere between a 1 in 25 to 50 yr event. Old erosion scarps have been found during building excavation works at Broadbeach over 100m shoreward of the present boulder wall alignment. For NGCBPS, a 50m storm cut [min] was determined for a nominal 1 in 50 yr event. Rips increase the local storm cut significantly. However, a lesser level of protection and cost was considered acceptable and the target was a 30-50m beach widening at the narrowest section, Narrowneck. A similar target was suggested and adopted for the central section of Palm Beach. A full re-assessment of storm cut is being undertaken as part of the Shoreline Management Plan.

**Options**

The expert assessment of the “stability” of Palm Beach shoreline concluded that ongoing erosion back to the seawall along the central section will be an ongoing problem. “Do nothing” options are not supported due to economic, amenity and safety issues. It is much better to implement well designed and constructed works at the best price in “good” weather rather than expensive knee jerk reactions during or after a severe erosion event. The safety risks associated with emergency erosion protection works should not be underestimated.

Extension of the Tallebudgera training wall is an obvious solution, but was not determined to be feasible because lengthening of the groyne to any significant extent would be detrimental to the effectiveness of sand bypassing to Burleigh without a sand bypass system. It would also require large nourishment quantities with the maximum benefit at the northern end of Palm Beach [where there is already a wide beach].

If the shoreline is extended seaward by large-scale nourishment, it would be out of equilibrium with the current alignment and gradually disperse out of the compartment. This was considered unsustainable in the long-term. Localised nourishment [e.g. between the mini-groynes] would behave in a similar way to previous attempts – without an artificial structure to maintain the artificially widened beach, the increased erosion rates experienced after placement of such a ‘slug’ of sand result in little short-term benefit and no long term benefit.

Extending the existing groynes or additional groynes was an option, but submerged control structures and associated nourishment are considered to provide the best solution to realigning and protecting the shoreline along the narrow central section without adversely impacting downdrift.

**Control Structure Performance - Salient Size**

The GENESIS model has been upgraded recently to better incorporate the effect of submerged control structures, however past experience and preliminary runs of GENESIS for Palm Beach show that the model performs poorly. As such, further investigation into GENESIS would have been inappropriate.

The calculation of salient size was empirically based. The empirical formulae used to predict salient size is based on a number of dominant variables, namely structure length parallel to the shoreline, distance offshore and crest depth. The relationship was derived from natural nearshore reefs located exclusively on the eastern
Australian coastline in order to reduce variability introduced by differing wave climates and sediment size. It is noted, however, that salient size is not constant but retains a degree of variability over time in response to the prevailing wave conditions.

**Control Structure Performance - Safety**
Safety in the coastal zone is a complex issue not able to be addressed by a few formulae. Safety to surfers and swimmers is primarily due to rips and wave “dumping” [plunging waves breaking in shallow water]. Spinal injuries usually occur in the shorebreak where steep waves plunge into shallow water.

Use of wave breaking intensity formulae has led to the inappropriate comparison of the proposed low-crested Palm Beach control structures to Shark Island [Cronulla], which at times can be a very dangerous natural break over a very shallow [above LAT], steep and jagged rocky reef.

Physical model testing [Corbett & Tomlinson, 2002] indicates that crest level is a critical determinant of safety and the levels specified have been modelled using flume testing and verified in the real world at Narrowneck. Crest heights have been kept well below low water and a toe to seaward of the structure has been added to provide roughness and flatten the effective seaward slope to promote a spilling wave break for increased safety and energy reduction.

**Control Structure Performance - Effect on Surfing**
Initially, it was considered by GCCC that surfing was not to be a primary issue in this location for a number of reasons. These included the view that Palm Beach is not generally recognised to be a key surfing location and the lack of suitable facilities and car parking to support a “high quality” and popular surf break in this location. As such, the original objective of the strategy is “not to cause adverse impacts on … surfing conditions” [GCCM, 2001]. In the development of the PBPS, GCCM understood that it was not engaged to develop a surfing reef, but to design a coastal point, if required. Although the area was not identified by Council as a key surfing location, it still provides a range of surfing experiences for the broader surfing community and at times some quality shore breaks are generated at locations where it has been identified that banks will form, and in particular as part of the overall sand transport mechanisms near the Currumbin Creek entrance (GCCM, 2004a). Local surfers have identified this bank feature for many years and in general have noted excellent banks along the section of beach from 11th Avenue to 4th Avenue with multiple banks and well defined take-off points. Away from these specific locations, the view expressed in earlier reports is that for wave heights which would be influenced by the submerged control structure, the general beach conditions would not be favourable for surfable shorebreaks.

When assessing the impact of the proposed strategy on surfing, both the frequency of wave breaking and the quality of the break needs to be considered. While wave breaking frequency is relatively easily established, break quality is subjective and is strongly related to the type of surfing, personal preference and individual skill level [Jackson, Tomlinson & D’Agata, 2001]. While there is increasing documentation regarding measuring waves for surfing, there is often a tendency to concentrate on a single craft - short surfboards.

The assessment of the effects of the control structure are based on the experience at Narrowneck and natural reef breaks, numerical modelling using REFDIF and DELFT3D-SWAN, physical model testing of similar profiles and extensive surfing experience. Extensive work undertaken indicates that, while wave dissipation,
particularly in larger wave conditions, will occur, waves will reform and continue to break as a shorebreak in the lee of the proposed control structures. The formation of a salient and favourable offshore bar formations in the lee of the control structures will likely result in an improvement to body and craft surfing in the lee of the control structures. The addition of wings on the structure itself, while improving the effectiveness of the structure in terms of beach protection, also provides the potential for surfing offshore. The wings will initiate wave breaking further seaward than the shore parallel bar, providing a “take off” location. There is flexibility to extend the wings in the future to further enhance surfing opportunities.

2.3.2 Recent Observations of Palm Beach

There have been a number of significant factors affecting the behaviour of Palm Beach over the last few years. This includes implementation of the Palm Beach Protection Strategy, particularly beach and offshore nourishment. While weather conditions were typically mild, there were also storm events in early 2006 which significantly affected the beach. The response of Palm Beach to these conditions has been observed using the ARGUS coastal imaging system.

Recent Nourishment

Since implementation of the Palm Beach Protection Strategy, ~385,000m$^3$ of sand has been placed as nearshore nourishment south of the 11th Avenue groyne [Figure 32 Figure 33]. Approx. 105,000m$^3$ of sand from Currumbin Creek has also been placed directly on the southern sections of Palm Beach.
Figure 32: Nearshore Nourishment Zone
Figure 33: Summary of Nearshore Nourishment

Weather Conditions
Weather conditions were relatively mild for Palm Beach between 2004 and 2006. There were 12 storm events with $H_{\text{max}}$ over 5m [Table 3], although the only significant event was in early March 2006 where wave heights reached over 10m [Figure 34].

Table 3: Storm events

<table>
<thead>
<tr>
<th>Month</th>
<th>No. of Storms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 04</td>
<td>1</td>
</tr>
<tr>
<td>Jan 05</td>
<td>2</td>
</tr>
<tr>
<td>June 05</td>
<td>1</td>
</tr>
<tr>
<td>Jan 06</td>
<td>1</td>
</tr>
<tr>
<td>March 06</td>
<td>3</td>
</tr>
<tr>
<td>July 06</td>
<td>1</td>
</tr>
<tr>
<td>Aug 06</td>
<td>1</td>
</tr>
<tr>
<td>Sept 06</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>
Beach Response

In June 2004, an ARGUS coastal imaging system was implemented at Palm Beach by Water Research Laboratory [WRL]. Similar to the one established for the Narrowneck Artificial Reef project, the cameras provide valuable monitoring data on the Palm Beach Protection Strategy [as it has been implemented so far] as well as additional data on the behaviour of the region since its implementation. For consistency, analysis utilises locations corresponding to established survey ETA lines [Figure 35]. Turner [2006] summarised the data collected in the 2.5 years since its implementation, with specific observations regarding the movement of the nearshore nourishment, as below.
Response to 2004 campaign

Directly inshore of the nearshore nourishment, Turner [2006] noted that:

“During the 12 month period June 2004 to May 2005 beach width changes at transects ETA31 & ETA32 were dominated by the nearshore nourishment campaign completed in December 2004. Commencing November – December 2004 the beach at ETA31 and ETA32 began to increase in width, and by May 2005 this region of the Palm Beach beachfront increased in width by the order of 40-50m. Commencing June 2005 and continuing through to mid September 2005, the beach at both ETA31 and ETA32 decreased by 20-30m as a portion of the nourishment volume moved northward and the beach in this vicinity of the embayment adjusted toward a new equilibrium alignment.”

This describes the migration of the nearshore nourishment onshore, resulting in an accreting shoreline over a period of some 6 months before migration of the material northward resulted in erosion of this section of beach over the following 3½ months.
While the shoreline did not reach its original position before the effects of the 2005 / 06 dredging campaign were noticeable, experienced erosion rates were between 5.7 and 8.6m per month. This indicates that if the 2005 / 06 campaign had not been undertaken, this section of coastline would likely have returned to its original position in 11 – 15 months.

Further north between the mini-groynes, Turner [2006] noted that:

"Commencing in March at the more southern ETA33 & ETA34 transects and a month later at the more northern ETA35, a distinct trend of beach widening was observed, with the beach width by mid September 2005 increased by 30-40m. This widening was attributed to the continued northward movement of sand placed within the nearshore zone of more southern transects some six months previously. ... A general trend of net erosion was observed from September 2005 to February 2006 at the more southern transects ETA33 & ETA34, and then distinctive and rapid storm erosion in the early March 2006."

This corresponds to the northward migration of material from the region directly inshore of the nourishment zone. The timing of the accretion and erosion patterns indicated that it took some 3 months for the affects of the nourishment to be noticeable between the mini-groynes. It is also clear that the benefits of the nourishment are reducing as the ‘slug’ moves further north [generating a 30-40m widening in the central section compared to a 40-50m widening directly inshore of the nourishment].

Response to 2005 / 06 campaign

Directly inshore of the nearshore nourishment area, Turner [2006] observed accretion from Nov - Dec 2005, corresponding to the beginning of the 2005 / 06 nourishment campaign. Beach widths achieved were similar to those associated with the 2004 works. While the additional beach width was lost during the March storms, nourishment continued through until April 2006 and this section of beach partially recovered and by November 2006 [7 months after nourishment was complete] remained 20m wider than at June 2004. [Turner, 2006]

Based on the experience during the 2004 campaign, accretion between the mini-groynes should have been noticeable Feb - Mar 2006. During this time, however, any accretionary trend as a result of dispersal of this material northward was negated by “distinctive and rapid storm erosion in early March 2006” although “varying degrees of beach recovery were monitored through to the end of November 2006” [Turner, 2006] and this recovery was no doubt aided by the nourishment.

Response to March 2006 storm

Directly inshore of the nearshore nourishment area, the beach was of the order of 40m wider as a result of the 2005 / 06 nourishment campaign prior to the March storms. Turner [2006] notes that “storm erosion in early March 2006 resulted in the temporary loss of this additional beach width” [i.e. erosion for a storm of this magnitude was successfully accommodated within the additional buffer provided by the nourishment. It should be considered, however, that the nearshore nourishment was still underway when the storm hit and placement of this volume of material in the nearshore zone would have artificially created a substantial storm bar in this location, reducing the need for the creation of a natural storm bar from the material on the upper beach [and associated erosion].
Further north, between the mini-groynes, the beach was experiencing erosion as the benefits of the 2004 nourishment campaign migrated further northward. Significant storm erosion was experienced during March 2006, exceeding any additional capacity provided by the nourishment and utilising the buffer already existing in June 2004. Turner [2006] notes that “by the end of November 2006 the beach width conditions had returned to very similar conditions to those that were monitored 2.5 years earlier in June 2004.

This clearly shows that, while nourishment can successfully provide short-term protection, it does not provide medium-term [let alone long-term] protection against storm erosion.

**Overall effect of nourishment**

The most recent monitoring report [Turner, 2006] was published in November 2006. At this point, the 2005 / 06 dredging campaign had been complete for over 6 months and while the March 2006 storms had resulted in substantial erosion, results suggest that recovery was essentially complete and the beaches seemed to have stabilised [Turner, 2006]. Comparison of beach changes since 2004 showed that:

“At the more northern ETA36 and ETA35 transects, the beach was around 10m narrower than the conditions that prevailed 2.5 years earlier in June 2004. At ETA34 located midway between the two groyne structures and ETA33 located immediately north of the 11th street groyne, by the end of November 2006 the beach width conditions had returned to very similar conditions to those that were monitored 2.5 years earlier in June 2004.” Directly inshore of nearshore nourishment, “the beach in this region was 20m wider than it was two and a half years ago in June 2004”.

The widening of the southern section of beach is likely the result of the latter stages of the 2005 / 06 campaign and this material will no doubt migrate northward in the manner of the 2004 campaign, leaving this section vulnerable once again while it temporarily widens the beaches immediately to the north.

The results seem to show that the placement of ~385,000m³ of sand onto Palm Beach has not provided a long-term widening of Palm Beach or the continuing provision of an improved storm buffer, although it no doubt mitigated the impact of the March 2006 storm event on the beaches in the short-term.

**2.3.3 Mode of Salient Response**

The functionality of submerged control structures for beach protection [i.e. salient creation] was further investigated by Ranasinghe & Turner [2004 & 2006] using the numerical model Mike 21 [developed by the Danish Hydraulic Institute] and 3D basin physical modelling. They investigated three parameters – distance offshore, crest submergence and longshore sediment transport rate. The structure tested was triangular in shape with a 45 degree half angle, a base width of 100m and slopes of 1:12. It was noted that “while the structure tested here is more complex than the conventional shore parallel design, the results obtained herein are expected to be, in the least, qualitatively applicable to conventional shore parallel submerged breakwaters.” It is also noted that testing was based on an unvarying flat slope [as such, distance offshore and the depth of water at the reef were directly linked] and did not allow for the complexities of bar systems and variable wave conditions.

They found that “the mode of shoreline response is governed by the interaction between the ambient longshore current and the structure induced nearshore
circulation pattern” [Figure 36]. As such, the distance offshore and predominant wave incidence angle are key parameters in determining the nature of the shoreline response to the structure [i.e. erosion or accretion]. While crest level affects the salient size, their results indicate that it does not appear to impact on the mode of shoreline response.

Figure 36: Structure-induced nearshore circulation pattern [a] \( S_a = 100 \text{m} \) [b] \( S_a = 250 \text{m} \) [Ranasinghe & Turner, 2006]

Ranasinghe and Turner propose a predictive empirical relationship between \( \frac{Y}{B} \) and \( \frac{S_a}{SZW} \) where

- \( Y \) = magnitude of shoreline change
- \( B \) = structure length
- \( S_a \) = distance from undisturbed shoreline to apex of structure crest
- \( SZW \) = natural surf zone width

They state that “shoreline accretion can be expected when \( \frac{S_a}{SZW} > 1.5 \), while shoreline erosion can be expected when \( \frac{S_a}{SZW} < 1 \)”. Practically, the definition of \( SZW \) is not precise and “should be estimated as appropriate for the design application using the associated wave conditions (e.g. mean wave conditions, design storm conditions etc.)” The relationship does indicate, however, that the selection of a location outside the typical wave breaking zone [i.e. further offshore] tends to result in more desirable nearshore circulation patterns and an accretionary trend in the lee of the control structure. The previously proposed control structures at Palm Beach were some 350m offshore and, as such, they were located beyond the typical storm bar [Figure 37]. The work by Ranasinghe & Turner would indicate that this would result in accretion in the lee of the control structure – consistent with numerical modelling, empirical relationships and prior experience.
2.3.4 Climate Change

The combined effects of sea-level rise and increase in intensity of storms will result in a progressively worse situation at Palm Beach. The latest IPCC (2007) report has suggested sea-level rise over the next 100 years of around 600 mm. There is of course a great deal of uncertainty in this and the rise could be significantly greater. There is no clear prediction for tropical cyclones or east coast lows, but there is a general agreement that storms will increase in intensity, and possibly with a general increase in sea temperatures there may be more frequent southern incursions of tropical cyclones. At this stage there has been no quantification of climate change scenarios for the Gold Coast coastline, but it can be stated with some certainty that in the future coastal erosion will be persistent and of greater magnitude than in the past.

The implications for the design of the PBPS are that the required volume for nourishment will continuously increase and that the 1 in 50 year event may not be adequate. Certainly from a simple application of the Bruun rule, most of Palm Beach will have a zero buffer against storm cut in 50 to 100 years time unless nourishment + coastal control works are undertaken. The increase in intensity of storms also has implications for the design of the “A” wall in that the original design storm for the wall may now underestimate future events.

The climate change debate – and subsequent upgrading of climate forcing predictions – has developed rapidly since the original PBPS strategy was proposed, and although there has not been a major shift in sea level rise estimates (600mm in 100 years), these now are considered optimistic rather extreme predictions. Again, although there has been no quantification to date, it seems certain that higher significant wave heights and storm surges will be experienced. As a result it is recommended that a future approach to shoreline management and planning, (including at Palm Beach) follows an approach which addresses the following:

- Phase 1: Known natural variability in climate and the optimistic climate change predictions. This is a business-as-usual approach and the current PBPS falls into this category. Management strategies should be effective for the next 20 to 50 years.
- Phase 2: Pessimistic climate change projections. In this case it is assumed that there will be significant loss of shore-face due to higher rates of sea level rise and extreme events, and that extensive beach nourishment and construction of coastal control structures will be require to maintain current beach amenity.
Phase 3: Extreme climate change catastrophe. In this case it is assumed that climate mitigation is ineffective and global temperatures rise above 2°C resulting in significant loss of ice sheets with consequent sea level rise of the order of 5 to 10 metres. In this case technological solutions will not suffice and relocation of communities will be required. Community debate on the socio-economic dimensions of this and strategic planning for this outcome should commence now so that plans can be developed over the next few decades, rather than commencing the planning process at the end of the design life of current management strategies.

2.3.5 Existing Multi-Functional Artificial Reefs

Improving surfing on the structure was not a primary purpose of the proposed Palm Beach control structures. Despite this, the incorporation of the ‘wings’ would have provided some measure of enhanced surfing on the structure which could easily be enhanced by future extension of these sections if it was deemed warranted. While ASR Ltd [2004] criticised the 45 degree orientation of the ‘wings’, nose half angles of existing reefs are often similar to this [including Mount Maunganui at 40 degrees, which was designed by ASR Ltd].

There have been a number of multi-functional artificial reefs that have been constructed [or partially constructed] worldwide [Figure 38 & Table 4] and a summary of these reefs was undertaken by Jackson & Corbett [2007]. Costs ranged from ~$33/m³ to ~$360/m³. In comparison to these existing structures, the originally proposed control structures at Palm Beach each had a volume of some 30,000m³ and a cost of ~$1.65M [equivalent to a unit rate of ~$55/m³]. Construction methodology has a large impact on the cost of these types of structures. The two partially complete reefs [both designed and project managed by ASR Ltd] utilised a patented construction methodology. Both projects have experienced construction difficulties that have already resulted in substantial cost and time overruns.

Figure 38: Existing Reef
### Table 4: Reef comparison [Jackson & Corbett, 2007]

<table>
<thead>
<tr>
<th>SURF &quot;REEF&quot; PROJECTS</th>
<th>Date constructed</th>
<th>COUNTRY</th>
<th>VOL [m³] approx</th>
<th>TYPE</th>
<th>total A$</th>
<th>$/m³ A$</th>
<th>Construction method</th>
<th>Tide Range [approx]</th>
<th>Average Wave climate Hs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Completed Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bargara</td>
<td>1997</td>
<td>Australia</td>
<td>300</td>
<td>Rock</td>
<td>$10,000</td>
<td>$33</td>
<td>Reprofiling existing rocks on headland with excavator at low tide</td>
<td>3.7m &lt;1m</td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>1998-99</td>
<td>Australia</td>
<td>5,000</td>
<td>Rock</td>
<td>$1,400,000</td>
<td>$280</td>
<td>Rock placed with excavator from barge</td>
<td>0.8m Summer 1-2m winter 1.5 - 2.5m</td>
<td></td>
</tr>
<tr>
<td>Narrowneck</td>
<td>1999-2000</td>
<td>Australia</td>
<td>70,000</td>
<td>SFGC non-woven</td>
<td>$2,800,000</td>
<td>$40</td>
<td>150 - 450t mega sand filled containers filled in hopper dredge and dropped.</td>
<td>2m 1m</td>
<td></td>
</tr>
<tr>
<td>Prattes</td>
<td>1999-01</td>
<td>USA</td>
<td>1,350</td>
<td>SFGC woven</td>
<td>$385,000</td>
<td>$285</td>
<td>14t sand filled containers filled on shore, loaded on barge and placed by crane from barge</td>
<td>1.6m &lt;1m</td>
<td></td>
</tr>
<tr>
<td><strong>Partially Constructed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mount Maunganui</td>
<td>2005-??</td>
<td>NZ</td>
<td>6,000</td>
<td>SFGC non-woven</td>
<td>$1,454,545</td>
<td>$242</td>
<td>mega sand filled containers attached to web, anchored and filled in situ [20% construction outstanding]</td>
<td>&gt;2.5m &lt;1m</td>
<td></td>
</tr>
<tr>
<td>Opunake</td>
<td>2006-??</td>
<td>NZ</td>
<td>5,000</td>
<td>SFGC non-woven</td>
<td>$1,800,000</td>
<td>$360</td>
<td>mega sand filled containers attached to web, anchored and filled in situ [construction stalled?]</td>
<td>&gt;3m</td>
<td></td>
</tr>
</tbody>
</table>
Monitoring has been undertaken on all of the completed projects to varying degrees and this provides valuable information for future reef projects. Relevant reports include GCCM [2007], Pattiaratchi [2003], Borrero & Nelsen [2003] and Bancroft [1999]. In terms of the impact of these structures on existing surf conditions, results of monitoring have shown that artificial reefs that result in the formation of a salient in their lee typically promote bar formations that reduce the likelihood of close-outs, thus improving the quality of the beach break. This would be particularly beneficial at Palm Beach, where parallel bar systems are often observed in the southern compartment. The modelling also clearly shows that the bars can merge with the reef, extending the break in the right conditions – behaviour that is well documented at the Narrowneck reef.

It should also be noted that construction of these multi-functional reefs, many of which were intended primarily for surfing, has clearly shown that the real world does not necessarily reflect the results of the models. Where models often use monochromatic long crested waves on a smooth (non-barred) seabed profile, in reality Gold Coast wave conditions are usually bi-modal and often short-crested and bathymetry has highly variable bar and rip systems. This has clearly been shown at Narrowneck, where there have only been a few examples of the modelled conditions.

2.4 Conclusions

- Present Condition
  - Central Palm Beach remains highly variable and vulnerable to complete loss of beaches and severe property damage as a result of short term storm erosion.
  - The artificial sand bypassing at the Tweed River entrance will ensure continued sand supply to Palm Beach in line with natural longshore sediment transport patterns. The TRESBP will not act as a one off beach nourishment project, delivering a volume of sand above and beyond natural quantities over the medium to long term timeframe.
  - Over time, the effects of climate change will expose the beaches to the affects of short term storm erosion on a more regular basis and with greater severity. It will also introduce the problem of longer term recession associated with higher water levels.
  - A “do nothing” approach leaves Palm Beach increasingly vulnerable complete beach loss as a result of storm erosion.

- Present Strategy: Beach Nourishment without Control Structure
  - Palm Beach has been artificially nourished on a regular basis from theCurrumbin Creek entrance since 1974. It has also been periodically nourished utilising offshore reserves since 1985 [including the recent placement of ~385,000m$^3$ of sand as part of the Palm Beach Protection Strategy]. None of these works have been successful at widening the beach in the medium to long term.
  - Data collected from the 2004 nourishment works indicate that, in mild conditions, nourishment of the order of 150,000m$^3$ results in a widening of the beach by 40-50m over a period of ~6 months and then the beach narrows to its original position over the following 5 - 9 months as the sand migrates
northward as a dispersing ‘slug’. It does not result in medium or long-term widening of the beach.

- Despite recent works, central Palm Beach remains too narrow to accommodate design storm events and is no wider than it was in 2004 when the nourishment component of the Palm Beach Protection Strategy was implemented. Revisions to the design storm and increases in sea level rise as a result of climate change will further extend the section of Palm beach unable to accommodate storm cut.

- Regular placement of large volumes of material of the order of the current nourishment, is not sustainable as the volume available from Currumbin Creek is insufficient [typically only 30 – 50,000m³ pa] and the offshore reserves are essentially finite.

- Nourishment alone cannot successfully provide a short to medium term solution to the vulnerability of Palm Beach. A long term solution must address climate change and the possibility of an inability to continually restore protective beach volume – with or without control structures.

**Control structure**

- There are many different types of control structures. The attraction of submerged structures derives from their low visual impact and their potential to incorporate recreational benefits. Numerical modelling, empirical relationships and past experience indicate that they would be an effective solution in this location.

- The previously proposed structure was designed to be primarily for shore protection. Additional modelling and work undertaken by Ranasinghe & Turner [2004 & 2006] support the original conclusion that the design would result in a widening of the beach along the vulnerable sections of Palm Beach. There is likely to be variability in the salient as a result of prevailing conditions [similar to that experienced at Narrowneck and also reflected in the high levels of variability in the natural beach width]. It is acknowledged, however, that understanding of the link between submerged structures and the resulting salient is still evolving.

- The previously proposed structure was designed so that it did not have a negative impact on existing surfing conditions. It was not intended to be a surfing reef. Experience suggests that the influence of submerged structures on sand bars in its lee generally results in an improvement to the existing beach break as well as providing a break on the reef itself in larger conditions [although it is acknowledged that, with the proposed design, the break would be short in conditions where it did not merge with the existing bar break]. The form of the structure allowed the extension of the works to incorporate a greater focus on surfing on the structure if this was deemed to be desirable.

- The proposed design was developed to meet the design objectives efficiently and effectively – within a very limited budget. Other designs can be considered by GCCM, particularly if surfing on the reef itself becomes a design criteria or a more substantial budget is available.
3 ENVIRONMENTAL ISSUES

This section deals with Council resolution 4b as set out in Section 1.5 of this report and the need for increased environmental survey (bio-diversity and hydrographic).

3.1 Bio-Diversity

Within the sandy environment of Palm Beach, there are two offshore rocky reefs; Palm Beach Reef and Palm Beach Bait Reef (offshore around 9th - 11th Avenue and 23rd - 25th Avenue). Rocky reefs are dynamic natural environments and are important environmentally as a habitat and shelter for many marine flora and fauna, physically as protection against storm waves and economically through both recreational and commercial fisheries and the diving industry. There are a range of human-induced threats to rocky reefs including overfishing, pollution, boat anchoring, beach nourishment practises, coastal infrastructure and alternation of coastal habitats, increased coastal development and development pressures (GCCM, unpublished).

These rocky outcrops at Palm Beach have been the subject of several previous studies. More recently an assessment of the biodiversity of Palm Beach reef was undertaken for the Tweed River Entrance Sand Bypassing Project as a control site in 2003 (Thorogood et al., 2003 cited in Smith et al., 2005). In addition, a further study was undertaken by UNE in 2004 as a baseline study to assess the impacts of sand deposited in the nearshore area of Palm Beach during beach nourishment (Smith et al., 2005). This report assessed both the benthic and fish community structure with the primary objective of establishing the current state of the communities at Palm Beach Bait Reef. The project has been designed to allow for further post-impact assessment.

At the time of the study no impact was detected for a small amount of dredged sand that was deposited adjacent to the reef and there was no evidence of recent sand burial of sessile reef species. A fine layer of silt was covering the surface of the reef which appears to be characteristic of these reefs with nearshore proximity (Smith et al., 2005). Both reefs at Palm Beach support a diverse benthic community including a dominance of hard and soft corals at Palm Beach Reef and a dominance of hydroids, sponges and bryozoans at Palm Beach Bait Reef. Fish communities appear to be both diverse and abundant (Smith et al., 2005).

Since this study was undertaken a further ~225,000 m$^3$ of sand has been deposited within the nearshore zone of Palm Beach during 2004-2006. It is currently unknown if this deposited sand has had any impacts on the reefs and it is recommended that further surveys are undertaken to determine the impacts, if any. Additionally this will provide valuable data for assessing the dynamics of nearshore rocky reefs and provide for further development of management options associated with coastal engineering works. Additional surveys are recommended to be undertaken following any coastal engineering activities associated with Palm Beach.

The importance of the nearshore rocky reefs on the Gold Coast is well recognised in terms of fisheries, sport (diving/snorkelling), education/interpretation and scientific research (Smith et al., 2005). Although reef habitats are dynamic, an overall reduction in reef size could eventually lead to a reduction in species and abundance through increased competition for resources.

As part of the Shoreline Management Plan an assessment of the impact of the localised beach nourishment associated with the dredging of Tallebudgera and
Currumbin Creeks is underway. It is recommended that this be undertaken at Palm Beach in association with the regular dredging of Currumbin Creek.

3.2 Hydrographic Survey

A detailed coastal process monitoring program is recommended to support the implementation of the recommended strategy in Section 2. This will include the current ARGUS system and routine Hydrographic survey.

Table 5 lists all of the likely and possible adverse and positive impacts. Impacts listed also include those which will monitor the performance and conformance with the strategy's objectives. Data requirements are presented in Table 6 and a proposed monitoring plan is presented in Table 7. The costs associated with plan are in addition to the regular activities undertaken by GCCC, and would be borne by GCCC or possibly the Queensland Government. The majority of the monitoring requirements will need to cover periods of at least 3 - 5 years to ensure seasonal and variations and possibly extreme events impacts are assessed.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Possible Impacts</th>
<th>Monitoring Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currumbin &amp; Tallebudgera Dredging</td>
<td>· Water quality</td>
<td>Short</td>
</tr>
<tr>
<td></td>
<td>· Change in Currumbin estuary tidal velocities /</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>heights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Entrance channel configuration</td>
<td>Long</td>
</tr>
<tr>
<td>Nourishment</td>
<td>· Improve beach amenity</td>
<td>Short</td>
</tr>
<tr>
<td></td>
<td>· Increase recreational / beach space</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>· Increase storm buffer</td>
<td>Long</td>
</tr>
<tr>
<td>Construction of coastal</td>
<td>· Impact on surfing wave quality</td>
<td>Long</td>
</tr>
<tr>
<td>Control structure/s</td>
<td>· Impact on beach / surf craft usage</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>· Impact on beach safety</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>· Change local flow hydrodynamics &amp; sediment</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>transport</td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Change in effectiveness of reef</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>· Salient growth and beach width</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td>· Increase recreational / beach space</td>
<td>Long</td>
</tr>
</tbody>
</table>
Table 6: Data Requirements

<table>
<thead>
<tr>
<th>Possible impact</th>
<th>Data required</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water quality</strong></td>
<td>pollution and turbidity levels at site and ambient</td>
<td>sediment &amp; water sampling</td>
</tr>
<tr>
<td></td>
<td>usage levels &amp; type</td>
<td>record lifeguard observations</td>
</tr>
<tr>
<td><strong>Beach amenity / usage/safety</strong></td>
<td>no &amp; type of incidents</td>
<td>lifeguard observations</td>
</tr>
<tr>
<td></td>
<td>weather conditions</td>
<td>weather stats</td>
</tr>
<tr>
<td></td>
<td>wave conditions</td>
<td>wave buoy records</td>
</tr>
<tr>
<td></td>
<td>current velocity, direction</td>
<td>current meters</td>
</tr>
<tr>
<td><strong>Local flow hydrodynamics,</strong></td>
<td>weather conditions</td>
<td>numerical modelling</td>
</tr>
<tr>
<td><strong>Sediment transport / Erosion</strong></td>
<td>wave conditions</td>
<td>weather stats</td>
</tr>
<tr>
<td></td>
<td>seabed &amp; beach profiles</td>
<td>wave buoy records</td>
</tr>
<tr>
<td><strong>Entrance Channel Configuration</strong></td>
<td>suspended sediment</td>
<td>hydrographic surveys</td>
</tr>
<tr>
<td><strong>Tidal velocities / heights</strong></td>
<td>seabed profiles</td>
<td>numerical modelling</td>
</tr>
<tr>
<td></td>
<td>current velocity, direction</td>
<td>tide gauges</td>
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<tr>
<td></td>
<td>tide heights</td>
<td>weather stats</td>
</tr>
<tr>
<td></td>
<td>weather conditions</td>
<td>wave buoy records</td>
</tr>
<tr>
<td></td>
<td>wave conditions</td>
<td>hydrographic surveys</td>
</tr>
<tr>
<td></td>
<td>seabed &amp; beach profiles</td>
<td>video monitoring</td>
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<td><strong>Storm buffer</strong></td>
<td>suspended sediment</td>
<td>numerical modelling</td>
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<td></td>
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<td>tide gauges</td>
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<td></td>
<td>weather conditions</td>
<td>weather stats</td>
</tr>
<tr>
<td></td>
<td>wave conditions</td>
<td>wave buoy records</td>
</tr>
<tr>
<td><strong>Surfing wave quality</strong></td>
<td>wave parameters</td>
<td>surf reports</td>
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<tr>
<td><strong>Change in effectiveness of control structure/s</strong></td>
<td>reef levels</td>
<td>lifeguard observations</td>
</tr>
<tr>
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<td>salient size / location</td>
<td>hydrographic surveys</td>
</tr>
<tr>
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<td>u/w inspections &amp; videos</td>
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<td>hydrographic surveys</td>
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<tr>
<td></td>
<td></td>
<td>aerial photographs</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Area Monitored</td>
<td>Method</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Beach and hydrographic surveys</td>
<td>Control point and nourishment limits</td>
<td>Detailed survey of beach and nearshore</td>
</tr>
<tr>
<td></td>
<td>Currumbin Creek to Tallebudgera Creek</td>
<td>Broad survey of regular lines Hydrographic</td>
</tr>
<tr>
<td></td>
<td>Currumbin Creek tidal delta and entrance, dredging site</td>
<td>Survey of regular lines Hydrographic survey</td>
</tr>
<tr>
<td></td>
<td>Control Structure</td>
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<td>Aerial photographs</td>
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<td>Control Structure</td>
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4 Vegetation Protection Strategy

This section deals with Council resolution 4c as set out in Section 1.5 of this report.

Palm Beach is a primarily residential area with a narrow beach dune system bound between Currumbin and Tallebudgera Creeks. Much of Palm Beach consists of beach front private properties with little open public space and minimal public access points to the beach. As a result of a history of persistent and extensive beach erosion the dunes are very narrow and no extensive dune system exists.

Sand dunes naturally fluctuate through the physical processes of erosion and accretion. Erosion events occur seasonally and during storm events due to associated high wave energy. The dunes provide a natural buffer to protect infrastructure from coastal erosion through the provision of a supply of sand during storm events. Dune vegetation plays an important role in reducing the impact of coastal erosion through stabilising the dunes, trapping wind blown sand (thus encouraging the growth and development of dunes) and assisting in the recovery of dunes after erosion events. The management and enhancement of dune vegetation is a key strategy in reducing shoreline recession, increasing the erosion buffer zone, increasing natural biodiversity and improving beach aesthetics.

The characteristics of the dunes at Palm Beach are controlled by the presence of the protective rock boulder wall aligned to the erosion scarp of the erosion events during the late 1960s and early 1970s. Since this period the dunes along much of the beach have developed into a fairly established, narrow, primary dune system. Sections of the dunes are in better quality than others, although invasive weeds are extensive throughout the swales and hind areas of the primary dune system. The strandline and frontal primary dune has reasonably extensive cover of the important dune stabiliser Spinifex sericeus, and has proved an important buffer in storm events. Generally there is a 50-60% cover of endemic groundlayer species in these areas, and there is also evidence of natural regeneration occurring with species such as Acacia sophorae returning to several sites.

There are two areas with relatively wider dunes and increased density of vegetation including Currumbin Spit, at the southern end of Palm Beach, and the northern section of Palm Beach adjacent to Tallebudgera Outdoor Education Centre. These dunes have approximately 60-70% cover of native groundlayer species present, with weed species also occurring in the understorey. Canopy species are predominantly Casusarina equisetifolia (horsetail she-oak) and Acacia sophorae (coastal wattle). Other canopy species occurring in smaller numbers include Banksia integrifolia (coastal banksia) and Cupaniopsis annarcardiodes (tuckeroo). Erosion problems after storm events in these two sites have been minor in comparison to the narrower dunal strip occurring throughout the majority of the Palm Beach coastline.

Endemic groundlayer species occurring in the strandline and foredune system of Palm Beach include:

- Spinifex sericeus (Coastal cpinifex)
- Ipomoea pes-carprae (beach morning glory)
- Canavalia rosea (Beach bean)
- Vigna marina (yellow beach bean)
- Tetragonia tetragonooides (Warrigal greens)
- Sesuvium portulacastrum (Sesuvium)
- Scaevola calendulacea (beach fan flower)
Weed encroachment is a major concern on the dunal vegetation at Palm Beach. Garden escapee species such as Gazania and Mother of Millions have impacted on site resulting in a reduction of the quality of native vegetation. The ability of the dunal sites to recover after weed works is strong, with a good quality, diverse seed source available in most dunal areas. Timely weed management works undertaken throughout the Palm Beach dune system will result in the regeneration of endemic dunal species, and increased resilience to human and naturally induced impacts. Revegetation of sites with appropriately sourced and planted endemic species will accelerate this process.

The importance of these native species as a buffer for storm events and from a diversity consideration is critical. Endemic species have the ability to withstand the conditions of a coastal ecosystem and environmental factors including low rainfall patterns. The narrow buffer zone occurring along the majority of the Palm Beach dune systems result in extensive scarping damage after storm events. The ability of primary dune stabilisers such as Spinifex sericeus as a catalyst to assist in the reformation of these dune systems is unparalleled.

The management and protection of the dune vegetation is considered an important action for the protection of Palm Beach. This was recommended by the PBPS Scoping Report, highlighted by the community during the initial community consultation of the Palm Beach Protection Strategy (GCCM, 2000) and further recommended by the PBPS Consultative Committee in 2004. Both local and state policy related to dune management was also highlighted in the PBPS report (GCCM, 2000).

The management of the dunal vegetation on the Gold Coast is primarily guided by the Gold Coast Planning Scheme – Policy 15 which is document defining management techniques for urban and non-urban dunes. This policy has been adopted by Gold Coast City Council and works on dune must adhere to this document. Further legislative requirements are guided under the Queensland State Coastal Management Plan (2001) and the South-east Queensland Regional Coastal Management Plan (EPA, 2006). Rehabilitation and conservation of coastal vegetation also meets the objectives of the Coastal Protection and Management Act 1995.

The Qld State Coastal Management Plan encourages that dune rehabilitation works are undertaken involving partnerships with stakeholders and it is recommended that Gold Coast City Council continues the support of the BeachCare program, which is currently active at Palm Beach.

The development of vegetation protection strategies has been recommended and would assist in the stabilisation of Palm Beach in light of the erosion risk and fluctuating beach profile. These strategies would need to focus on stabilisation of the current dune system, enhance growth of the dune systems, stabilise any sand accretion resulting from erosion protection works whilst improving amenity and enhancing biodiversity.

Vegetation protection strategies should include, but are not limited to, vegetation management plans (including a site assessment, weed management and rehabilitation process), alignment with relevant policies such as the Gold Coast City Council Planning Policy 15 and State and Regional Coastal Management Plans, consideration into proposed erosion protection strategies and community consultation. The strategies should also consider the impact of climate change.
Monitoring and evaluation of the site is also recommended and would include vegetation surveys, photo-point monitoring and reporting.

Further recommendation is provided to reassess Gold Coast City Council’s Planning Policy 15. Several members of the industry have raised concerns regarding the policy and its recommendation of several environmentally appropriate exotic species in addition to native dune vegetation. It is recommended to involve appropriate stakeholders to provide comment regarding this policy. Further amendments should then be made to the policy as deemed appropriate by Gold Coast City Council.

5 Coastal Access

This section deals with Council resolution 4d as set out in Section 1.5 of this report.

Palm Beach is a highly modified coastal system with extensive development along the beachfront. The PBPS identified that many of the properties adjacent to the beach at Palm Beach are built on the active beach system and many are vulnerable to coastal erosion (GCCM, 2000). Evidence of this are the past significant erosion events during the 1960s and 1970s where sections of the beach front road reserve was lost to beach erosion leaving many properties very close to the beach and vulnerable to further erosion. Further erosion events in 1996 and 2000 reinforced the threat of erosion to many of these properties. Previous loss of the road reserve has resulted in reduced access to the beach at Palm Beach. Dune encroachment (privatisation of public land) has also been an issue at Palm Beach and impacts on the public’s access to public Crown Land.

The PBPS highlighted the lack of public access to Palm Beach as a key issue in the management of the area. Reference is made, within the report, to comments provided by Gold Coast City Council (GCCC) and the Environmental Protection Agency (EPA) and during the initial community consultation of the PBPS (GCCM 2000). GCCC recognised the there is a lack of public access and a need for access to be improved and not interrupted. The EPA also stipulated that during any coastal protection works measures should be provided to ensure increased public access. Both the Queensland State Coastal Management Plan (2001) and South-east Queensland Regional Coastal Management Plan (2006) recognise the need for increased and well managed public access in light of the increasing population growth, particularly in South-east Queensland, and the associated increasing demand on coastal resources. Public access to coastal resources should be planned and managed so as to protect the resource, its value and ensure public safety (EPA, 2006).

The Gold Coast City Council Local Area Plan for Palm Beach describes the urban form of Palm Beach as linear [and parallel to the beach] with most retail services to the west of the Gold Coast Highway (GCCC, 2003). Palm Beach provides accommodation and services for both residents and tourists. It also states that the existing grid pattern of streets provides pedestrian access to the central area and to the beach. The PBPS recognised that Palm Beach primarily experiences a lack of public parking when accessing the beach. Given the current population growth in the area, particularly in housing estates west of Palm Beach and areas such as Currumbin and Currumbin Valley, Elanora and Tallebudgera adequate parking needs to be provided to those visiting the beach or appropriate public transport with associated incentives needs to be provided as an alternative.
There are four main public access points along Palm Beach including the Tallebudgera Outdoor Education Centre (northern end), the Tallebudgera Surf Life Saving Club (northern end), Palm Beach Surf Life Saving Club (central area) and Currumbin Spit (southern end). Each of these facilities provides a public carpark of approximately 60-100 parking spaces. Further parking is available at points along the Gold Coast Highway. There are also 13 access points at street ends running perpendicular to Palm Beach, each with on-street parking and public access onto the beach. These street ends vary in size and parking availability for visitors. As much of the development adjacent to the beach front is private residential there is limited opportunity for public access within these areas. There is one section of public access with a turfed walkway from Tallebudgera Surf Life Saving Club south to 23rd Avenue, along both The Esplanade and in front of private property.

Gold Coast City Council have developed the Oceanway project which aims to provide a pathway and access to the beach foreshores along the length of the Gold Coast from Point Danger in the south to The Spit in the north. Sections of the Oceanway are complete with many sections still under construction or proposed. Paved pathways do currently exist from Tallebudgera Creek to the Tallebudgera Surf Club and Rockview Park. Other Oceanway projects currently in planning stages include Tallebudgera Surf Club to 23rd Ave. (called the TD23A Oceanway project), with potential for future Oceanway works from 4th Ave to Lacey's Lane, and Lacey's Lane to the Currumbin Creek Bridge. Much of the Oceanway at Palm Beach runs along Jefferson Lane behind the beach. The Oceanway supports Gold Coast City Council’s Active and Healthy program through promotion of active lifestyles and availability of open spaces to enhance these lifestyles. Further development of the Oceanway at Palm Beach adjacent to the beach would be an ideal means of increasing public access to Palm Beach whilst promoting a healthy, outdoor lifestyle and reducing the need for parking and use of private cars.

Given the current population of Palm Beach, the growth rate of surrounding suburbs and the overall Gold Coast in general there is a need for increased access to Gold Coast beaches. Improved access is required through pedestrian access points, pathways connecting beaches, parking availability and improved public transport for both local residents and visitors. There is a need for a long term strategy to deliver improved access to Palm Beach through an assessment of usage of the beach, visitor and resident needs, socio-economic changes, future population and tourism growth. The Local Area Plan should reflect these needs.

6 DREDGING PROGRAMS

This section deals with Council resolution 4e as set out in Section 1.5 of this report.

The issues associated with the role of the dredging of Tallebudgera and Currumbin Creek in the dynamics of Palm Beach were addressed in the original Palm Beach Protection Strategy report. Concurrent with the community consultation process in 2004, a Currumbin Entrance Research Program (CERP) was developed as a vehicle for examining the dredging effectiveness and identifying other options. This program was reliant on support from the Queensland Transport for its viability. This support was not forthcoming, and the program faltered along with minimal activity such as the study of the wave dynamics at the entrance (Castelle et al., 2006), and an assessment of the effect of entrance sand build-up on flooding (Castelle, 2006). More recently, a decision support system being developed for the Shoreline Management Plan has been tested against a dredging program in Tallebudgera Creek.
In light of the position taken by Queensland Transport and the other activities since it was prepared, the CERP has been revised and is presented as Appendix 1. This sets out a plan of activities which would provide a basis for setting a more effective dredging plan.

As an outcome of the community consultative process in 2004, a community advisory committee was established to provide direction for the regular dredging program in Currumbin Creek. This has been very effective in capturing community input and knowledge and in giving support for Council’s activities. This involvement of this committee has been included in the revised CERP.

7  **Recommendations**

In response to the issues raised in the Council Resolution following the community consultation process in 2004, and as discussed in the various sections above, the following recommendations are made to progress the Palm Beach Protection Strategy.

1. Proceed with construction of coastal control structures as proposed in the PBPS Stage 1 and 2 Reports by GCCM and supported by Prof Colin Apelt during the independent peer review. Adopt the design modifications as set out in the PBPS Addendum Report, in particular the lowering of the maximum crest level by 1m.

2. Adopt the staged approach of constructing and monitoring the first reef before proceeding to the second and third. Carry out extensive monitoring to inform the implementation of the strategy.

3. Address the uncertainty in coastal response identified by Prof Apelt with a comprehensive adaptive management approach to construction whereby, the outcomes of the monitoring program are used to modify construction schedules and design elements if required.

4. Implement a detailed Coastal Monitoring Program to consolidate existing data streams and to introduce new routine measurements. A schedule is presented in Section 3 and includes:

- ARGUS coastal imaging system
- Hydrographic surveys
- Collection of additional wave data
- Beach state and beach amenity data

5. Undertake an ecosystem assessment of:

- the impact of beach nourishment on the beach ecosystem
- the changes that have occurred on the Palm Beach Reef as a result of the offshore nourishment
- the water quality impacts of any dredging or construction works

6. Undertake a review of the GCCC vegetation management policy, and the policy should be actively implemented at Palm Beach.
7. Develop a long term strategy to deliver improved access to Palm Beach through an assessment of usage of the beach, visitor and resident needs, socio-economic changes, future population and tourism growth. The Local Area Plan will need to reflect these needs. This was a key recommendation for long-term studies in the original Palm Beach Protection Strategy.

8. Implement the revised Currumbin Entrance Research Program.
8 Costs

The following costs (Table 8) are first-order estimate of the various components covered in the recommendations.

Table 8: Estimated costs of recommended actions

<table>
<thead>
<tr>
<th>Item</th>
<th>Price at Contract Award</th>
<th>Revised Estimate</th>
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<tbody>
<tr>
<td>Construction of submerged reef off 19th Ave, Palm Beach ²</td>
<td>$1.9M</td>
<td>$2.4M ¹</td>
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<tr>
<td>Nourishment</td>
<td>$1.6M</td>
<td>$2.0M ¹</td>
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<td>Monitoring – CERP (3 years - see Appendix)</td>
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<td>$833,500</td>
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<td>Additional Hydrographic monitoring³ – see Table 7</td>
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<td>$140,800 pa</td>
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<td>Ecological assessment – Palm Beach Reef – see Section 3</td>
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<td>$30,000 per survey</td>
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<td>Revision of the Vegetation Management Policy – see Section 4</td>
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<td>$10,000</td>
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<tr>
<td>Socio-economic analysis⁴ – see Section 5</td>
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<td>$300,000</td>
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</table>

1. Revised prices are based on ABS Statistics [i.e. 22.32% increase in costs] In the four years since the Palm Beach contract was awarded to McQuade Marine in 2003, ABS statistics indicate that prices have increased by approximately 22% in the general construction industry. Given that both supply and installation of geotextile containers is heavily dependent on fuel prices [in comparison to the general construction industry], the actual increase in costs could be substantially higher.

2. Costs are based on the original container layout and contract schedule as a revised container layout has not been undertaken for the recommended lowered crest level.

3. In addition to regular GCCC survey activities.

4. GCCC funded study to assess local area social and economic issues for cost-benefit justification of major coastal protection works.
9 REFERENCES

Apelt, C.J. 2004  Detailed review of the planning and design activities undertaken for Gold Coast City Council by the Griffith Centre for Coastal Management [GCCM], a unit of Griffith University, relative to the Palm Beach Protection Strategy and to the Palm Beach Artificial Reef. prepared for Gold Coast City Council


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APPENDIX
CURRUMBIN ENTRANCE RESEARCH PROGRAM

OCTOBER 2007 REVISION
Revised Proposal for the Establishment of a Currumbin Entrance Research Program – An Overview

1 Original Program Aims and background

The aim of this program is to develop a sustainable long-term channel maintenance strategy for the lower reaches of Currumbin Creek that addresses the various constraints on the natural characteristics of the estuary and adjacent beaches, and on recreational usage of the entrance.

The objectives are:

- To investigate the historical changes affecting Currumbin entrance and to correlate the various dredging, coastal management and other activities with specific hydrodynamic and sedimentary responses within the entrance and on the adjacent beaches.
- To examine the flow and sediment transport characteristics using a hybrid numerical/scaled physical model.
- To develop a predictive capability for changes within the entrance over periods of days to years.
- To undertake trials of innovative and cost-effective approaches to channel maintenance using both traditional dredging techniques as well as alternative technology.
- To identify potential safety issues for entrance users.
- To develop a decision framework for future dredging activities based on an understanding of community issues and environmental and technical constraints.

These aims and objectives remain valid, except that there is no longer an opportunity to undertake physical modelling.

2 Background

The recent history of Currumbin Creek entrance has seen rapid growth in the use of the entrance for access to the ocean by fishermen; as a world class surfing site, and as a recreational area accommodating still and open water activities. The Volunteer Marine Rescue (VMR) is based at the entrance and data suggests that the entrance is one of the busiest in Queensland for all types of water craft. In addition, development further upstream has meant that there are increasing concerns over water quality and flooding. The entrance is also an integral part of the active littoral sand movement along the southern Gold Coast beaches.

Prior to the 1970s the entrance was highly variable in terms of the location of the discharge point and the entrance shoals characteristics. Following the major impacts in the 1960s and early 1970s from cyclonic waves and flooding, the entrance was trained, initially with a rock wall on the southern side out to Currumbin rock and then in the early 1980s with a wall on the northern side. This effectively stabilized the location of the discharge point preventing the cyclical behaviour of spit migration northward and breakthrough during flood events. Natural processes continued of course with the entrance infilling with sand and causing flood and water quality issues. A regular dredging program commenced in the 1980s and continues when required with dredging occurring usually in the lead up to the summer months. Sand dredged from the internal shoals has been discharged on the southern part of Palm Beach at locations relatively close to the entrance.
The studies undertaken for the Palm Beach Protection strategy (D'Agata et al, 2001) have clearly identified the importance of the dynamics of sedimentary patterns in the vicinity of the entrance in terms of dredge discharge location and timing of dredging activity. Other studies (Tomlinson, 1991 and Voisey et al, 2003) have shown that the training works have done little to modify natural processes of infilling of the entrance from the littoral sediments.

The current dredging management strategies have often come under criticism from various sectors, in particular on issues related to the dredging of the offshore bar. The GCCC dredging program has been restricted to the internal shoals, with the Department of Transport taking the view that as the entrance is deemed not navigable, it would not take responsibility for bar dredging.

Community concerns over access and safety issued accelerated in 2003 with the formation of the FIX Currumbin Creek Committee (FIX) and it's lobbying to have the bar maintained. The community issues over the proposed Palm Beach Protection Strategy (PBPS) also interfaced with the concerns of FIX because of the view that the PBPS nourishment should be sourced from the entrance.

The call for action over the dredging and safety issues at Currumbin were brought to a head in May 2004 with a meeting of key stakeholders. The main outcome of this meeting was a request from the Gold Coast City Council Mayor and senior officers of Queensland Transport for the Griffith Centre for Coastal Management (GCCM) to develop a research and development program to address the various issues related to the creek entrance.

Throughout 2004 the FIX committee liaised very effectively with GCCC in terms of the operational aspects of the current Currumbin Creek dredging program by GCCC. Despite the co-operation and application of local knowledge, the characteristics of the sand movement in response to the dredging have demonstrated that the system is highly variable and it is imperative that this variability be codified and that more flexible dredging solutions be identified.

The original CERP proposal was prepared presenting a robust scientific approach to the investigation of workable options for low-cost dredging options to ensure that Currumbin Creek Entrance remains navigable more often and that environmental values are maintained and coastal processes not adversely influenced. An important aspect taken into consideration was that of public safety given the diverse range of users particularly in the vicinity of the entrance and bar. The CERP proposal was presented to the Queensland Department of Transport and the Gold Coast City Council. It received enthusiastic support from Council, but QT did not offer funding support, as their view is that Currumbin is not designated a navigable entrance. Consequently the program was not implemented, but it has provided a framework for a number of related activities as discussed in other sections of this report.

Also since the original CERP was prepared, the community advisory group has been meeting regularly to provide input to the plans for the regular maintenance dredging. Some new insights have been gained from this regarding the effectiveness of the dredging and the impact on littoral processes on Palm Beach. However, in terms of moving towards a new cost-effective low impact solution to the issue, there has been no major progress.
3 Methodology

a. Program overview

There are a number of environmental technical and social issues that both interact, and need addressing, in order to establish an appropriate long term solution to entrance stability and improvement in outcomes for Palm Beach. The issues include: flooding, water quality, dredging costs, liability, impact on recreational users, VMR operations, Palm Beach stability, stability of structural elements, impacts on natural reefs and surf break.

A three-year program is proposed which will address all of these issues in a holistic fashion. The program comprises four interconnected activities as follows:

- Entrance Dynamics
- Community Engagement
- Monitoring
- Channel Maintenance Options

The relationship between these activities is shown in Figure 1, and a brief description of each of these activities follows.

b. Entrance Dynamics

The aim of this activity is to develop understanding and predictive capability for behaviour of the entrance and adjacent beaches. The activity builds on a major investigation into tidal inlet/adjacent beach interaction undertaken by GCCCM in partnership with the Queensland Environmental Protection Agency (QEPA) as part of the Cooperative Research Centre for Coastal Zone Estuary and Waterway Management's (Coastal CRC) Open Coastline Project. This project examined idealized entrance/beach conditions using physical and numerical modelling. It is proposed to extend the numerical modelling undertaken in this project and the more recent work by Castelle (2006) to represent real conditions at Currumbin Creek entrance. The model testing will build up a set of scenarios for the various dredging options being considered and the relevant responses under a range of wave and flow conditions. The numerical modelling will be carried out using the DELFT3D model developed by GCCM for the Coastal CRC project. This activity will also deliver outcomes for flood risk assessment and the impact the entrance sedimentation is having on flooding. The modelling work will be supported by a program of physical process measurement providing model calibration.

c. Community Engagement

This activity represents an interface between the local community, local government and state government interests and jurisdictions. Given the diverse range of values the community places on the entrance it is important to both gauge the significance and interrelationship of the various interests and to establish effective methods of information dissemination throughout the duration of the project. It is proposed to undertake community attitudes assessment as part of a major study of community involvement in coastal management being undertaken by the Centre for Resource and Environmental Studies at the Australian National University (ANU). A key element of this work will be an assessment of liability. Community values are a key
component of the Gold Coast Shoreline Management Plan, and it is expected that issues related to dredging programs will be addressed.

GCCM’s Coast Ed program provides a suitable vehicle for dissemination of information through the printed media and the Internet. CoastEd facilitators will also deliver information sessions at schools and community groups. Appropriate methods for raising the general boating community’s awareness of the dangers of navigating the entrance will be developed.

d. Monitoring

A comprehensive monitoring program is recommended in the GCCM Report No. 69 on an update of recommendations for the PBPS. The proposed monitoring includes a number of elements considered to be part of the CERP, but which need to be undertaken regardless. For completeness the monitoring requirements specific to the CERP are as follows:

- Monitoring of channel bathymetry, beach profiles at the entrance and beach profiles at the discharge site by GCCC’s Hydrographic Survey Team is essential. Intensive survey will be required before and after dredging activity.

- Innovative approaches to remote monitoring are proposed by combining the broad-scale detection of beach changes at the entrance available through the Palm Beach ARGUS system operated by the University of New South Wales on behalf of GCCC, with more detailed video imagery utilising the coastal camera operated by Coastalwatch P/L at the VMR base. This camera will be relocated to the VMR tower and will provide data not only on the change in entrance morphology, but also valuable statistics on water craft and other users.

- Monitoring of the impact on beach ecology of the nourishment.

- Water quality parameters within the estuary are routinely acquired by GCCC and will be accessed for correlation with the entrance behaviour.

e. Channel Maintenance Options

A program of assessment of alternative approaches to maintenance dredging will underpin all of the other activities. Given that large-scale systems such as the Tweed River Entrance Bypassing Project (TRESBP) are inappropriate for Currumbin Creek, and given that any solution will need to be cost-effective, it is proposed that two main activities be undertaken.

Firstly, the concept of fluidised mobilization of sediment during the outgoing (or incoming) tide will be examined. A device will be constructed which is portable and which can be rapidly deployed. The involvement of local boating community is critical for this and it is proposed to integrate members of FIX in the program and to develop and deploy their “Bar-Buster” concepts.

Other proprietary fluidizing system may also be trailed depending on the co-operation of their proponents. These trials will be carried out at various times in the first year of the program both independently and in combination with the routine dredging program.

The second phase of this project is to undertake traditional dredging, but according to specific protocols developed from the entrance dynamics modelling scenarios. These protocols may influence the dredging location, timing and discharge points.
The assessment of the effectiveness of the alternative strategies will be undertaken as part of a PhD student project. The student will take responsibility for the design and implementation of the monitoring program, the analysis of data and the formulation of strategy recommendations.

4 Program Outcomes

The main outcome of this program will be a framework for resolution of the often conflicting constraints on the use of small tidal entrances for recreational navigation. This framework will acknowledge:

- the natural sedimentary behaviour of the entrance;
- the need to implement a channel maintenance program which follows the IENCE (Infrastructure to Enhance the Natural Capacity of the Environment) concept; and
- the many different uses of the entrance.

The key outputs will be:

- A model of Currumbin Creek entrance which can be used to test a range of dredging options over a range of wave and flow conditions
- Guidelines for low-cost IENCE-based channel maintenance which builds on the recommendations of the PBPS
- A flood risk assessment for various entrance sedimentary conditions
- A community consultation process addressing the diverse uses and liability issues
- A number of reports, theses and papers identifying the generic application of program findings to other small-scale tidal entrances.

5 Program Management

a. Project Agreements

The program will be delivered as an integrated suite of projects some of which are components of other programs and may be delivered under separate contractual arrangements. GCCM will provide the co-ordination of these activities to ensure that the outcomes are reached.

b. Program Reference Group

The program requires input and oversight from a number of stakeholders. It is proposed to establish a Project Reference Group, the membership of which is shown on Figure 1.

c. Staffing

The program will require the involvement of staff from GCCC, QT, QEPA, and GU both as in-kind contributions and as cash-funded positions as shown in Table 1. Other significant contributions are also shown.

d. Resources

Equipment and material resource requirements are indicated in Table 2.
e. Activity Schedules

Although there has been some limited activity related to the program as set out here, it is expected that duration of the program will be 3 years. Key activities will be undertaken according to a schedule as follows.

- The entrance dynamics activity will be completed by July 2008 in accordance with Coastal CRC funding guidelines.
- The alternative channel maintenance techniques will be trialled in the first year of the program following the recent traditional dredging campaign.
- The modified traditional dredging trials will be carried out in the second year based on protocols developed in Year 1 in the entrance dynamics modeling project.
- The alternative technologies will continued to be trialled throughout Year 2 and 3 with the results of all activities brought together by the PhD student at the end of Year 3.
- Monitoring will be carried over the 3 years as required.
- Community issues and coastal education activities will be carried out over the 3 years.

6 Budget

There are a number of existing or proposed project activities which fit within the CERP, but which already have funding allocated. These include a sediment transport modelling study and flood risk assessment funded by GCCC; beach ecology and nourishment study funded through the Shoreline Management Plan, and the ARGUS monitoring.

Additional funding is required for the following activities: PhD student stipend and operational costs; bar-buster trials, alternative dredge contracts; model scenario testing and decision support system, detailed video monitoring of entrance behaviour and estuary bathymetry and flow velocity model calibration data collection.

A broad estimate for the new funding allocations required for the program is given in Table 2.

In summary, the program is estimated to cost over 3 years.

7 Funding Sources

The program is proposed as a collaborative research and development venture with the new funding coming from a range of sources. The following sources have been identified.

- **Griffith University.** Cash and in-kind contributions in support of a PhD student, project co-ordination and CoastEd activities. Griffith University will contribute $5,000 cash per year in support the PhD studentship.
- **Gold Coast City Council.** Cash and in-kind contributions in support of a range of activities including modelling, bathymetric survey, offshore reef assessment and annual dredging programs. This may be sourced from the existing annual dredging budget or from new requests.
State Government. Additional new funding is required. In-kind support from QEPA in the form of wave data is also required.

A summary of the schedule of new cash funding required is shown below. The allocation for the state Government is based on

<table>
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<th>Funding Source</th>
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<td>$289,000</td>
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8 References

Figure 1: Program Overview
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<tr>
<th>Staff Contributions</th>
<th>Staff</th>
<th>Organization</th>
<th>Principal Role</th>
<th>%FTE In-kind</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
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<td></td>
<td>Rodger Tomlinson</td>
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<td>Darrell Strauss</td>
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<td>Peta Williams</td>
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<th>Other participants</th>
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<th>In-kind</th>
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<td>Karl de Piva</td>
<td>Bar-buster concept, operational support</td>
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<td>John McGrath</td>
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<td>Neil Lazarow</td>
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<td>As required</td>
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<tr>
<td>GCCC Hydrographic Survey Team (Michael Walsh)</td>
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<tr>
<td>GCCC Flood and Waterway Management team (Hamid Mirfendereski)</td>
<td>Sediment Transport model and flood risk assessment</td>
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## Table 2: New Funding Budget

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<th>Budget 2010</th>
<th>Budget Sub-total</th>
<th>Duration, Years</th>
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<td>Bathymetry and flow velocity</td>
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**Entrance Dynamics and Flood Risk Assessment Project**

A Coastal CRC project agreement will be established covering a collaborative project between GCCM and QEPA involving a contribution of $75,000 cash and significant in-kind support in terms of the time of staff and technical support. This agreement will take the form of a standard Coastal CRC agreement and will cover the development of the hybrid model as an extension of the previous Coastal CRC Open Coastlines Project. GCCC will be a key stakeholder and industry partner.

The entrance behaviour modelling tasks will be integrated with a proposed GCCC project funded by local, state and federal governments which is assessing the importance of entrance sedimentation on flood risk assessment ($100,000 cash). This work covers both Currumbin and Tallebudgera Creeks, and will utilize both GCCC MIKE 21 and GCCCM Delft3D software. The model configurations required for both entrance behavior scenarios and flood risk assessment are effectively the same and both project outcomes can be delivered simultaneously. The modelling tasks will be undertaken GCCM and QEPA in partnership with GCCC’s Flood Strategies Section.

Two of the student projects will be incorporated into the CRC project. The community attitudes activity will be undertaken as a student project at ANU by an associate student of the Coastal CRC. The Masters project on the geomorphological framework for planning will be established as an associate project with the Coastal CRC and will be supervised by Griffith University staff who are members of the CRC.

The key outcome of this project will be the establishment of scenarios for effective channel maintenance which meet community and government expectations.

**CoastEd**

The Currumbin Entrance program will be incorporated into GCCM’s Coasted routine activities, and will be covered by the over-arching agreement between GU and GCCC.

**Channel Maintenance Options and Assessment**

This project will be established under the over-arching agreement between GU and GCCC acting as lead agent for funding agencies. The project includes the establishment, deployment, trialling and management of the mobile fluidiser; and a PhD student project. The PhD student will be enrolled at GU. The project will under the overall management of sub-consultants International Coastal Management P/L. The project will be supported by internal GCCC activities namely: hydrographic survey by the Hydrographic Survey Team, provision of water quality data by the Catchment Management Unit and the incorporation of the annual GCCC funded dredging program.

**Nearshore Monitoring**

A GCCM project will be established in partnership with Coastalwatch P/L and NMSC to monitor and assess the usage characteristics of the entrance through remote video imagery and the biological condition of the natural reefs in the vicinity of the entrance.
Kirra Wave Study
A Report to Gold Coast City Council as a component of the Gold Coast Shoreline Management Plan

Griffith Centre for Coastal Management
Research Report No 59
February 2007
PREPARED BY:
NEIL LAZAROW
BRUNO CASTELLE

In partnership with Griffith University
**Synopsis**: The *Kirra Wave Study* is a community initiated study to investigate and develop options that are anticipated to lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity.

**Keywords**: Kirra, Waves, Sand Bypassing
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1. EXECUTIVE SUMMARY

1.1 Background

Over the past 10 years, a combination of factors has resulted in the decline in surf quality at Kirra Beach, up to a point today, where the wave seldom breaks in a manner suitable for surfing. A modification to the groyne combined with the effects of the Tweed River Entrance Sand Bypassing Project has significantly altered the local geomorphology resulting in improved coastal security but at the same time a loss of a significant recreational asset. The loss is believed to have had a serious affect on amenity and safety as well as community well-being and the economic flow-on effects that ‘Kirra’ delivers.

The ‘Kirra Wave Study’ is a community initiated study to investigate and develop options that are anticipated to lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity and is part of the stakeholder engagement process within the Gold Coast Shoreline Management Plan (GCSMP).

Gold Coast City Council officially commenced the GCSMP in 2005. It is a 3-year program aimed at improving our understanding of our beach environments and focuses research and planning on how we manage our beaches and shoreline. Supporting the sustainability of the natural environment will underpin our lifestyles and economy into the future. The goal of the GCSMP is to develop coastal protection measures to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions without compromising our way of life.

In late 2005, the Griffith Centre for Coastal Management developed a project proposal to investigate and develop options that would lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity. The project has received support from the local community, industry, local government and elected officials. See Appendix 1 for more details on support for this project.

The project had three primary tasks:

1) Run a series of community meetings to canvass ideas and options that those in the community believed would lead to an anticipated improvement in surf break amenity and safety on the southern Gold Coast, specifically Kirra beach.

2) Undertake computer modelling based on the shortlisted options to see which would be the best possible approach while at the same time not having a detrimental affect on coastal protection.

3) To document (film) the process, create a short film/documentary (15-25 mins) of the process and to make the documentary available for education and publicity purposes, including screening the documentary on TV.

The purpose of this report is to describe the community engagement process used and to present recommendations to GCCC on how surfing amenity might be improved in Coolangatta Bay, with a specific focus on Kirra Point. These recommendations need to be considered against the expected condition of the bay in a few years time, the time it might take for an intervention to have any effect and the possible economic, management and liability considerations around these issues.
1.2 Summary of findings

GCCM has worked with the local community to investigate a series ‘community’ options that may lead to an improvement in surf quality in Coolangatta Bay, with a specific focus on Kirra Point. The goal of this Griffith University project is to present a series of options to the local community on how surfing amenity might be improved at Kirra. The central focus of the research was to determine if any extra works above the current Tweed River Entrance Sand Bypassing Project (TRESBP) would lead to an improvement in wave quality within a given time period.

The range of options investigated includes:

- Modifications to Big Kirra Point Groyne.
- Supplementary outlet to the west.
- Extend the ‘grid system’ for dredged sand to be placed further to the west.
- Realign the beach profile at Kirra.
- TRESBP operates according to current management plans.

Combinations of these five options were also investigated.

All options were modelled using Delft3D (a coastal process modelling program) simulations based on an input of 1.8m SE swell conditions entering the bay at 1.2m. All simulations were run over a 12-month period. Using a prescriptive and limited set of variables means that the results should be interpreted with some sensitivity. For example, a prediction from the model that indicates it may take 12 months to reach a particular scenario, may actually take somewhere between 9-18 months depending on conditions. This is on top of any time needed to conduct further studies, design, approve and construct extra infrastructure.

Major findings are as follows:

- A supplementary outlet to take at least 75% of the bypass slurry to the west of North Kirra SLSC is most likely to assist in returning and maintaining favourable surf quality to Kirra Point in the shortest period of time. Other factors will of course assist in this process.
- When the Kirra Point groyne was shortened in the mid-1990s not all of the foundation stones were removed. Removing these stones or adding a short length to the end of the groyne will create a ‘smoother’ end to the groyne which will allow sand to flow more smoothly around the point and also provide a safer structure.
- Moving the dredge spoil drop locations further to the north will also assist in ‘clearing out the bay’.
- The extension of Kirra Point Groyne to its pre-1996 length (+30M) will have little effect on surf quality in the short to medium term if the sand bypass and dredging operations continue as they currently are. In the event of the bypass system being turned off, the impact of a groyne extension would be more beneficial.
- Realigning the beach profile at Kirra which may involve beach scraping and the construction of a ‘lagoon’ type hole that would encourage the shoreline to erode landwards at an angle is likely to have a high short-term effect but is unlikely to hold over the longer term. Further, this strategy will not assist greatly in deepening the nearshore sand banks, a critical component needed to improve wave quality.
Turning off the sand bypass system will, in the short term, achieve a similar result for improved wave quality at Kirra, to redirecting the sand through a supplementary outlet to the north.

A large storm event or sequence of storm events will assist in moving sand further to the north and out of Coolangatta Bay but this will also see a loss in the sandbanks for a period of time.

1.3 Recommendations

1. GCCC investigate options and costs associated with extending the location for dredge spoil deposits to the west of the current grid system. An agreement would need to be reached between the two state governments, Council and the contractor to make changes to existing contractual arrangements. If funding is available, it may be possible for an arrangement to be in place prior to the 2007 Tweed River dredging campaign. It will cost approximately $500,000 - $800,000 p/a to ship 200,000m³ of sand (amount dredged in 2006) further west; depending on how far west the sand was deposited. If the area immediately west of Coolangatta Creek was chosen as the deposit site, then the cost would be less than $500,000. An alternative option is for the TRESBP project EIS to be revised with the intention of expanding the grid system. Revising the EIS would also permit an investigation of sand placement to the south of the Tweed River as well as the investigation of other improvements to the Act (for example defining recreational amenity) and project agreement. Funding would also need to be sourced for revising the EIS.

2. An investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken, including the acceptability of this option to the NSW Government, Qld Government and Gold Coast City Council. Such a system will most likely cost in the vicinity of $4,000,000 to construct and approximately $100,000 per year to operate and maintain based on at least 75% of the sand volume (excluding the sand being pumped to Duranbah) being discharged at this new outlet for approximately 2 years. In consultation with the community, the project management team may make a decision to readjust the volumes of sand being pumped to the various outlets. An extra benefit of a supplementary outlet is the potential for a ‘new’ wave or series of waves to be created in the vicinity of the outlet, similar to the benefit of the outlet at South Stradbroke Island. A supplementary outlet will give the project the scope to adjust volumes over time and maximise the benefit of the project, not just for safe navigation of the Tweed but also with a stronger concern for an improvement in safety and recreational amenity on the southern Gold Coast beaches.

3. Kirra Point Groyne will need to be addressed. As part of this investigation, the value of cleaning up the end of the groyne or in time removing the groyne altogether should be considered.

Note: At the public meeting on the 30th January 2007, there was a strong consensus on recommendations 1 & 2. The community consensus was that recommendation 3 be modified to specifically call for Kirra Point Groyne (Big Groyne) to be extended to its pre-1996 length (+30m). A fourth recommendation from the community was that Gold Coast City Council commission the Griffith Centre for Coastal Management to continue its investigations.
1.4 Other Considerations

The ‘Kirra’ issue is one of significant importance to many, including community, industry and government. The economic value of recreation and in particular recreational surfing to the southern Gold Coast is significant. A combined GCCM, GCCC and Australian National University study will report on this mid-late 2007 and is another factor that needs to be considered.

The scope of this report was limited to considering if further alterations to the physical processes may lead to an improvement in surf quality at rate faster than if TRESBP continued as usual over the next few years. This study does not consider how community consensus might be achieved on this issue or whether the respective governments would be willing to entertain changes to project plans, management systems, environmental reports or legislation. If the recommendations suggested in this report are to be acted upon, there will be a number of issues that need to be overcome. These are:

- The aesthetics of a supplementary outlet in the North Kirra / Bilinga area and the concerns that local residents might have with respect to safety and access;
- The impact of current and proposed actions on the marine environment;
- Future coastal planning and management along the Gold Coast, including the possibility of more offshore structures;
- Potential to impact on the desalination plant pipeline system;
- Impact on beaches to the west / north, including Currumbin entrance;
- Addressing the inconsistencies within the TRESBP legislation with respect to adequately defining the goals of the Act as they refer to recreational amenity and surf quality;
- Finding and maintaining consensus within the local community about a preferred course of action;
- Securing a commitment from the relevant levels of government to the preferred course of action; and
- Securing funds for further investigations and then design, construction, operations and maintenance of any infrastructure or works.

1.5 Further Research

With the presentation of this report to GCCC, GCCM’s brief for this project concludes. Clearly though, this project and this process have not run their full course. The recommendations from this project as well as the issues raised outside of the project brief provide a number of opportunities for further research and investigation. A recommendation that GCCC commission GCCM to conduct further research on this issue was unanimously passed at the public meeting on 30 January 2007. Key issues for further investigation include:

1. As per recommendation No 1, investigation of the best location for the placement of dredged sand, costs, and cost sharing opportunities;
2. As per recommendation No 2, an investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken. This investigation would include an examination of physical processes, design, costs, potential partnerships and risks associated with such a project;
3. As per recommendation No 3, an investigation of the ‘Kirra equation’, a detailed study to attempt to map the best morphological and wave climate conditions for optimum surf quality at Kirra Point; and

4. Investigating the inconsistencies within Qld and NSW legislation with respect to adequately defining recreational amenity and surf quality and in particular how it relates to the management of the TRESBP and GCCC’s coastal planning and management goals.
2. INTRODUCTION

2.1 Background to the study

For over 40 years, Kirra Beach has been the bastion of surfing on the Gold Coast. The wave at Kirra, both before the groyne was built in the early 1970’s and subsequently, has regularly been rated as being the best surfing wave in the world. Around this and other waves, surfing has grown to become a major recreational and commercial activity in South-East Queensland. Surfing forms a major pillar of the Gold Coast culture, is a major community asset and is also a significant contributor to the local economy, yet we know little about the value of surfing to individuals and to communities in any formal sense.

A combination of engineering works in and around Coolangatta Bay has altered natural coastal processes in this area for over 100 years. Modifications to the coastline include the construction and subsequent extension of training walls for the Tweed River, construction of seawalls, dredging, beach nourishment campaigns, construction of groynes and more recently the commencement of the Tweed River Entrance Sand Bypassing Project. Our desire to live by the coast, the development of public and private infrastructure and the rise in the value of coastal real estate has put many local governments in a position where they have been required to protect property from the forces of the ocean rather than allow the ocean to naturally align itself along the coastline, a process which would require a commitment to planned retreat.

A further complication to the planning process is the fact that much of the coastal development over the past 30 years has taken place in a period of relative calm and many experts believe we are now entering a period where we are likely to see more frequent and severe storms as well as a longer-term rise in sea levels. GCCC planning schemes take into account these natural variations in coastal processes.

In Australia, the modification of our coastal resources can only be understood within the context of coastal settlement and population growth in the coastal zone. This is the dominant paradigm for coastal planning and management today. Currently, 86% of our population (ABS 1998) lives within 30mins drive of the beach and we can expect many of the 11-15 million extra Australians predicted by the middle of the century to want to live near the coast (Davis and Weller 1993).

A lifestyle by the coast represents something more than the prospect of food, clothing and shelter – it has become synonymous with the great Australian dream - and ‘the beach’ must surely rival ‘the bush’ as being the current manifestation of this dream. Dutton (1985) writes, “the tradition of Australians at the beach, in its many ways, is of profound importance to the national character.”

On average, the Gold Coast tourism region hosts over 75,000 visitors everyday. This figure includes international, domestic overnight and daytrip visitors, and represents approximately 16% of all people in the Gold Coast region on any given day. For the year ending June 2004, the Gold Coast received a total of 4,285,000 tourists with 65% declaring the purpose of the visit was for holiday/leisure. Further research into nature-based tourism on the Gold Coast (Gold Coast City Council 2003) has shown that 56% of all overnight visitors and 30% of all day-trippers go to the beach during their stay on the Gold Coast. As well as high levels of tourist visitation to beaches, the Gold Coast is said to boast the second largest resident surfing population in Australia after Sydney. The Gold Coast is home to some of the best-known surf breaks in the world, including Snapper Rocks, Kirra, Currumbin Alley, Burleigh...
Heads and South Stradbroke Island and has been a popular surfing destination for over 40 years.

Today, it is estimated that the global surfing population is close to 20 million, with over two million surfers in Australia and close to two-and-a-half million surfers in the USA (Kampion 2003). Surfing takes place in diverse coastal locations around the world (including Antarctica) and is expanding both in intensity in traditional locations, as well as in reach into new environments often in the developing world (Carroll 2004).

Dolnicar and Fluker (2003) and Carroll (2004) write that surfing is now worth an estimated $8 billion dollars per annum and reaches into most countries on the planet. Initial investigations by this author and current work by Nelson (2006) indicate that while this number includes the clothing retail arms of the major surf apparel companies, it is likely to significantly under account for the total economic value of recreational surfing. An earlier report into the value of recreational surfing estimated that the gross market expenditure of recreational surfing was around $20 million p/a at South Stradbroke Island (Lazarow 2006). Current studies are being undertaken to investigate the value of recreational surfing at Burleigh Heads, Palm Beach, Currumbin, Coolangatta Bay and Duranbah.

The value of surfing to society and the imprint of surfing on our lives and lifestyles has grown significantly over the past three decades. This combined with the significant growth in participation and rising popularity of surfing in many countries, means that the importance of the economic value of surfing to various regions cannot be understated. Surfing today represents a very profitable market, an increasing growth industry (Lanagan 2002), a reason people move to areas and plays a major part in the tourism strategies for many coastal locations in Australia.

More than this, surfing brings something else to communities and people. It links generations, it brings people together, it provides an avenue for outdoors based physical activity and it has helped build towns and communities. Little has actually been written or documented about the ‘community good’ or value to ‘civil society’ that surfers and surfing can bring to communities and locales. This ‘social good’ question forms part of this examination. The Economics section of this paper provides a useful discussion the issue of total economic value.

There are a number of studies that describe the importance of surf tourism and sustainable development in the Indo-Pacific region (Buckley 2002, Dolnicar and Fluker 2003) but to date there has been very little investigation into the value of surfing at major surf destinations (by weight of numbers of surfers) around the world, possibly because they are viewed as the places we live and not the places we visit and maybe because such areas of research are not seen to be of a serious mainstream concern. Nevertheless, the socio-economic value of surfing to these communities is believed to be significant and any negative impact to the surfing amenity in these locations may have serious consequences for the resident surfing population, visitors and the local surf industry. The broader investigation of which this paper is a part makes a distinction between surfers as tourists (surf tourism) and surfers as locals. For example, Bell and Leeworthy (1990) tested the theory that the tourist beach visit decision is different to those travelling short distances (day visitors and residents). They argue that travel costs for an entire trip are viewed as an investment while on-site costs per day were considered as costs.

There is no doubt that beaches and beach based recreation is the driver behind the lives and lifestyles of many Gold Coast residents as well as the majority of visitors who frequent our beaches each year. The beaches of the Gold Coast have achieved iconic status within the local, regional national and international community – for a number of reasons.
GCCC recognised the importance of the need to better understand the values that the community and visitors place on our beaches and the range and locations of activities that take place. The Gold Coast Shoreline Management Plan makes a significant move forward with its strong focus on developing a greater understanding of not only the physical and ecological health of our beaches but also contributing to our knowledge of human activities and the value of the beaches. Understanding beach use and the value of the beaches to both the residents of the Gold Coast and our many visitors must be a strong part of the planning process. This shift in management focus from a traditional approach that focused on how to protect private and public built infrastructure from the ocean to a more holistic approach that recognises that coastal planning and management for the Gold Coast must recognise and plan for what happens on the eastern side of the boulder walls is a positive approach that will see the Gold Coast continue to be a leader in coastal planning and management. The proposed Ocean Beaches and Foreshores Strategy will go a step further and provide more detailed data on Gold Coast beach recreation.

A high energy coastline is often subjected to extreme levels of wave energy. When a coastal property boundary is fixed, as is much of the urbanised east coast of Australia, there is often limited opportunity for people to relocate their properties (retreat) in the face of an advancing ocean. Our system of property ownership also does not have the flexibility to allow property boundaries to be readily relocated. Interestingly, in the past few years, the insurance industry has taken a stronger interest in climate change modelling and it may be more difficult for coastal property owners to insure their homes and land at current market rates into the future.

One of the most significant issues for GCCC is the potential loss or loss of public space as a result of changes to the shoreline profile. The value of the beach to residents, visitors and the business community here on the Gold Coast means that it is no longer an acceptable option to simply allow the beach to disappear.

Appendix 2 provides a detailed project chronology.

### 2.2 History of Coolangatta Bay morphology

Early sketches of Coolangatta Bay and Kirra date back to 1840. From the start of the Twentieth Century through the 1910s and 1920s, Kirra grew to become a popular recreational beach area. With the opening of the South Coast Road in the early 1930s, the Southern Gold Coast continued to grow in popularity as a weekend and holiday destination - many years before Surfers Paradise and Southport became popular destinations. Camping at Kirra was very popular. The wide beach and low lying dunal system at North Kirra provided ideal camping grounds. By the late 1930s the bathing houses and kiosk along the promenade had been replaced by the Kirra Pavilion and more than ever, crowds flocked to the beach. Of course Mother Nature doesn’t always play along. The east coast of Australia and the Gold Coast in particular is exposed to high energy oceanic conditions. Coolangatta Bay was hammered by cyclone swells in 1936, the year after the Pavilion was opened and then again in the early 1940s, which caused significant beach erosion. Seawalls were shored up and extended in order to protect coastal property. But the residents of the Gold Coast soon forgot about the devastating potential of Mother Nature as a period of relative calm returned to the region and locals and visitors returned to the beach in even greater numbers. The lessons of the past, however, were not forgotten as the large seawalls along the back of the beach demonstrate.

Through the late 1950s and early 1960s, the beaches remained quite healthy; however, things would soon change. The extension of the Tweed River Walls by approximately 380m from 1962 – 1965 to improve navigation conditions at the entrance effectively ‘turned the tap off’ and significantly reduced the natural supply of sand into Coolangatta Bay. These walls
created a trap for the natural longshore drift, resulting in loss of sand supply to the southern Gold Coast beaches (DHL, 1970), particularly in Coolangatta Bay.

A big storm season in 1967 further reduced the volumes of sand on the beach and potentially exposed coastal property to greater risk. The point break and bay setup at Kirra Beach provided great surfing conditions prior to the construction of the Big Groyne in 1972. As a result of ongoing erosion caused by a combination of large seas and the extension of the Tweed River walls which prevented the flow of sand into Coolangatta Bay, a large groyne was constructed at Kirra Point in 1972, in an attempt to hold sand on Coolangatta Beach. The angle of the groyne improved the length of wave riding at Kirra Point and is said by many, including ex-world champion Wayne ‘Rabbit’ Bartholomew, to have improved the quality of the ride also.

In 1974, South East Queensland was hit by a series of cyclones and east coast lows over a five-month period. The reduction in the natural sand transport round Point Danger and into Coolangatta Bay as a result of the extensions to the Tweed River training walls had weakened the ability of the beaches on Coolangatta Bay to respond to storm events. The sequence of cyclone and storm events in early 1974 was severe and since then we have not witnessed a similar storm season. The beaches at Kirra and North Kirra were completely eroded and put the bay into a period of high erosion for almost a generation. The massive storms of the late 1960s and early 1970s succeeded in stripping the beach at Coolangatta to reveal bits of old cars and concrete that were used to secure the coastline after the storms of the 1930s. In 1975 a smaller groyne at Miles St was constructed westwards of the first groyne.

Over the past 30 years, a number of major beach nourishment campaigns have been undertaken. In 1974/75 a trial project consisting of 76,000m³ of sand from the Tweed River, followed in 1985 by 315,000 m³. From 1988-1991 a campaign to move sand from offshore onto the beaches and nearshore system was undertaken; and then in 1995, the Tweed River Entrance Sand Bypassing Project (TRESBP) project commenced. In 1995, approximately 30m was removed from the end of Kirra Point Groyne in order to reduce the impacts of erosion at Coolangatta and Kirra. Using a dredge the TRESBP clears out sand from the Tweed River entrance and deposits it in an offshore grid in Coolangatta Bay. A sand bypass system also picks up sand from the area immediately south of the southern wall of the Tweed River. This sand is then piped in a slurry form (80% water and 20% sand) to 4 outlets – Duranbah, East Snapper (Froggies), West Snapper and Kirra Point.

Over the past 10 years, a combination of factors has resulted in the decline in quality of the wave at Kirra Beach. Shortening of the groyne combined with the effects of the Tweed River sand-bypassing project has modified the local geomorphology resulting in the loss of a significant recreational asset. This loss has had a serious affect on amenity and safety as well as community well-being and the economic flow-ons that ‘Kirra’ delivers. The most significant impact on surf quality at Kirra Point has been the impact of the Tweed River Entrance Sand Bypassing Project.

The Tweed River Entrance Sand Bypassing Project is a project governed through mirror acts of Parliament in NSW and Qld. In Qld, it is the Tweed River Entrance Sand Bypassing Project Agreement Act (Act No.9 of 1998). The purpose of the Act is to provide for a sand bypassing project to improve and continuously maintain:

(a) the amenity of the southern Gold Coast beaches; and
(b) the navigability of the Tweed River entrance (S4)

See Appendix 3 for further details on the TRESBP and the Act.
2.3 Summary of TRESBP operations to date

In the 12 months prior to the removal of a section of Kirra Point Groyne in 1996, Stage 1A of the Tweed River Estuary Sand Bypassing Project (TRESBP) delivered approximately 2,300,000 m³ of sand to the beaches and nearshore zone of Coolangatta Bay with the specific focus of ‘re-establishing depleted upper beach and nearshore sand levels’ (Boswood 2001).

In April 1995, 1,500,000 m³ of sand was placed in the nearshore zone in the 6-10m depth range. In May, 600,000 m³ was placed on the upper beaches; and in the 5 months following this, a further 200,000 m³ was placed in the nearshore zone in the 0-5m depth range (remember an olympic pool contains 2,500 m³ of sand). This dredging campaign moved almost 50% of the total volume of sand that has been dredged to date. The TRESBP dredging campaign, combined with the removal of part of the groyne in 1996 led to a large and sudden change to the structure of the bay (filling in holes, smoothing the bay floor, raising the seabed height etc). This program of works succeeded in the objective of creating a wider beach but had the effect of significantly altering wave quality.

Since the bypass operations commenced in March 2001, the annual average volume of sand pumped (to March 2006) has been 681,909 m³, with a maximum amount of 755,072 m³ pumped in the year ended March 2004.

Prior to the bypass operations commencing, 3,580,067 m³ of sand was dredged from the Tweed River. The annual average of sand dredged from April 2001 – April 2006 has been 292,438 m³ with a maximum amount of 498,898 m³ in 2001-02 and a minimum amount of 169,926 m³ in 2004-05. The average annual rate of sand deposited (dredged + pumped) since the bypass commenced operations is 974,596 m³ (These figures have been taken from the TRESBP website). Further information on the TRESBP dredging and pumping programs is available on the TRESBP website: www.tweedsandbypass.nsw.gov.au

At the August 2006 Advisory Committee meeting for the TRESBP, the community was informed that the project will now deliver a volume of sand closer to the identified ‘natural’ littoral drift of 500,000 m³ per year, and we can expect to see a downscaling of the dredging operations over the next few years.

2.4 Recent overview of physical processes in Coolangatta Bay

In mid-2006, researchers from GCCM were provided with a limited data set by the TRESBP team. This data set allowed us to map morphological changes to Coolangatta Bay based on this information. The following is a summary of the GCCM research paper by Castelle et al 2006 (see Attachment 4).

1. The significant and rapid evolution of Coolangatta Bay morphology is due to two main factors: the large amount of sand available updrift (this surplus of sand is no longer available updrift), and the intense and quasi-permanent westward longshore sediment transport along Coolangatta Bay. A set of simulations were undertaken in order to assess the evolution of both wave and flow patterns within the Bay over the period 1995-2005. Results show the presence of an intense and almost spatially homogeneous longshore current along the bay. Embayments and headlands (except Snapper Rocks) do not have any impact on the longshore current shape to the point where, Greenmount Hill and Kirra Point do not act as headlands anymore.

2. Coolangatta Bay experienced significant morphological changes over the past decade. Accretion of the seabed floor has reached 6 m in some areas like Kirra Beach where the seaward shoreline migration attained 200 m.
3. Kirra beach seems to act as a sink. This is not surprising given that this section of coastline experienced the greatest negative impact of the erosion wave that followed the construction of the Tweed walls. Nowadays, Kirra beach continues to infill despite the recent decrease in pumped sand quantities. This process will end as soon as both the shoreline and the nearshore bar will become straight between transects PSM18 and K17, resulting in an almost morphological equilibrium of Kirra Beach (see Figure 2 in Attachment 4).

4. There is no equilibrium of Coolangatta Bay yet. Indeed, the nearshore sand bar, the wave, flow and sediment transport patterns are continuously evolving. Moreover, recent information suggests that, within the next few years, the pumped quantities will decrease and probably be around 500 000 m³/yr due to the decrease of the available sand quantities updrift of the Tweed River.

See Appendix 4 for a more detailed summary of the GCCM investigation into the morphology of Coolangatta Bay.

2.5 Inconsistencies in the legislation – defining recreational amenity

We’ve already established that the consequences of a loss of a valued marine recreational asset have far reaching affects on the health and wellbeing of a community.

A specific set of criteria is defined for what constitutes ‘safe’ navigational access of the entrance of the Tweed River, however, a similarly rigorous approach was not leant to the other objective, that of improving recreational amenity of the southern Gold Coast Beaches.

From a policy perspective, the SEQ Regional Coastal Plan, Section 2.1.10 states that sites which are regionally significant for recreation and tourism should be identified and protected and Section 2.3.1 states that there is no net loss of public access to the foreshore or of public usability of coastal waters. This is to be maintained, protected and enhanced.

Recreational facilities are included in the definition of areas of State Significance within this Plan. However, neither the State Coastal Management Plan (2001) nor the Qld Coastal Act (1995) define recreational amenity. For that matter neither do the coastal policies in NSW, Victoria or WA. For the purposes of the SEQ Regional Coastal Plan, recreational amenity was judged on the basis of facilities being constructed (as opposed to natural areas) and the Gold Coast’s beaches were excluded.

With respect to the TRESBP, no standards for recreational amenity have been defined in the Act and this means that there will always be some uncertainty with respect to exactly what constitutes an improvement or for that matter, a loss of recreational amenity. Further to this, the Act does not make provision for compensation or forewarning of the loss of amenity for a given period of time and there is no formal obligation to address this issue.

Recreational amenity, however, is referred to at length in the EIS for the project. For example, in Technical Appendix III: Surf Impact Assessment, (p.44, 1997) of the EIS for the TRESBP the following statement is made about Kirra: “Kirra Point is a natural rocky headland that extends about 100m into the sea. A beach bar forms during high wave energy over which 2-4m waves break with a peel angle near the limits of surfability. It is one of the world’s renowned surf sites.”

During the public consultation process for the Draft Plan, an attempt to get the beaches of the Gold Coast listed as areas of state significant (social and economic) was denied by the Qld EPA on the grounds that the beaches of the Gold Coast can not be classified as areas of
state economic significance for recreation because they are 'natural' rather than constructed facilities.

It could and should be argued that the Project Managers (NSW Government) established an Advisory Committee as part of the Heads of Agreement for the TRESBP to represent the surfing community's interests directly to the Project. The Advisory Committee meets on a quarterly basis and has done so since the commencement of the sand-bypassing operations.

This has particular importance when one considers that Schedule 2 p.70 of the Act specifically states that: "The States hereby agree that neither will undertake activities which are detrimental to or compromise the securing of the other's objectives."

2.6 Measuring surf quality

The TRESBP along with GCCC organised and ran a beach and surf monitoring group from 2001 – 2004. Group membership was comprised individuals from the local community and stakeholder groups. The group was disbanded in 2004. It is unclear whether the monitoring results had any impact on project management. Appendix 5 provides an example of the monitoring sheet used by the group.

There are a number of ways to measure surf quality that do not necessarily rely on the after the fact testimony of a small number of people or commercial surf publications that trade on photos of good waves. For example, surf quality monitoring is / was undertaken at the following locations:

- Pratte's reef (California, USA)
- Duranbah (Tweed, Australia)

A number of models have been produced for the artificial reef industry. International Coastal Management and Amalgamates, Solutions and Research (ASR) are the two leading companies that have undertaken investigations in this arena.

A more recent approach to measuring surf quality is described by Lazarow (2006). This model incorporates a hierarchy that includes wave quality, wave frequency and surfer safety (environmental and physical). Using this model, one needs to understand wave climate, what constitutes good waves at a specific location and have an understanding of the surfing experience at specific locales.

These models are described in further detail in Appendix 5.

This is an important research and planning question for GCCC and the TRESBP that requires further investigation. To not do so might risk exposing parties to possible legislative challenges similar to the Pratte's Reef example.
3. INVESTIGATIONS

The range of options investigated includes:

1. Modifications to Kirra Point Groyne.
2. Supplementary outlet to the west.
3. Extend the ‘grid system’ for dredged sand to be placed further to the west.
4. Realign the beach profile at Kirra.
5. TRESBP operates according to current management plans.

As well as these 5 options a series of models was also undertaken that investigate combinations of options.

3.1 Options in detail

1. Modifications to Kirra Point Groyne. This option involved investigating the benefit of:
   a. Extending Kirra Point Groyne back to the pre-1996 length (+30m).
   b. Extending Kirra Point Groyne by 50m from pre-1996 length (+80m).
   c. Removing Kirra Point Groyne (-30m).

   These options were modelled with the TRESBP system operating at 500,000m³ p/a and with the TRESBP system off. Modelling with the TRESBP system off also helps to give an indication of how Kirra Point would behave if a supplementary outlet was constructed to the west and received all of the sand for a period of time.

2. Building a supplementary outlet to the west (between North Kirra and Bilinga SLSCs). This option involves investigating the benefit of creating a supplementary outlet in the North Kirra / Bilinga area.
   a. This option was modelled to take 100% (5000,000m³) of bypass sand per year, the total volume expected to be pumped (excluding the sand earmarked for Duranbah).
   b. This option was modelled to take 75% of bypass sand per year (excluding the sand earmarked for Duranbah) with 25% of sand discharged through the Snapper Rocks East outlet.

3. Extend the ‘grid system’ for dredged sand to be placed further to the west. This option involves investigating the benefit of extending the grid system further to the west, which will enable the dredge to dump sand further along the coast.
   a. This model was derived by examining Options 2a and 2b. A model depicting the supplementary outlet receiving 100% of the bypass discharge would be roughly equivalent to that outlet receiving 60-75% of total discharge and 100% of the dredge spoil being placed to the west of Coolangatta Creek.

4. Realign the beach profile at Kirra. This option involved investigating 2 options that may assist in realigning the beach and sandbank profile at Kirra
a. This option involves using heavy machinery to scrape back the shoreline on the western side of Kirra Point Groyne. This option was not modelled because the DELFT3D model does not apply to beach processes shoreward of the beach break.

b. This option involves the construction of a ‘lagoon’ type system that may encourage the shoreline and sandbank to migrate shorewards at an angle that would improve surf quality. The construction of a 60m long x 5m deep x 20m wide lagoon was modelled.

5. TRESBP operates according to current management plans. GCCM is led to believe that TRESBP intend to pump volumes of sand much closer to the natural littoral flow. This would mean a significant reduction in 2001-2006 combined volumes (almost 50%) for pumping and dredging. The TRESBP has put forward a position statement suggesting the typical conditions that we may expect at Duranbah and Coolangatta Bay, including Kirra, in 3 years time. They are as follows:

a. Duranbah Beach to be similar to now – i.e. it would need to be nourished once or twice a year. Snapper Rocks to provide good consistent surfing, but not provide the long rides of the early 2000s.

b. Rainbow Bay to be similar to now – i.e. variable and not as wide as in the early 2000s.

c. Greenmount Beach will also be variable. Typically it is expected to recede up to 30-50m at the Greenmount Headland end with some separation of surfing breaks between Snapper Rocks and Greenmount.

d. Coolangatta Beach (closer to the Kirra Point groyne) to be similar to now, but with smaller inner nearshore shoals.

e. Kirra Beach to recede about 100m to near the end of the Miles Street Groyne.

f. Kirra Point to become more prominent, and “point break” surfing conditions to become more frequent.

g. Kirra Reef to be significantly larger – about 3,000 square metres in area.

(Information provided by Ian Taylor Project Manager, Tweed River Entrance Sand Bypassing Project on 11/08/06)

This scenario was also modelled to incorporate a series of storm / cyclonic events.

3.2 Potential bias related to the modelling

- All GCCM models were run using uncalibrated models based on a steady wave climate of consistent south-east swells of 1.8m, entering the bay at 1.2m over a 12 month period. They are thus estimates and do not take into account changing conditions over the time period.

- The estimates generated in the modelling process present indicative time frames for change only and this may change as a result of natural conditions e.g. when the model predicts 12 months, it may actually take somewhere between 9-18 months.

- An important consideration for any works proposed is that achieving environmental approvals, except for direct GCCC action, may take between 6-18 months in addition to the timeframe indicated in the table below.
### 3.4 Summary and comparison of options

Note: Options rated in terms of improvement in surfing only

<table>
<thead>
<tr>
<th>No</th>
<th>Option</th>
<th>Timeframe for modelling</th>
<th>Decision-making authority</th>
<th>Estimate d Cost</th>
<th>Short-term succes s at Kirra</th>
<th>Longer-term success at Kirra</th>
<th>Impact on other users</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Extend Kirra Point Groyne by 30m and continue pumping</td>
<td>12-18 months</td>
<td>GCCC, Qld Government</td>
<td>Investigation $50K Capital $500K</td>
<td>Medium-High</td>
<td>Low-Medium</td>
<td>Immediate benefit to surf quality but likely to soon disappear as more sand is trapped and beach widens at Coolangatta; sandbank at Snapper and in bay likely to be pushed further out to sea; Kirra Reef remains covered over; swimming conditions still hazardous.</td>
<td>NO</td>
</tr>
<tr>
<td>1.2</td>
<td>Extend Kirra Point Groyne 30m and stop pumping (similar to extending groyne and using a supplementary outlet)</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>?</td>
<td>Low</td>
<td>Medium-High</td>
<td>Coolangatta and Kirra likely to reduce in size; swimming safer; Kirra Reef exposed.</td>
<td>NO</td>
</tr>
<tr>
<td>1.3</td>
<td>Remove Kirra Point Groyne and continue pumping</td>
<td>12-18 months</td>
<td>GCCC, Qld Government</td>
<td>?</td>
<td></td>
<td></td>
<td>Beaches realign, Kirra Reef exposed more rapidly.</td>
<td>NO</td>
</tr>
<tr>
<td>1.4</td>
<td>Remove Kirra Point Groyne and stop pumping</td>
<td>12-18 months</td>
<td>GCCC, Qld Government</td>
<td>?</td>
<td>Medium</td>
<td>Medium-High</td>
<td>Similar to current in short term, risk to SLSC building and then property over longer term.</td>
<td>NO</td>
</tr>
<tr>
<td>1.5</td>
<td>Extend Kirra Point Groyne by 80m and</td>
<td>12-18 months</td>
<td>GCCC, Qld</td>
<td>?</td>
<td>Low</td>
<td>Low</td>
<td>Beaches widen</td>
<td>NO</td>
</tr>
<tr>
<td>No</td>
<td>Option</td>
<td>Timeframe for modelling</td>
<td>Decision-making authority</td>
<td>Estimate d Cost</td>
<td>Short-term success at Kirra</td>
<td>Longer-term success at Kirra</td>
<td>Impact on other users</td>
<td>Recommended</td>
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<tr>
<td></td>
<td>continue pumping</td>
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<td>Government</td>
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<td></td>
<td>dramatically and beach amenity reduces, surf quality likely to decrease, swimming conditions potentially more hazardous.</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Extend Kirra Point Groyne by 80m and stop pumping</td>
<td>12-18 months</td>
<td>GCCC, Qld Government</td>
<td>Investigation $80K</td>
<td>Low</td>
<td>Low</td>
<td>Beaches to rapidly reduce in width, risk to infrastructure, loss of amenity.</td>
<td>No</td>
</tr>
<tr>
<td>2.1</td>
<td>Supplementary outlet with 100% of bypass discharge (excluding Dbah amount)</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Investigation $100K</td>
<td>High</td>
<td>High</td>
<td>Immediate widening of beaches at Bilinga and Tugun, structures may interrupting access and views at Bilinga beach; swimming conditions and beach amenity likely to improve at Coolangatta and Kirra.</td>
<td>No</td>
</tr>
<tr>
<td>2.2</td>
<td>Supplementary outlet with 75% of bypass discharge and 25% discharge at Snapper Rocks East outlet (excluding Dbah amount)</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Investigation $100K</td>
<td>High</td>
<td>High</td>
<td>Immediate widening of beaches at Bilinga and Tugun, structures may interrupting access and views at Bilinga beach; swimming conditions and beach amenity likely to improve at Coolangatta and Kirra.</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>Option</td>
<td>Timeframe for modelling</td>
<td>Decision-making authority</td>
<td>Estimate d Cost</td>
<td>Short-term success at Kirra</td>
<td>Longer-term success at Kirra</td>
<td>Impact on other users</td>
<td>Recommended</td>
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<tr>
<td>3.1</td>
<td>Dredge spoil area to be moved west of Coolangatta Creek outlet</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Approx $500K - $800K pa</td>
<td>Low</td>
<td>Low-Medium</td>
<td>Coolangatta and Kirra; surf conditions at Snapper to be maintained.</td>
<td>Yes</td>
</tr>
<tr>
<td>4.1</td>
<td>Realign beach profile by building a lagoon with TRESBP operating to spec</td>
<td>12-18 months</td>
<td>GCCC, possibly Qld Government</td>
<td>$750,000 p/a</td>
<td>High</td>
<td>High-medium</td>
<td>Short-term benefits but no guarantee of longer-term success; safety concerns; disruption to access and use of beach; views may be interrupted.</td>
<td>No</td>
</tr>
<tr>
<td>5.1</td>
<td>TRESBP operates according to spec</td>
<td>3 years</td>
<td>NSW Government</td>
<td>Low</td>
<td>Low-Medium</td>
<td>No significant impact expected in short-term, but in combination with other options likely to lead to improved conditions for surf; Kirra Reef may be exposed more quickly.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>TRESBP operates according to spec and we have a series of storms / cyclones</td>
<td>Natural conditions</td>
<td></td>
<td>Low</td>
<td>Potentially High</td>
<td>Potential loss of amenity in the short-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Option</td>
<td>Timeframe for modelling</td>
<td>Decision-making authority</td>
<td>Estimate d Cost</td>
<td>Short-term succes s at Kirra</td>
<td>Longer-term success at Kirra</td>
<td>Impact on other users</td>
<td>Recommended</td>
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<tr>
<td>5.3</td>
<td>Stop TRESBP</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Regular beach nourishment costs of around $4M pa to compensate for loss of sand supply</td>
<td>Medium</td>
<td>Medium - High</td>
<td>Short-term benefits; surf conditions at Snapper likely to deteriorate; with time you would get SLSCs at risk from storm events and other infrastructure; no useable beach at high tide</td>
<td>No</td>
</tr>
<tr>
<td><strong>Combination options</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5.4</td>
<td>Extend Kirra Point Groyne by 30m, 2.2 &amp; 3.1</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Investigation $150K Capital $4.5M Operating $900K</td>
<td>High</td>
<td>High</td>
<td>Immediate widening of beaches at Bilinga and Tugun, structures may interrupting access and views at Bilinga beach; swimming conditions and beach amenity likely to improve at Coolangatta and Kirra; surf conditions</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>Option</td>
<td>Timeframe for modelling</td>
<td>Decision-making authority</td>
<td>Estimate Cost</td>
<td>Short-term success at Kirra</td>
<td>Longer-term success at Kirra</td>
<td>Impact on other users</td>
<td>Recommended</td>
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</tr>
<tr>
<td>5.5</td>
<td>2.2 &amp; 3.1</td>
<td>12-18 months</td>
<td>GCCC, Qld Government, NSW Government</td>
<td>Investigation $100K Capital $4M Operating $900K</td>
<td>High</td>
<td>High</td>
<td>Immediate widening of beaches at Bilinga and Tugun, structures may interrupting access and views at Bilinga beach; swimming conditions and beach amenity likely to improve at Coolangatta and Kirra; surf conditions at Snapper to be maintained; surf conditions at other breaks likely to improve.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
3.5 Major findings

1. A supplementary outlet to take at least 75% of the bypass slurry to the west of North Kirra SLSC is most likely to assist in returning and maintaining favourable surf quality to Kirra Point in the shortest period of time. Other factors will of course assist in this process.

2. When the Kirra Point groyne was shortened in the mid-1990s not all of the foundation stones were removed. Removing these stones or adding a short length to the end of the groyne will create a ‘smoother’ end to the groyne which will allow sand to flow more smoothly around the point and also provide a safer structure.

3. Moving the dredge spoil drop locations further to the west will also assist in ‘clearing out the bay’.

4. The extension of Kirra Point Groyne to its pre-1996 length (+30M) will have little effect on surf quality in the short to medium term if the sand bypass and dredging operations continue as they currently are. In the event of the bypass system being turned off, the impact of a groyne extension would be more beneficial.

5. Realigning the beach profile at Kirra which may involve beach scraping and the construction of a ‘lagoon’ type hole that would encourage the shoreline to erode landwards at an angle is likely to have a high short-term effect but is unlikely to hold over the longer term. Further, this strategy will not assist greatly in deepening the nearshore sand banks, a critical component needed to improve wave quality.

6. Turning off the sand bypass system will, in the short term, achieve a similar result to redirecting the sand through a supplementary outlet to the west.

7. A large storm event or sequence of storm events will assist in moving sand further to the west and out of Coolangatta Bay but this will also see a loss in the sandbanks for a period of time.
4. **RECOMMENDATIONS**

1. GCCC investigate options and costs associated with extending the location for dredge spoil deposits to the west of the current grid system. An agreement would need to be reached between the two state governments, Council and the contractor to make changes to existing contractual arrangements. If funding is available, it may be possible for an arrangement to be in place prior to the 2007 Tweed River dredging campaign. It will cost approximately $500,000 - $800,000 p/a to ship 200,000m³ of sand (amount dredged in 2006) further west, depending on how far west the sand was deposited. If the area immediately west of Coolangatta Creek was chosen as the deposit site, then the cost would be less than $500,000. An alternative option is for the TRESBP project EIS to be revised with the intention of expanding the grid system. Revising the EIS would also permit an investigation of sand placement to the south of the Tweed River as well as the investigation of other improvements to the Act (for example defining recreational amenity) and project agreement. Funding would also need to be sourced for revising the EIS.

2. An investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken, including the acceptability of this option to the NSW Government, Qld Government and Gold Coast City Council. Such a system will most likely cost in the vicinity of $4,000,000 to construct and approximately $100,000 per year to operate and maintain based on at least 75% of the sand volume (excluding the sand being pumped to Duranbah) being discharged at this new outlet for approximately 2 years. In consultation with the community, the project management team may make a decision to readjust the volumes of sand being pumped to the various outlets. An extra benefit of a supplementary outlet is the potential for a ‘new’ wave or series of waves to be created in the vicinity of the outlet, similar to the benefit of the outlet at South Stradbroke Island. A supplementary outlet will give the project the scope to adjust volumes over time and maximise the benefit of the project, not just for safe navigation of the Tweed but also with a stronger concern for an improvement in safety and recreational amenity on the southern Gold Coast beaches.

3. Kirra Point Groyne will need to be addressed. As part of this investigation, the value of cleaning up the end of the groyne or in time removing the groyne altogether should be considered.

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**Note:** At the public meeting on the 30th January 2007, there was a strong consensus on recommendations 1 & 2. The community consensus was that recommendation 3 be modified to specifically call for Kirra Point Groyne (Big Groyne) to be extended to its pre-1996 length (+30m). A fourth recommendation from the community was that Gold Coast City Council commission the Griffith Centre for Coastal Management to continue its investigations.

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4.1 **Other Considerations**

The ‘Kirra’ issue is one of significant importance to many, including community, industry and government. The economic value of recreation and in particular recreational surfing to the southern Gold Coast is significant. A combined GCCM, GCCC and Australian National University study will report on this mid-late 2007 and is another factor that needs to be considered.

The scope of this report was limited to considering if further alterations to the physical processes may lead to an improvement in surf quality at rate faster than if TRESBP continued as usual over the next few years. This study does not consider how community
consensus might be achieved on this issue or whether the respective governments would be willing to entertain changes to project plans, management systems, environmental reports or legislation. If the recommendations suggested in this report are to be acted upon, there will be a number of issues that need to be overcome. These are:

- The aesthetics of a supplementary outlet in the North Kirra / Bilinga area and the concerns that local residents might have with respect to safety and access;
- The impact of current and proposed actions on the marine environment;
- Future coastal planning and management along the Gold Coast, including the possibility of more offshore structures;
- Potential to impact on the desalination plant pipeline system;
- Impact on beaches to the west / north, including Currumbin entrance;
- Addressing the inconsistencies within the TRESBP legislation with respect to adequately defining the goals of the Act as they refer to recreational amenity and surf quality;
- Finding and maintaining consensus within the local community about a preferred course of action;
- Securing a commitment from the relevant levels of government to the preferred course of action; and
- Securing funds for further investigations and then design, construction, operations and maintenance of any infrastructure or works.

4.2 The next steps

With the presentation of this report to GCCC, GCCM’s brief for this project concludes. Clearly though, this project and this process have not run their full course. The recommendations from this project as well as the issues raised outside of the project brief provide a number of opportunities for further research and investigation. A recommendation that GCCC commission GCCM to conduct further research on this issue was unanimously passed at the public meeting on 30 January 2007. Key issues for further investigation include:

1. As per recommendation No 1, investigation of the best location for the placement of dredged sand, costs, and cost sharing opportunities;
2. As per recommendation No 2, an investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken. This investigation would include an examination of physical processes, design, costs, potential partnerships and risks associated with such a project;
3. As per recommendation No 3, an investigation of the ‘Kirra equation’, a detailed study to attempt to map the best morphological and wave climate conditions for optimum surf quality at Kirra Point;
4. Securing a commitment from the relevant levels of government to the preferred course of action;
5. Investigations of potential funding sources, including the possibility of public / private partnerships; and
6. Investigating the inconsistencies within Qld and NSW legislation with respect to adequately defining recreational amenity and surf quality and in particular how it relates to the management of the TRESBP and GCCC’s coastal planning and management goals.
5. **CONCLUSION**

Following the presentation of findings to the community on January 30 2007, this report has been finalised and has now been presented to GCCC for consideration. Many in the community have also taken it upon themselves to initiate support for this project and the possibility of private / public partnerships is something that GCCC should consider.

6. **REFERENCES**

**APPENDIX 1 - SUPPORT FOR THE PROJECT**

This project has support in writing from government, academia, industry and the community sector.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Partner</th>
<th>Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Government (elected)</td>
<td>Councillor Chris Robbins, Gold Coast City Council</td>
<td>Local divisional Councillor; support at the political level for this project and for the Shoreline Management Plan; member of TRESBP Advisory Committee</td>
</tr>
<tr>
<td>Local Government (elected)</td>
<td>Councillor Greg Betts, Gold Coast City Council</td>
<td>Support at the political level for this project and for the Shoreline Management Plan; support for recreational surfing interests in particular.</td>
</tr>
<tr>
<td>Local Government</td>
<td>Mr. Greg Stuart, Coastal Strategies Coordinator, Engineering Assets and Planning, Gold Coast City Council</td>
<td>Project Manager of the Shoreline Management Plan; advice on coastal engineering; community engagement; public policy; access to material and information as required; member of TRESBP Working Group.</td>
</tr>
<tr>
<td>NRM Sector</td>
<td>Ms Sarah Castle, Southern Community Partnerships Manager, SEQ Catchments</td>
<td>NRM link for the project; financial support for components of the project; assistance with community engagement strategies and networks; links to other programs.</td>
</tr>
<tr>
<td>Community Groups</td>
<td>Mr. Geoff Withycombe, Chairman of the Board of Directors, Surfrider Foundation Australia</td>
<td>Major national eNGO supporting the project; key local organisation; links to members, networks and industry.</td>
</tr>
<tr>
<td>Community Groups</td>
<td>Mr. Stuart Ball, President Kirra Surfriders Club</td>
<td>Long-term local resident and ‘local-expert’; Significant umbrella user group; strong historical and cultural attachment to site; links to members, networks and industry.</td>
</tr>
<tr>
<td>Industry</td>
<td>Mr. Wayne ‘Rabbit’ Bartholomew, President Association of Surfing Professionals (ASP) International</td>
<td>The unofficial ‘Mayor’ of Coolangatta; an important and well-respected individual local supporter of the project; CEO of the international professional surfing body; vital link to key individuals and groups locally and internationally; access to material and information as required.</td>
</tr>
<tr>
<td>Industry</td>
<td>Mr. Bruce Lee, Team Manager, Billabong</td>
<td>Long-term local resident and ‘local-expert’; also industry link to Billabong, who have agreed to provide access to archival film</td>
</tr>
</tbody>
</table>
### Sector Partner Involvement

<table>
<thead>
<tr>
<th>Sector</th>
<th>Partner</th>
<th>Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>Mr. Andrew Stark, CEO of Surfing Queensland</td>
<td>Footage for this project; vital link to key individuals and groups locally and internationally.</td>
</tr>
<tr>
<td>State Government (elected)</td>
<td>The Hon Jann Stuckey MP, State Member for Currumbin</td>
<td>Support at the political level for this project and for the Shoreline Management Plan; specific concerns over surfing issues related to crowding, wave quality and education; Coordinator, Guardians of the Points.</td>
</tr>
</tbody>
</table>
## APPENDIX 2 - PROJECT CHRONOLOGY

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td></td>
</tr>
<tr>
<td>Jul-Sept</td>
<td>As a part of the GCSMP requirement to engage with key stakeholders, GCCM researchers met with a range of groups and individuals on the coast. The issue of wave quality at Kirra and surrounding surf breaks was a key issue raised during these discussions and the suggestion for a project to examine community suggestions to improving wave quality be undertaken was put forward as a project of significant importance for the community.</td>
</tr>
<tr>
<td>Oct</td>
<td>Draft GCCM Project Proposal Prepared as part of the GCSMP</td>
</tr>
<tr>
<td>Oct</td>
<td>Project concept approved by Prof Tomlinson</td>
</tr>
<tr>
<td>Oct</td>
<td>Key stakeholders approached; project proposal discussed; letter of support sought and received from all stakeholders</td>
</tr>
<tr>
<td>Oct</td>
<td>Griffith University Community Partnerships Grant Application for a Community initiated study to develop options for coastal protection and enhanced surf break amenity at Kirra Beach, Qld, submitted along with letters of support. Application unsuccessful.</td>
</tr>
<tr>
<td>Dec</td>
<td>Meeting with TRESBP</td>
</tr>
<tr>
<td></td>
<td>Present = Tomlinson, Lazarow, Taylor, Rangger</td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>GCCM Director agrees to direct $5000.00 towards educational component of project. This funding allows for the contracting of a film studio (South Pacific Films) to begin work on the development of an educational documentary about the project and process</td>
</tr>
<tr>
<td>Jan</td>
<td>Meeting with 'Surf Elders' to discuss and get approval for commencement of project. Meeting held at ASP offices in Coolangatta. Present = Lazarow, Tomlinson, Shearer, Bartholomew, Dean, Nowak, Butel, Arnott, Ball</td>
</tr>
<tr>
<td>Feb</td>
<td>Info sheets on beaches and surfing and wave quality on the southern Gold Coast released</td>
</tr>
<tr>
<td>Feb - June</td>
<td>Interviews with key stakeholders, literature review, participant observation, attendance at meetings as required</td>
</tr>
<tr>
<td>Jun</td>
<td>Preparation for and advertisement of Experts Panel</td>
</tr>
<tr>
<td>Jun</td>
<td>Info sheet on wave quality – withdrawn at request of TRESBP</td>
</tr>
<tr>
<td>July 3</td>
<td>Experts Panel on improving surfing amenity at Kirra held at Coolangatta Bowls Club</td>
</tr>
<tr>
<td>July 6</td>
<td>Follow up meeting for Kirra held at Coolangatta Bowls Club</td>
</tr>
<tr>
<td>Aug</td>
<td>Amended info sheet on wave quality released</td>
</tr>
<tr>
<td>Aug</td>
<td>Article in Gold Coast Surf magazine</td>
</tr>
<tr>
<td>Oct</td>
<td>Griffith University Community Partnerships Grant Application for a Community initiated study to develop options for coastal protection and enhanced surf break amenity at Kirra Beach, Qld, submitted along with letters of support. Application unsuccessful.</td>
</tr>
<tr>
<td>Sept</td>
<td>Contribution to article in Surfer magazine</td>
</tr>
<tr>
<td>Oct</td>
<td>Info sheet on Kirra Project Update released</td>
</tr>
<tr>
<td>Oct</td>
<td>Article published in Surfing World magazine</td>
</tr>
<tr>
<td>Oct-Dec</td>
<td>Modelling of options prepared through Experts Panel from July</td>
</tr>
<tr>
<td>Nov</td>
<td>SEQ Catchments application for funding for the documentary successful ($500.00)</td>
</tr>
<tr>
<td>Dec-08</td>
<td>Internal presentation to GCSMP and GCCC staff on options Present = Lazarow, Tomlinson, Castelle, Strauss, Stuart</td>
</tr>
<tr>
<td>Dec-15</td>
<td>Presentation to GCCC and external Government stakeholders of findings from modelling of options Present = Swain, Tomlinson, Langan, Shearer, Lazarow, Robinson, Robbins, McGrath, Stuart, Abbs, Lawson, Rangger, Boswood</td>
</tr>
<tr>
<td>Dec</td>
<td>Finalisation of modelling options</td>
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<tr>
<td>Date</td>
<td>Event</td>
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<td>----------------------------------------------------------------------</td>
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<tr>
<td>Dec</td>
<td>Preparation of summary report to community</td>
</tr>
<tr>
<td>Dec</td>
<td>Preparation of full report to GCCC</td>
</tr>
<tr>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>Story on coastalwatch.com</td>
</tr>
<tr>
<td>Jan-30</td>
<td>Presentation of findings and distribution of report to community at public meeting</td>
</tr>
<tr>
<td>Feb</td>
<td>Article on recreational amenity in Marine and Coastal Community Network newsletter</td>
</tr>
<tr>
<td>Jan-Feb</td>
<td>Extensive media coverage on result of public meeting: Daily Mail, Courier Mail, Gold Coast Bulletin, 730 Report</td>
</tr>
<tr>
<td>Feb</td>
<td>Final project report submitted to Gold Coast City Council</td>
</tr>
</tbody>
</table>

**Project highlights**

- Experts Panel and public meeting in July with over 250 participants;
- Over 20 interviews with key industry, government and community stakeholders (as part of the documentary video production);
- Over 30 related local radio (4), newspaper (20+) and television stories (4);
- Article in the Griffith Gazette, Issue 4, 2006;
- Articles in national and international surfing magazines;
- Ongoing national and international interest, including a partnership with surf company Billabong to provide the project with access to archival video footage;
- Internet based coverage on sites including Griffith University, Swellnet, AskHuey and Coastalwatch; and
- Over 100 people attend public meeting on January 30, 2007 to discuss findings of GCCM study.
APPENDIX 3 - TWEED RIVER ENTRANCE SAND BYPASSING PROJECT

The Tweed River Entrance Sand Bypassing Project is a project governed through mirror acts of Parliament in NSW and Qld. In Qld, it is the Tweed River Entrance Sand Bypassing Project Agreement Act (Act No.9 of 1998). The purpose of the Act is to provide for a sand bypassing project to improve and continuously maintain:

(a) the amenity of the southern Gold Coast beaches; and
(b) the navigability of the Tweed River entrance (S4)

Section 8 of the Act appoints the State of NSW as the Coordinating State and Qld is the State of Review (S8.6.2). A contractual arrangement exists for a 23-year operational contract for the delivery of sand through the bypass system. NSW contributes 50% (approx $4million p/a), Gold Coast City Council and the Qld Government each contribute 25% of the annual operational cost of the project.

Section 8.7.3 of the Act states that where the Reviewing State does not agree with:

a) any assessment of risk made by the Coordinating State; or
b) any action proposed by the Coordinating State for the management of any risk including the activities listed in clause 8.7.4 the Reviewing State may refer the matter to the Working Group or, at its sole discretion, to the Ministerial Council for determination. A matter may be referred to the Ministerial Council whether or not it has previously been referred to the Working Group and whether or not the Working Group has made a determination and in such case the determination of the Ministerial Council shall prevail.

The Coordinating State will not proceed with any proposed action while a determination referred to in this clause is pending with respect to that action.

Section 8.10.4 of the Act states that the Reviewing State may obtain an independent audit of monitoring provided that an independent audit shall be at the expense of the Reviewing State unless the audit reveals a substantial failure in the monitoring in which case it shall be a Shared Project Cost.

Section 11.1 of the Act states that the Parties acknowledge that activities incidental to the Project such as the environmental approval process may identify works which must be undertaken in order to ensure that the objectives of one or both Parties are achieved in accordance with all legal requirements. Such works shall be undertaken by or on behalf of the Party in whose territory those works are required and, subject to clause 11.2, at the cost of that Party.

Schedule 1 of the Act is the Deed of Agreement, made on 2 March 1995 between NSW and Queensland. It reads as follows:

a) NSW and Queensland have agreed to the implementation of a project to be known as the Tweed River Entrance Sand Bypassing Project.

b) The purpose of this Agreement is to enhance and maintain the attributes of the Gold Coast—Tweed Heads region and more specifically the Tweed River estuary and the southern Gold Coast beaches and to achieve the respective objectives of the Parties. NSW's objective is “to establish and maintain a navigable depth of water of at least 3.5 metres below Indian Spring Low Water (ISLW) in the approach to and within the entrance...
channel to the Tweed River over a width equal to that between the rubble mound breakwaters” and Queensland’s objective is “to achieve a continuing supply of sand to the Southern Gold Coast beaches at a rate consistent with the natural littoral drift rates updrift and downdrift, together with the supply of such additional sand to the beaches as is required to restore the recreational amenity of the beaches and to maintain it”. The intention is to achieve the objectives in perpetuity.

Schedule 2 of the Act, known as the Heads of Agreement sets out the management arrangements for the project. Section 3 of the Heads of Agreement describes the general benefits of the project as anticipated to be:

a) the improvement in the safety of navigation of the River entrance with the consequent benefits to recreational boating, tourism, property values and the fishing industry;

b) improved tidal flushing of the River estuary, improving quality, mitigation of flooding, and enhancing development potential; and

c) the restoration, widening and long-term maintenance of the (southern Gold Coast) Beaches, with associated benefits to tourism, recreation, property values and the reduction of erosion threats.

To ensure that there is close liaison and co-operation and to ensure the efficient and effective delivery of the Project a Working Group will be formed. The Working Group will be responsible to both Ministers. In addition, the Ministers will be advised by an Advisory Committee.

The Working Group will comprise three members from each State to be nominated by the respective Minister. At the Ministers' discretion one member from each State may be chosen to represent the relevant local government authority. The Working Group will be responsible for implementing the Project including strategic action planning, financial control, policy setting and review at State Government level (S4.2)

The Advisory Committee will comprise two officers from each State to be nominated by the respective Minister, one representative each from Tweed Council and Gold Coast City Council to be nominated by the respective Council and four community representatives (two from each State) to be nominated by the respective Minister. At least one of the State Government officers from each State on the Advisory Committee must also be a member of the Working Group.

The Advisory Committee will give advice on the following:

- Preparation of environmental impact assessment and tender documents for the bypass.
- Calling tenders.
- Acceptance of tenders.
- Preparation of a plan of management.
- Management and implementation of the works.
- Issues of relevance to the local community.
- Other matters referred to it by the Ministers (S4.3).

“The States hereby agree that neither will undertake activities which are detrimental to or compromise the securing of the other's objectives.” (Schedule 2 p.70).
APPENDIX 4 – IMPACT OF BEACH NOURISHMENT ON THE COOLANGATTA BAY
(Paper presented at the 2006 NSW Coastal Conference, Coffs Harbour)

Impact of beach nourishment on Coolangatta Bay morphology over the period 1995-2005

Bruno Castelle¹, Neil Lazarow², Guillaume Marty³ and Rodger Tomlinson⁴

Griffith Centre for Coastal Management, Gold Coast Campus, Griffith University, PMB 50
Gold Coast Mail Centre, Queensland 9726, Australia

¹ Senior Research Assistant, Ph:(07)5552 8520, b.castelle@griffith.edu.au
² Research Fellow
³ Intern
⁴ Professor and Director

Introduction

Coastal erosion is a worldwide occurrence along sea shores which has been reported in the literature for several decades. Beach nourishment, rather than civil engineering structures, is nowadays used worldwide. Major advances in the technology of beach nourishment have been made over the past 3 decades (Houston, 1991; Dean, 1996; Elko et al., 2005). Generally speaking, beach nourishment involves the placement of sediment on an eroding beach to migrate the shoreline seaward in order to promote storm protection, natural habitat and beach amenity. Due to the widespread use of beach nourishment worldwide (Hamm et al., 2002), it is now important that not only coastal engineers but also geoscientists investigating coastal processes understand the performance of beach nourishments.

Coolangatta Bay (Figure 1), located at the border of the states of Queensland and New South Wales, is a major international and national tourism destination. The Tweed River entrance training walls, located southward to Coolangatta Bay, were extended seaward approximately 380 m in the early 1960s to improve navigation conditions at the entrance. These walls also created a trap for the natural longshore drift, resulting in loss of sand supply to the southern Gold Coast beaches (DHL, 1970), particularly in Coolangatta Bay. Coolangatta Bay beaches eroded to an extent that sea walls were constructed to protect property and infrastructure. Coolangatta Bay beaches had not fully recovered by the early 90s, despite various groyne constructions and beach nourishment works. Since 1995, under the Tweed River Entrance Sand Bypassing Project (TRESBP), a number of dredging campaigns and the implementation of a permanent sand bypass system in 2001 has resulted in significant changes of Coolangatta Bay morphology. Beaches are now very wide and healthy, and they are now thought to be the only Gold Coast beaches able to manage a high succession of high wave events.

This paper investigates the influence of wave climate, nourishment works and permanent sand bypassing on Coolangatta Bay morphology for the period 1995-2005. This study is based on accurate bathymetric surveys, quantification of beach nourishment and artificial sand bypassing and wave modelling.
Figure 1. Location and general settings of Coolangatta Bay (Queensland, Australia), and layout of the permanent sand bypassing system

Study area

Location and settings

The 70 km long Gold Coast, in Queensland, has been Australia’s premier holiday resort for more than 40 years. Coolangatta Bay is located at the southern end of the Gold Coast and has a northern exposure (Fig. 1). The area is characterized by the presence of the Tweed River entrance and a major headland called Point Danger. The area of investigation covers approximately 6 km of coastline, comprising 3 distinct embayments within Coolangatta Bay: Rainbow Bay, Coolangatta Beach and Kirra Beach.

The tidal cycle is as for all Gold Coast beaches, with a semi-diurnal cycle, varying from 0.2 to 2 m, with a mean of 1 m. The area is exposed to energetic swells. Three swell regimes can be considered dominant on the coastal dynamics (Castelle et al., 2006a). The first one is S to SE swells in winter and spring, which contribute to the main component of the northerly littoral drift. The second swell regime is generated by Tropical Cyclones with a NE to E direction and significant wave height up to 8 m. The third swell regime is generated by East Coast Lows, which is a common storm type in the Gold Coast region, resulting in gale winds and NE to SE wave direction. The sediment consists of fine sand ($d_{50}=200 \mu m$). The estimated net rate of littoral sand transport is $500 000 m^3/yr$ toward the north (Turner et al., 2006). The Tweed River contributes a small sand supply to the Coolangatta Bay and acts more like a sediment sink.

In the early 1960s, the Tweed River entrance training walls were extended seawards approximately 380 m to improve navigation conditions. The loss of longshore sand supply from the south resulted in progressive recession of Coolangatta Bay beaches. The Gold Coast also experienced severe storms in 1967 (McGrath, 1967), 1972 and 1974 when high energy wave conditions and gust winds caused major erosion and devastation to the coast.

A few measures were approved such as building groynes and beach nourishment campaigns to try to restore and maintain the southern Gold Coast beaches. Moreover, the wall...
extensions improved navigation conditions for almost 20 years before a sand bar moved past the end of the southern training wall to infill the channel once more. By the early 1990s, despite previous nourishment campaigns, both southern Gold Coast beaches erosion and navigation conditions were severe. To achieve the Queensland objective of restoring and maintaining beach amenity, a series of nourishment works have been undertaken over the past 10 years under the Tweed River Entrance Sand Bypassing Project (TRESBP).

**Nourishment works**

The TRESBP has been formulated in order to overcome both the significant erosion of the southern Gold Coast beaches and the navigation issues due to the Tweed River entrance infilling. Stage 1 involved removing the sand bar from the Tweed River entrance to provide material for the initial restoration of the southern Gold Coast beaches. As part of this campaign, 600,000 m³ of sand was placed on the upper beaches from Rainbow Bay in the east to North Kirra in the west. Additional sand quantities were placed in the nearshore (Dyson et al. 2001). Stage 2 resulted from refinements to the Stage 1 placement areas (Boswood et al., 2001; Colleter et al., 2001). An exclusion deposition zone also provided a 100 m buffer around Kirra natural reef. Most of the sand was placed in an area to the east of Snapper Rocks (see deposition areas on Fig. 1). Sand placed in this area was transported by the longshore drift and naturally fed the sandbanks and beaches of the southern Gold Coast. The TRESBP (Stage 2) saw the implementation in 2001 of a sand bypassing system (see Fig. 2) to collect sand from the southern side of the Tweed River entrance and transport it to the southern Gold Coast beaches in perpetuity (Dyson et al., 2001). The sand was pumped in 5 different locations within Coolangatta Bay (see outlet locations on Fig. 1). Most of the sand was pumped at the Snapper Rock outlet, at the eastern extremity of Coolangatta Bay.

The nourishments during the period 1995 to 2005 are detailed below:

- **1995-1996**: Stage 1A Dredging of Tweed River Entrance and associated nourishment of the southern Gold Coast beaches (2 300 000 m³)
- **1997-1998 Stage 1B** Dredging of Tweed River Entrance and associated nourishment of the southern Gold Coast beaches (800 000 m³)
- **2000-2002 Stage 2A** Dredging of Tweed River Entrance and associated nourishment of the southern Gold Coast beaches (1 100 000 m³)
- **2003-2006 Stage 2B** Dredging of Tweed River Entrance and associated nourishment of the southern Gold Coast beaches (500 700 m³)
- **2001**: Start of the permanent Sand bypassing system

**Methods and materials**

**Surveys**

Figure 2 shows the area of interest for the present study, and the available survey data for the period is from 17/9/1987 to 15/7/2005. Survey data has been collected in this area by a number of organisations for a variety of investigations and projects. Not all the surveys have been taken on the same survey lines and not all the survey data collected has been available for the present study. The main survey lines covering the area were the ETA lines 12 to 18 (generally spaced at about 400 m). In the 1970's and 1980's, due to the severe erosion of Coolangatta Bay, the Gold Coast City Council established other sets of survey lines at Coolangatta Beach (CG lines), Kirra Beach (K lines) and Rainbow Bay (RB lines). Survey data were used to compute the bathymetry map of Coolangatta Bay and sand volumes in different beach units. Specific survey lines were chosen to compute both the shoreline
position and beach volume. There is an extensive range of shoreline indicators reported in the literature (Boak and Turner, 2006). In the present study, the shoreline position is defined as the intersection of the beach profile with the Mean Sea Level (MSL) which corresponds approximately to 0 in the Australian Height Datum (AHD) at the Gold Coast beaches. For each survey line, the beach volume is calculated from dune start to the shoreline datum (subaerial beach volume) and from the shoreline to the 15 m depth contour (nearshore beach volume). Indeed, results show that the changes in bottom profiles are not significant seaward to about 15 m below AHD.

The location of the specific survey lines are shown on Figure 2. The survey lines cover the bay from North Kirra (transect K28) to Rainbow Bay (RB5). They were chosen because they are representative of the Coolangatta Bay alongshore variations and because a large number of survey were undertaken on these specific transects.

**Numerical modelling**

In the present study, numerical wave modelling has been undertaken in order to assess the wave condition. The spectral wave model SWAN (Booij et al., 1999) is used in stationary mode. Triad interaction is taken into account in the computations. The breaking wave model chosen herein is the bore-based model of Battjes and Janssen (1978), with a constant breaker parameter $\gamma=0.73$ following Battjes and Stive (1983). The wave forcing provided by the global wave model WW3 (Tolman, 1991) nearest output point (see Fig. 1) is applied to the offshore and lateral boundaries of the model. A grid at a cell size of 250 m is implemented on the Gold Coast area (see Fig. 1). The tide level is treated as constant equal to 0 AHD, i.e. at mid tide. Stationary computations are done every 24 hours from the 1st of February 1997 to the 1st of August 2005. Wave outputs are requested along Coolangatta Bay at 10 m depth in order to assess the longshore variability of the forcing.

To assess wave-induced currents in Coolangatta Bay, a curvilinear refined grid is implemented on Coolangatta Bay and nested in the coarse wave grid described above. The flow module of the modelling system DELFT3D is used in the present study (Lesser et al., 2004). DELFT3D has been used extensively world-wide for coastal process studies and is
well suited for coastal hydrodynamics over complex bathymetries like Coolangatta Bay. The flow module used herein is 2-D mode (depth averaged). The governing equations of the flow module are the depth-averaged continuity equation and the depth-averaged momentum equations in horizontal direction. The wave induced force is given by the spatial gradient of the radiation stress tensor (Longuet-Higgins and Stewart, 1964) and the tide is treated as constant, as for wave modelling.

Results

Evolution of Coolangatta Bay morphology

Figure 3 shows the evolution of the computed Coolangatta Bay morphology over the period 1997-2005. The most significant changes occurred to a depth of 15 m below the mean sea level. For example, the difference between the March 2000 configuration and the July 2005 configuration reveals significant changes of the sub-aerial beach. Rainbow Bay beach is the beach that experienced the least significant changes over the study period, while Coolangatta beach and particularly Kirra beach intensively evolved. Accretion reached 6 m over the period in some areas of Kirra beach and Miles Street groyne is now mostly under the sand. The water reaches Kirra Point groyne only at high tide. Both Coolangatta and Kirra beach are now about 200 m wide with non-vegetated dunes reaching 6 m above AHD. Since 2002, Rainbow beach has experienced a weak erosive state, Coolangatta Beach seems to have reached a quasi-equilibrium state and Kirra beach continues to gain sand.

The nearshore area also experienced intense changes. Before 2001, the nearshore bar was following the embayments and nowadays Coolangatta bay exhibits a wide and straight nearshore bar. This straight nearshore bar development started in 2001 and coincides with the start of the permanent sand bypassing. This nearshore bar eventually changed its orientation westward to Kirra groyne between 2002 and 2005. This change in the nearshore bar configuration is associated with an intense beach width growth of Kirra Beach. Nowadays, this nearshore bar is located within the area of the Kirra natural reefs (see Fig. 1). These significant morphological changes of Coolangatta Bay coincide with the TRESBP implementation and a more detailed investigation is required to assess the relative influence of offshore wave conditions, dredging works and artificial sand bypassing.
Figure 3. Evolution of Coolangatta Bay from 1997 to 2005: beach widening and formation of a straight and wide nearshore bar. The thick dot line is the shoreline location (0 AHD) and the thick line is the spring high tide sea level.

Relative influence of beach nourishment and wave forcing

Figure 4 shows the time series of the shoreline position and beach volume for each specific beach profile, as offshore wave conditions and the monthly amount of both pumped and deposited sand in the bay (with information on deposition areas). Firstly, this figure shows that the recent significant evolution of Coolangatta Bay was mainly due to the TRESBP as would have been expected given that there has been significant over-pumping of sand relative to the natural potential to move sand alongshore. Indeed, offshore wave conditions do not seem to have a significant impact on the global evolution of the bay. Indeed, this period has been relatively calm period for the Gold Coast beaches with no severe erosive event.

Both Stage 1A and Stage 1B dredging had a significant impact on the shoreline position of the eastern part of Coolangatta Bay. The western part of Coolangatta Bay does not experience significant change of the shoreline position over the period prior to the artificial sand bypassing plant implementation. The start of the artificial sand bypassing results in an almost immediate seaward migration of the shoreline in the whole bay (except the eastern extremity: K17 and K28). At the beginning (early 2001), beach width increases are observed at the eastern extremity of Coolangatta Bay i.e. Rainbow Bay (RB5 on Fig. 4). In late 2001, beach width increases at Coolangatta Beach (CG6 and CG9), then at Kirra in 2002. Since 2002, the shoreline position in the eastern part of Coolangatta Bay (RB5, CG9, CG6) is almost stable, with a slight downward trend.
Figure 4. Time series of significant wave height in the Bay, pumping and dredging quantities, and shoreline position at the specific transects over the period 1995-2005. OSRE: Snapper Rock East Outlet; OSRW: Snapper Rock East Outlet; OK: Kirra Outlet; OD: Duranbah Outlet; OG: Greenmount Outlet
The impact of the dredging works is easier to investigate looking at the recent evolution of the nearshore beach volumes. Figure 5 shows the time series over the same period of the nearshore volume of the specific transects. It shows that both Stage 1A and Stage 1B resulted in a significant increase of the nearshore beach volume in the whole bay. Since 2000, the nearshore volume of the bay has been progressively decreasing, particularly in the eastern part. This is due to the combined effect of the shoreline migration of the previously deposited sand which welds to the shore, and the decreasing nearshore beach width due to the artificial sand bypassing which results in an immediate increase of the subaerial beach width. Indeed, the plot of the evolution of the subaerial beach (not presented in this paper) shows an increase of the subaerial beach volume which is significantly more important than the decrease of the nearshore beach volume.

Figure 5. Time series of the nearshore volume of the specific transects over the study period

Changes in coastal processes

This significant and rapid evolution of Coolangatta Bay morphology is due to two main factors: the large amount of sand available updrift, and the intense and quasi-permanent westward longshore sediment transport along Coolangatta Bay. A set of simulations were undertaken in order to assess the evolution of both wave and flow patterns within the Bay over the period 1995-2005.

Figure 6 shows the computed flow patterns in Coolangatta Bay in the 1997 configuration, for offshore wave conditions: significant wave height $H_s=2.5$ m, peak wave period $T=8.5$ s and wave incidence to the South/North axis $\theta=110^\circ$ (E-SE swell). This simulation shows a predominant westward longshore current along the bay. This longshore current follows the embayments, sometimes resulting in the formation of a weak counter-clockwise circulation cell (Fig. 6.C). This longshore current is also accelerated in front of each small headland delimiting an embayment. The wave-induced current magnitude reaches 2 m/s near Rainbow Bay and Snapper Rocks which is a quite significant intensity given $H_s$ only reaches 2 m at the breaking point at Snapper Rocks. Coolangatta Bay is characterized by an intense
longshore current all year long, under sufficient offshore wave conditions. Figure 7 shows the flow pattern within the bay for the same offshore wave conditions for the 2004 Coolangatta Bay morphology. Results show the presence of an intense and almost spatially homogeneous longshore current along the bay. Embayments and headlands (except Snapper Rocks) do not have any impact on the longshore current shape to the point where, Greenmount Hill and Kirra Point do not act as headlands anymore.

Figure 6. A: Computed wave-induced current intensity (m/s) in Coolangatta Bay (1997 configuration) for offshore significant the offshore wave conditions: E-SE swell with Hs=2.5 m and Tp=8 s.; B: zoom of wave-induced current vectors near Kirra groyne; C: Zoom of wave-induced current vectors near Greenmount Hill.
Figure 7. A: Computed wave-induced current intensity (m/s) in Coolangatta Bay (2004 configuration) for offshore significant the offshore wave conditions: E-SE swell with $H_s=2.5$ m and $T_p=8$ s.; B: zoom of wave-induced current vectors near Kirra groyne; C: Zoom of wave-induced current vectors near Greenmount Hill.

**Discussion and conclusions**

Coolangatta Bay experienced significant morphological changes over the past decade. Accretion of the sea floor has reached 6 m in some areas like Kirra Beach where the seaward shoreline migration attained 200 m. In comparison with the catastrophic beach configurations in the 80s, we can affirm that the TRESPB has been successful in both increasing the beach width and enhancing the ability of the southern Gold Coast beaches to manage extreme events. The main outcomes of the present study are:

1. Artificial sand bypassing has the most significant impact on the Coolangatta Bay morphology. Indeed, the sand is pumped in shallow water (mostly at the Snapper Rock East Outlet) and is immediately transported by the longshore current and naturally feeds the sandbanks and beaches of Coolangatta Bay. This process proved to be much more efficient than depositing the dredged sand in the nearshore area which requires a significant period of low energy condition in order for the deposited bump to migrate shoreward and weld to the shore.

2. The Coolangatta Bay beaches are very wide. The shoreline seaward migration ranges from 50 m in Rainbow Bay to more than 200 m at Kirra Beach in comparison to the shoreline
prior to the TRESBP. The subaerial beach is currently a significant buffer against a severe storm event. Indeed, a recent study showed that the beaches of Kirra and Coolangatta are currently the most able to manage extreme event of all the Gold Coast beaches (Castelle et al., 2006c).

(3) Kirra beach seems to act as a sink. This is not surprising given that this section of coastline experienced the greatest negative impact of the erosion wave that followed the construction of the Tweed walls. Nowadays, Kirra beach continues to infill despite the recent decrease in pumped sand quantities. This process will end as soon as both the shoreline and the nearshore bar will become straight between transects PSM18 and K17, resulting in an almost morphological equilibrium of Kirra Beach.

(4) There is no equilibrium of Coolangatta Bay yet. Indeed, the nearshore sand bar, the wave, flow and sediment transport patterns are continuously evolving. Moreover, recent information suggests that, within the next few years, the pumped quantities will decrease and probably be around 500 000 m³/yr due to the decrease of the available sand quantities updrift of the Tweed River. So the system needs to be given a few years to settle down in order for the overall success to be judged accurately.

At the time of writing this paper, the TRESBP has been successful in providing wide and healthy beaches within Coolangatta Bay. However, and unfortunately, it can be admitted that, worldwide, no beach nourishment or coastal engineering works program will ever meet everybody’s wishes. The TRESBP is another example, as several issues have been raised recently by the community despite the obvious overall success of the engineering components of the project. Nowadays, locals and tourists think that beaches are too wide, especially at Kirra, that surfing, swimming, fishing, diving and beach use amenity has been compromised as a result of over pumping. The nearshore bar is now so wide that the natural reef seaward of Kirra Beach (Fig. 1) is threatened to be fully covered by tons of sand, which raises both fishing and ecological integrity issues. The formation of the straight and wide nearshore bar, known by the surfers as “Superbank”, resulted in the formation of 2 km long wave (from Snapper Rocks to Kirra) rated as one of the best surf breaks in the world. However, Kirra’s world-class wave disappeared at the same time, and as surf rage boils over at Superbank, a lot of local surfers want to have the early 90s configuration back, when there were distinct surf breaks within Coolangatta Bay.

Again, we have to wait a few years to let the system settle down as a result of over pumping, i.e. the overall success must not be judged yet as the TRESBP is working to a 2009 timeline. However we can say that, given the catastrophic state of the Coolangatta Bay beaches in the early 90s and the cyclone threat on the Gold Coast, the TRESBP resulted in a significant and rapid improvement of beach width. At the time of writing this paper, the Coolangatta Bay beaches are wide and are thought to be the only Gold Coast beaches able to manage extreme events. The nourishment strategy used during this project has successfully delivered large amounts of sand to the Gold Coast embayment, although it has been up to now controversial from many community perspectives.

Acknowledgements:

The research presented in this paper was conducted under the Gold Coast Shoreline Management Plan (A Gold Coast City Council Project). The authors wish to acknowledge the permission of the Tweed River Entrance Sand Bypassing Project (TRESBP), NSW Department of Lands and Queensland Environmental Protection Agency (QEPA). The authors wish to thank the Gold Coast City Council for providing some of the field surveys and Debbie Abbs for providing the WW3 forcing for the study period.
References


APPENDIX 5 - MEASURING SURF QUALITY

Pratte’s Reef, California

Volunteers were used to take quasi-daily reports of surf and at various locations along nearby beaches. A volunteer fills out a standardized Surf Environment Observation (SEO) form within the U.S. Army Corps of Engineer's Littoral Environment Observation program. This form include estimates of wave height and period, a count of the weather conditions and an estimate of the near shore current direction entered into a database for analysis and the results are presented below.

Volunteers recorded over 427 Surf Environment Observations (SEO) during the two years monitoring of Pratte's reef. Of these, 393 were recorded at the reef site and 34 were recorded at other nearby beaches. The single most important result from these observations is the almost complete lack of surfers at the reef. Although there were a handful of reports of people surfing at the reef, these almost never coincided with an SEO observer being present. This underscores the reality that Pratte's did not perform as well as hoped in terms of surf quality improvement.

Over the two years of Pratte’s Reef, there has been somewhere on the order of 10 surf sessions at the reef. This is very disappointing when compared to the number of people that surfed a few km south at El Porto (tens to hundreds every day) or 200 meters north at Shitpipe (up to 10 at least bimonthly). However, the number of times Pratte's was surfed was probably the same or greater than any other spot between the El Segundo jetty and Shitpipe (not counting the jetty or Shitpipe itself). This demonstrates that Pratte’s did create a minor improvement in the surfability of an otherwise unsurfed stretch of beach. However, this small number of surfers could also have been attracted by the novelty of the nation’s first artificial surfing reef.

Almost all of the surfing that takes place between the El Segundo Jetty and Marina Del Rey is dependent on a man made structure to create surfable waves. This an important point to consider when discussing artificial reefs and surfing in central and southern Santa Monica Bay.

This information comes from http://www.surfrider.org/artificialreef/results.pdf

Duranbah

The following system was developed by Tom Alletson from Tweed Shire Council and modified for use on Gold Coast City Beaches by Neil Lazarow.

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<th>Tide (m)</th>
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</table>
ANU investigation into surf quality

As part of his PhD research, Lazarow has explored the concept of measuring surf quality. This research introduces a new concept to the literature on recreational use of the coastal zone, that of ‘wave hierarchy’. Wave hierarchy refers specifically to a prioritised set of values ascribed to waves that are ridden by surfers (a surfer is classified as a person who uses their body or a non-motorised craft to ride the breaking face of a wave). Wave hierarchy is described as follows:

1. Wave quality
2. Wave frequency
3. Surfer safety

Wave quality may be construed by an outsider to the surfing community as being highly subjective as it varies from location to location. This apparent subjectivity, however, may rather be interpreted as the dominant local view of how the wave generally breaks and the aspects best ascribed to producing a wave that performs this way. The concept of beauty and form rather than being subjective, become entirely objective and assessable. Wave quality may be positively or negatively impacted upon by both natural events and human interventions.

Wave frequency refers to the frequency of a ‘surfable’ wave at a particular location. Wave frequency can be described in terms of dominant wind and swell patterns that affect the swell period and therefore the frequency of waves to a particular location. Wave frequency can be impacted by natural weather patterns, shore and seabed configuration and human intervention. Of significance however, is the attribute of ‘surfing’ to the concept of wave frequency. Wave frequency then refers to the number of surfable waves at a particular location and the impact that both natural events and human intervention may have in these locales.

Surfer safety is generally described in two parts. Firstly, the environmental or biophysical conditions that may mitigate against a surfer's physical health such as water quality which may lead to ear, nose, throat or intestinal illnesses, suitability to prevailing conditions and overcrowding which may lead to physical injury, for example, as a result of being struck accidentally by a board. Secondly, surfer safety can be described by what Glenn Hening (pers. Comms. 2004) describes as the eco-psychological conditions surrounding the surfing experience such as surf rage, aggressiveness, and vandalism on the one hand and mentoring, sharing, physical activity, joy and laughter on the other hand.

To understand what a good wave is and what good conditions for waves are implies the need for both an understanding of what good waves are generally (incorporating concepts such as wave height, wedge and peel angle, topography), what constitutes good waves at a specific location and also an understanding of the surfing experience at specific locales. While there is probably significant consensus amongst surfers about the top five to ten best waves in the world, it is clear that the surfing experience is much more than just a search for perfect waves.
TRESBP

This is a copy of an evaluation sheet from the TRESBP beach and surf monitoring group.

Tweed River Entrance Sand Bypassing Project

BNG Evaluation Sheet: - SNAPPER ROCKS

DATE: 27th July 2002

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<td>2. Good surf for body board riders</td>
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<td>3. Adequate beach width</td>
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<td>4. Sand quality</td>
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<td>Too much sand</td>
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<tr>
<td>5. Water quality</td>
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<td>6</td>
</tr>
<tr>
<td>6. Good conditions for fishing</td>
<td>1.17</td>
<td>No Water</td>
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<td>7. Overall</td>
<td>1.83</td>
<td>Water too shallow, turbid and congested</td>
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</table>

GENERAL COMMENTS: -

Wind: S/SE 15 to 20 kn
Tide: low tide
Swell: 1 to 1.5m from SE

- The close off-shore reefs have been choked with sand. The water depth has made fishing a non-event. What used to be a good fishing spot with jewfish and pelagic
species evident given the right conditions has become a marine desert, rock marine life is all but extinct.

- Configuration is non-existent
- Profile is non-existent
- Far too much sand
- Can’t believe there is so much sand… What destruction of the eco-system. I would snorkel around the rocks – my kids would wade in the rock pools and observe all the marine life. Now it’s just a desert. Would definitely NOT recommend o/seas friends and family to visit here – The Sahara Desert is closer.

- Contrary to the rubbish being promulgated by vested interests, re “enhanced surfing conditions” resulting from the sand bypassing system; conditions at Snapper have too few improvements to counter other areas of deterioration locally, as well as the destruction of surfing and swimming at Rainbow Bay, Greenmount and Kirra. There is developing anger concerning the “systems” systematic destruction of local beach amenities.
12 March 2004

Chief Executive Officer
Gold Coast City Council
PO Box 5042
GOLD COAST MAIL CENTRE QLD 9729
Attention: Greg Stuart

Amended Coastal Management Plan for the Gold Coast

Dear Sir

I refer to your application of 24 December 2001 to amend the Coastal Management Plan for Beach Protection within Coastal Management Control District Nos 2 and 11 (the Coastal Management Plan) to allow for the works described in the Palm Beach Beach Protection Strategy.

I advise that Governor in Council approved the amendments to the Plan on the 9 October 2003 and attached is a copy of the amended Coastal Management Plan. In accordance with section 185(2) of the Coastal Protection and Management Act 1995 the Coastal Management Plan continues in force until a Regional Coastal Management Plan takes effect. It is anticipated that the works described in the Coastal Management Plan will be incorporated into the Regional Coastal Management Plan.

The EPA is a concurrence agency under schedule 2, item 26 of the Integrated Planning Regulation 1998 for operational works that is assessable development under schedule 8, part 1, item 3D of the Integrated Planning Act 1997. The EPA considers that the approved Coastal Management Plan constitutes its concurrence response for the works described in the Plan. Accordingly it is not necessary for Council to refer any works described in the Coastal Management Plan to the EPA as a concurrence agency unless the works deviate from those described in the Plan.
Should you have any queries regarding this matter please contact Paul Prenzler on the above telephone number.

Yours faithfully

[Signature]

Paul O'Keeffe
Operations Manager Coastal
BEACH PROTECTION AUTHORITY

SCHEME PREPARED BY THE BEACH PROTECTION AUTHORITY

PURSUANT TO THE BEACH PROTECTION ACT 1968-1970

FOR THE PROTECTION OF ALL BEACHES SITUATED AT THE GOLD COAST

WITHIN BEACH EROSION CONTROL DISTRICTS NOS. 2 AND 11

AGAINST BOTH EROSION AND ENCROACHMENT BY THE SEA

March 1973
(Amended October 2003)

THIS SCHEME WAS PREPARED BY GOVERNOR-IN-COUNCIL
ON 9TH AUGUST, 1973 SUBJECT TO CERTAIN ALTERATIONS
DETERMINED BY THE GOVERNOR-IN-COUNCIL AND NOW
INCLUDED HEREIN.

THIS SCHEME WAS AMENDED BY GOVERNOR-IN-COUNCIL
ON 21 MARCH 1985, 25 MARCH 1999 AND 9 OCTOBER 2003 AND
THESE AMENDMENTS ARE INCLUDED HEREIN.
1. Provisions of “The Beach Protection Act 1968”

“The Beach Protection Act 1968” provides that as soon as is practicable after a beach erosion control district is declared the Beach Protection Authority shall cause to be prepared a scheme or several schemes (as the Authority thinks fit) for the protection of all beaches within the district against erosion, or encroachment by the sea, or both (as the Authority deems necessary).

Where several schemes are to be prepared each scheme shall be prepared in relation to one or more of the beaches within the district and a beach included in one scheme shall not be included in any other scheme.

The Act further provides that when the scheme is prepared the Authority shall -

(a) furnish a copy of the scheme to the Local Authority into the Area whereof the beach erosion control district in question extends or, if it extends into the Areas of two or more Local Authorities, then to each such Local Authority;

(b) by advertisement published at least once in at least one newspaper circulating in the locality in which the beach erosion control district in question is situated, give notice that a copy of the scheme is open for inspection for the period specified in the advertisement at the office or offices respectively of the Local Authority or Local Authorities named in the advertisement.

The Local Authority which is furnished with a copy of the scheme, shall keep such copy open for public inspection at its office at all times when its office is open for the transaction for public business during the period of ninety days next following the date when the copy was furnished to it.

During the inspection period of ninety days or within one week after its termination any person (including the Local Authority which is furnished with a copy of the scheme) who considers that he will be aggrieved by the carrying out of any works proposed by the scheme may object to the scheme.

The objection shall be in writing, shall be addressed to the Secretary, Beach Protection Authority, PO Box 155, Brisbane Albert Street, 4002, and shall set out the grounds of
objection and the facts and circumstances relied on by the objector in support of those grounds.

A ground of objection may be that the implementation of the scheme will impose an undue financial burden on the objector.

An objection may be made by a group of persons.

An objection may be posted to or lodged with the Local Authority at the office whereof a copy of the scheme is required to be kept open for public inspection, and the Local Authority shall forthwith forward to the Secretary every objection received by it.

The Beach Protection Authority shall forthwith consider every objection made as prescribed and received by the Secretary not later than one week after the termination of the inspection period and in this regard an objection received by the Local Authority shall be deemed to have been received by the Secretary.

The Authority is then required to furnish to the Minister for Conservation, Marine and Aboriginal Affairs for submission to the Governor-in-Council -

(a) The scheme
(b) Every objection made to the scheme
(c) The representations by the Authority in respect of such objections
(d) Such other information and particulars with respect to the scheme and objections thereto as the Minister requires.

The Governor-in-Council may -

(a) approve the scheme as submitted
(b) approve the scheme subject to such alterations or modifications as the Governor-in-Council determines
(c) reject the scheme.

2. Declaration of Districts

The Governor-in-Council by Order in Council made on 14th November, 1968, declared that part of the coast between the mouth of the Nerang River and Narrow Neck to be a Beach Erosion Control District (No. 2) and by Order in Council made on 8th March, 1973 declared that part of the coast between Narrow Neck and Point Danger to be a Beach Erosion Control District (No. 11). Copies of maps showing the boundaries of such Beach Erosion Control Districts are open to public inspection in
the offices of the Surveyor General, George Street, Brisbane and the Council of the City of Gold Coast, Nerang Street, Southport at all times during which such offices are open for the transaction of public business.

3. **Investigations**

In 1964 the Government of Queensland commissioned the Delft Hydraulics Laboratory of Holland to examine the erosion problems of the beaches of the City of Gold Coast and to recommend a programme of investigations. Following receipt of the Laboratory’s recommendations in 1965 a programme of field investigation was undertaken by the Co-ordinator-General’s Department, the Beach Protection Authority and the Gold Coast City Council in the period to 1970 - and the data obtained was forwarded to the Laboratory for evaluation and recommendations on the most practical and economic solutions to the problems.

4. **Report**

The Delft Hydraulics Laboratory presented a report Number R257 to the Queensland Government in 1970. The report was accepted by the Government and the Beach Protection Authority and its recommendations endorsed by the Beach Protection Authority as the most logical solution to the erosion problems.

5. **Nature of the Erosion Problem**

The behaviour of the coastline of the City of Gold Coast shows two distinct phenomena.

The most obvious phenomenon is the rapid transport of sand from the beaches to offshore bars under the action of steep waves produced by storms near the coast, and the gradual replacement of this sand from the bars to the beaches under the action of fair weather ocean swell.

Since near coast storms occur most often in summer, the general pattern of behaviour is one of erosion in summer and return to the beaches of most of the eroded material during the quieter winter months.

In addition to the temporary effects of this seasonal erosion/accretion cycle there is a continuing loss of sand from the beaches resulting in a gradual recession of the shoreline.

This permanent loss of sand occurs because the predominant wave direction is from the South-east Quarter generating a predominantly northerly current parallel to the coastline with a capacity to transport sand increasing progressively from Point Danger to the Spit.

Thus for any section of beach along the Gold Coast there is an imbalance between the quantity of sand transported to it and the quantity transported away. This loss of sand is permanent.
The rock walls constructed along badly eroded sections of the coast-line have been useful for protection of property but have slowed the natural restoration of beaches after cyclones because of the way in which the walls reflect wave energy.

They do not prevent continuing permanent sand removal since sand continues to be lost permanently from in front of the walls with gradual deterioration of the beaches and a similar deterioration in the effectiveness of the walls as protection to property.

6. Scheme of Works

A. Objectives

The objectives of the scheme of works are -

(a) to restore the dunes and beaches within Beach Erosion Control Districts 2 and 11 to a condition such that major cyclonic erosion can be accepted without interference to the principle that recreational beaches of a high standard are retained at all times;

(b) to maintain the dunes and beaches in the restored condition by providing for the effects of long term continuing erosion; and

(c) to carry out the restoration and maintenance in such a manner that no detrimental interference is caused to any areas of coastline situated outside Beach Erosion Control District Nos. 2 and 11.

B. Method

The scheme provides for -

(a) extensive direct nourishment of the beaches and nearshore areas with sand taken from sources outside the zones of sediment transport;

(b) the construction of dunes to act as a reservoir of sand for cyclonic erosion;

(c) the stabilization of those dunes with suitable vegetation to prevent losses from wind erosion;

(d) the protection of stabilizing vegetation;

(e) the construction of groynes at the mouths of the Nerang River, Tallebudgerra Creek and Currumbin Creek to help retain the sand restored to the beaches;

(f) the provision of an artificial reef constructed of sand filled geotextile bags at Narrow Neck;
the construction of pipe outlets from Point Danger to Kirra to pump sand as part of the Tweed River Entrance Sand Bypassing Project; and

Amendments (f) and (g) approved by Governor in Council, 25 March 1999.

(h) the provision of three artificial reefs constructed of sand filled geotextile bags at Palm Beach.

Amendment (h) approved by Governor in Council, 9 October 2003.

C. Details

The following detailed works are proposed by the Beach Protection Authority in respect of Beach Erosion Control Districts Numbers 2 and 11.

(a) The pumping of the total requirements of sand for initial and continuing nourishment of the Gold Coast Beaches from any of the following sources -

(i) The Southport Broadwater

(ii) Tallebudgera Creek

(iii) Currumbin Creek


Amendment to (iv) approved by Governor in Council, 25 March 1999.

(v) Offshore beyond the line of the surveyed contour for the level of 50 feet below State Datum. Where it can be shown to the satisfaction of the Beach Protection Authority that the zone of sand movement terminates at a shallower depth than the contour for the level of 50 feet below State Datum then sand pumping from this shallower depth may be allowed.

(b) The direct placement of sand on the Gold Coast beaches and nearshore areas as shown in plans numbered SC 1253B, SC1254, and SC1255C and in the quantities detailed in Table 1 hereto. Placement of sand from Point Danger to Kirra shall be in accordance with the Tweed River Entrance Sand Bypassing Project, Permanent Bypassing System, Environmental Impact Statement / Impact Assessment Study and the Tweed River Entrance Sand Bypassing Project Agreement Act 1998.
Amendment to (b) approved by Governor in Council, 25 March 1999.

(c) The shaping of sand above high water mark to form a dune for which important dimensions are shown on plan SC 1253B.

(d) The protection of the dunes by planting sand spinifex with other salt and sand tolerant species and construction of sand drift fencing as shown on plan SC 1253B.

(e) The protection of dune vegetation against damage by pedestrian and vehicular traffic by construction of walkways and fences as shown on plan SC 1253B.

(f) The construction of rock groynes at the following locations as shown on plans SC 1253B, SC1254 and SC1255C.

(i) Nerang River Entrance on the Spit

(ii) Tallebudgera Creek Entrance south bank

(iii)Currumbin Creek between Currumbin Rock and mainland.

The location of the groyne to be constructed at the Nerang River Entrance on the Spit shall be determined from a comprehensive model investigation.

(g) The construction of a groyne 120 metres in length at the following location as shown on Plan SC1255B (held at the office of the Beach Protection Authority)

Lang Street at North Kirra.

The above groyne construction is to be accompanied by the pumping of at least 150,000 cubic metres of sand to the south of the groyne concurrent with groyne construction.

Amendment (g) approved by Governor in Council, 21 March, 1985.

(h) The construction of an artificial reef at Narrow Neck, Main Beach as shown on plan SC1253B and in accordance with Gold Coast City Council Drawing No. 41327.

With regard to the artificial reef at Narrow Neck, if, in the opinion of the Beach Protection Authority, the reef is having a detrimental effect on the beach, the Gold Coast City Council shall either remove or modify the reef as so directed by the Authority. The cost of such removal or modification will not be eligible for subsidy under the
category of “Sea and River Erosion Prevention Works in Tidal Areas” under the Local Governing Bodies’ Annual Capital Works Subsidy Scheme as amended in December 1996.

Amendment (h) approved by Governor in Council, 25 March 1999.

(i) The construction of three artificial reefs at Palm Beach as shown on plan SC1255C and in accordance with Griffith Centre for Coastal Management Drawing No. PBBS-01 Rev C, PBBS-02 Rev A, PBBS-04 Rev A and PBBS-07 Rev B.

With regard to the artificial reefs at Palm Beach, if, in the opinion of the Beach Protection Authority, the reefs are having a detrimental effect on the beach, the Gold Coast City Council shall either remove or modify the reefs as so directed by the Authority. The cost of such removal or modification will not be eligible for subsidy under the category of “Sea and River Erosion Prevention Works in Tidal Areas” under the Local Governing Bodies’ Annual Capital Works Subsidy Scheme as amended in December 1996

Amendment (i) approved by Governor in Council 9 October 2003.

7. Costs of the Works

The Beach Protection Authority estimates that the present day costs of the works listed in this scheme will be -

(a) Sand replenishment required to protect the beaches immediately against a severe cyclone season, groin construction, dune vegetation and dune fencing and walkways. $14, 570, 000

(b) Annual costs required to replenish sand losses by long term erosion, maintain groynes and maintain dune vegetation, fencing and walkways. $474, 000 per annum

Actual costs will be influenced by construction methods used, sources of sand available and the time at which the works are carried out.

8. Implementation of Works

Implementation of the beach protection works outlined in this scheme is a matter for the Gold Coast City Council which shall be the Constructing Authority.

The Gold Coast City Council shall be responsible for acquisition of land or obtaining necessary approvals where any works to be implemented will encroach upon freehold land, leasehold land, mining leases or dredging claims.
9. Payment for Works

Financing of the works outlined in this scheme is the responsibility of the Gold Coast City Council. At present, a subsidy of 20% is payable by the State Government on all capital works for beach protection and this subsidy is increased to 33.1 / 3% where the works may subsequently be used in conjunction with navigation requirements.

10. Approval of Proposed Works

Plans showing details of any works proposed for construction under this scheme shall be submitted by the Gold Coast City Council to the Beach Protection Authority for approval prior to commencement of construction.

In addition, “The Harbours Act 1955 to 1968” requires that plans of any works on land lying under the sea within Queensland waters shall be deposited at the office of the Marine Board of Queensland for approval by the Governor-in-Council prior to commencement of construction.

11. Additional Information

For the information of the public, a copy of the Delft Hydraulics Laboratory Report R257 (three volumes) shall be displayed with this scheme.

Copies of the “Beach Protection Act 1968-1970” are available for purchase from the Government Printer. A copy of the Act shall be displayed with this scheme.

The State Government has approved that the Gold Coast City Council may proceed with the following works which now form part of the scheme -

(a) construction of the groyne at Currumbin

(b) sand replenishment of the beaches at Coolangatta and Kirra; and

(c) sand replenishment of the beaches at Palm Beach.

Olwyn Crimp
SECRETARY
BEACH PROTECTION AUTHORITY
<table>
<thead>
<tr>
<th>Beach</th>
<th>Initial Restoration Quantity for protection against cyclone attack including long term erosion requirements until 1980</th>
<th>Estimated quantity required annually to replace sand lost by long term permanent erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenmount - Coolangatta Creek</td>
<td>1,056,000 cu. yds (808,000 cubic metres)</td>
<td>261,590 cu. yds to 1,569,541 cu. yds / year (200,000 cubic metres to 1.2 million cubic metres / year) to match the annual littoral drift in accordance with the Tweed River Entrance Sand Bypassing Project Agreement Act 1998 Amendment to this quantity approved by Governor in Council, 25 March 1999.</td>
</tr>
<tr>
<td>Coolangatta Creek - Flat Rock Creek</td>
<td>2,376,000 cu. yds (1,817,000 cubic metres)</td>
<td>50,000 cu. yds/year (39,000 cubic metres/year)</td>
</tr>
<tr>
<td>Flat Rock Creek - Currimbin Creek</td>
<td>704,000 cu. yds (539,000 cubic metres)</td>
<td>20,000 cu. yds/year (16,000 cubic metres/year)</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>2,112,000 cu. yds (1,615,000 cubic metres)</td>
<td>70,000 cu. yds/year (54,000 cubic metres/year)</td>
</tr>
<tr>
<td>Burleigh - South Nobby</td>
<td>792,000 cu. yds (606,000 cubic metres)</td>
<td>31,000 cu. yds/year (24,000 cubic metres/year)</td>
</tr>
<tr>
<td>South Nobby - Narrow Neck</td>
<td>5,104,000 cu. yds (3,903,000 cubic metres)</td>
<td>197,000 cu. yds/year (151,000 cubic metres/year)</td>
</tr>
<tr>
<td>Narrow Neck - Nerang River</td>
<td>3,168,000 cu. yds (2,423,000 cubic metres)</td>
<td>122,000 cu. yds/year (91,000 cubic metres/year)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>15,312,000 cu. yds (11,711,000 cubic metres)</td>
<td>490,000 cu. yds/year (375,000 cubic metres/year) plus allowance for amount bypassed across the Tweed River Amendment to this quantity approved by Governor in Council, 25 March 1999.</td>
</tr>
</tbody>
</table>

Note: The estimated quantities required annually to replace sand lost by long term permanent erosion are based on the data presently available but are tentative only and will be re-assessed as additional data becomes available.
1. Works include:
   a) Continue regular dredging from Currumbin Creek onto Palm Beach beaches, or alternatively
   b) Nourish and maintain beaches from Currumbin Creek to Tallebudgera Creek as required to provide adequate cyclone erosion buffer. Sand to be sourced from:
      - Currumbin Creek
      - Building Sites
      - Offshore
   c) Construct three (3) berms to protect beaches and reduce ongoing nourishment. Construction to be staged.
   d) Complete continuous boulder wall along sea wall line to GCCC std.

2. Datasets:
   Vertical: AHD
   Horizontal: AMG

3. For details of works see drawings:
   02 Typical Beach Profile
   03 Deposition Area
   04 Berm Layout Co-ordinates
   05 Currumbin Creek Dredge Area
   06 Offshore Dredge Area
   07 Berm Design Details
   09 Currumbin Creek Typical Cross-Sections

Legend:
- Approximate location of existing shark nets
- Proposed Dredge Areas
- Proposed Nourishment Areas
Notes
1. Datum
   Vertical : AHD
   Horizontal : AMG

2. Tidal Levels (Snapper Rocks)
   HAT = RL +1.11m AHD
   MLWS = RL -0.69m AHD
   MLWS = RL -0.67m AHD
   LAT = RL -0.98m AHD

3. Nourishment works do not involve removal
   of sand from existing dune and upper beach areas.

X-Section from
Est.32 surveyed as below:
- 213774
- 2774
- 1/1074
- (67/78)
- 17/594
- 10.1201

Typical Upper Limit of Beach Nourishment Profile
Typical long-term average
Nearshore Nourishment
Design Profile (varies)

HAT RL +1.11m AHD
RL 0.0m AHD
LAT RL -0.98m AHD

BERM Crest Level = 2.5m AHD

GOLD COAST BEACH PROTECTION STRATEGY
FOR GOLD COAST CITY COUNCIL

NOT TO BE COPIED
WITHOUT WRITTEN APPROVAL

PH: 07 55 548 500
FACsimile: 07 55 548 500
EMAIL: dccinfo@gcc.com.au

DRAWN: B. Corbett B.Eng.
APPROVED: R. Turner BEng Hons
DATE: 12/7/02
AUTHORIZED: R. Turner BEng Hons
Notes

1. Datum
   Vertical: AHD
   Horizontal: AMG

2. Tidal Levels (Snapper Rocks)
   HAT = RL 1.11m AHD
   MLWS = RL 0.65m AHD
   MLUS = RL 4.67m AHD
   LAT = RL -0.98m AHD

3. Proposed deposition areas defined by the co-ordinates:
   DA  545138 E  6891770 N
   DB  545288 E  6893064 N
   DC  545638 E  6893304 N
   DD  545848 E  6893700 N
   DE  546177 E  6894034 N
   DF  546872 E  6894513 N
   DG  547408 E  689132 N
   DH  547408 E  6898519 N
   DI  547230 E  6884333 N

   DJ • DA: line of breakwater
   Note: seaward limits of deposition areas approximately
   follow the RL 0m contour from 1994 survey by GCCC

4. Existing approved S86 deposition areas to be relinquished
   and replaced with proposed deposition area.

5. Initial nourishment quantity with present beach and nearshore levels
   is 600,000m³ to be placed in conjunction with bern construction [may be staged].
   A further 90,000m³ is required for bern construction using
   sand-filled geotextile containers.
   Ongoing nourishment as required within limits set in
   drawings PBBPS-05B and 06B.

6. Volume of sand placed on foreshore and nearshore to be monitored.
1. Datums
Vertical: AHD
Horizontal: AMG

2. Tidal Levels (Smaller Rocks)
HAT = RL 1.11m AHD
MOWS = RL 0.65m AHD
MLWS = RL -0.07m AHD
LAT = RL -0.98m AHD

3. Proposed berm construction areas are defined by the co-ordinates:

<table>
<thead>
<tr>
<th>Point</th>
<th>E (m)</th>
<th>N (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>54601</td>
<td>689609</td>
</tr>
<tr>
<td>BB</td>
<td>54625</td>
<td>689609</td>
</tr>
<tr>
<td>BC</td>
<td>54621</td>
<td>689623</td>
</tr>
<tr>
<td>BD</td>
<td>54617</td>
<td>689640</td>
</tr>
<tr>
<td>BE</td>
<td>54626</td>
<td>689624</td>
</tr>
<tr>
<td>BF</td>
<td>54673</td>
<td>689695</td>
</tr>
<tr>
<td>BG</td>
<td>54646</td>
<td>689607</td>
</tr>
<tr>
<td>BH</td>
<td>54643</td>
<td>688987</td>
</tr>
<tr>
<td>BI</td>
<td>54651</td>
<td>688972</td>
</tr>
<tr>
<td>BJ</td>
<td>54633</td>
<td>688969</td>
</tr>
<tr>
<td>BK</td>
<td>54674</td>
<td>688951</td>
</tr>
<tr>
<td>BL</td>
<td>54672</td>
<td>688938</td>
</tr>
</tbody>
</table>

4. For further detail of berm size and layout, see drawing PBPS - 07
Notes
1. Datums
Vertical: AHD
Horizontal: AGI

2. Tidal Levels (Snapper Rocks)
HAT = RL 1.11m AHD
MLWS = RL 0.65m AHD
MLWN = RL 0.65m AHD
LAT = RL -0.90m AHD

3. Contours from 26/6/02 survey by GCCC

4. Currimin Creek dredge area defined by co-ordinates:
   CA  54.7486m E  6888.16m N
   CB  54.7573m E  6888.48m N
   CC  54.7447m E  6887.73m N
   CD  54.7405m E  6888.19m N
   CE  54.7401m E  6888.08m N
   CF  54.7612m E  6887.69m N
   CG  54.7010m E  6888.31m N
   CH  54.7156m E  6889.77m N
   CI  54.7043m E  6888.39m N
   Cj  54.7076m E  6888.26m N
   CK  54.7078m E  6888.62m N
   CL  54.7077m E  6888.72m N
   CM  54.6979m E  6888.33m N
   CN  54.6699m E  6888.08m N
   CO  54.6629m E  6888.42m N
   CP  54.6873m E  6884.49m N
   CQ  54.6815m E  6886.88m N
   CR  54.6779m E  6884.16m N
   CS  54.6525m E  6888.23m N
   CT  54.7066m E  6888.20m N
   CU  54.7126m E  6888.11m N
   CV  54.7278m E  6888.93m N
   CW  54.7343m E  6887.87m N

5. Final profiles to approximate naturally occurring profiles.
Dredge depth to be limited to above RL 0.60m AHD

6. Side border to be 1V : 3H

7. For typical dredging section, see drawing PBBPS-09

8. Volume dredged from existing dredge area to be limited to a maximum of 80,000m³ annually.

9. No marine plants are to be disturbed.

10. Dredging works are to be carried out during the periods of September - October and February - April. No dredging to be undertaken for a period of 2 days either side of, and the day of, the full and new moon phases.

11. All dredge pipelines to be marked by yellow flashing lights and, if necessary, navigation markers to be established to guide vessels around or through the dredge area.

12. Any snags or obstructions encountered during dredging operations shall be removed and disposed of in accordance with the Regional Harbour Master.
Notes

1. Datums:
   Vertical : AHD
   Horizontal : AMG

2. Tidal Levels (Snapper Rocks):
   HAT = RL 1.1m AHd
   MLWS = RL 0.65m AHd
   LAT = RL 0.498m AHd

3. Construction to be limited within construction boxes (co-ordinates given on drawing PBPS04)

4. Changes in sand bed and berm levels are expected.

5. Design CRZ levels are maximum.

6. Settlement and changes in berm shape to be monitored and berm maintained as required.

7. Bem to be constructed of long sand-filled geotextile containers (~5 tonne) or asphalt, or alternatives.

LEGEND

Special Mark Bency

Average Seafloor Depth Contours (A.HD)

BERM DESIGN DETAILS

---

PALM BEACH
BEACH PROTECTION STRATEGY
FOR GOLD COAST CITY COUNCIL

SCALE As Shown
DATE 12/7/02
DRAWN E., Coles E.E.

AUTHORISED
R. Tinkham, NPER 3

REVISIONS
A. Farny, added Dimensions added 9/8/02
B. Notes added 10/9/02

DRAWING NO PBPS - 07
REV. B
Notes
Final bag layout to achieve design shape to be determined during construction to suit seabed profile.

LEGEND
Special Mark Busy

TYPICAL STANDARD SAND FILLED GEOTEXTILE BAG X-SECTIONS

Typical Cross-section

BEACH PROTECTION STRATEGY FOR GOLD COAST CITY COUNCIL

SCALE As Shown
DATE 12/7/02
DRAWN B. Collett B.E.

AUTHORISED
PREVIOUS

APPLICATIONS

A. Jackson RPEQ 2002

BERM CONSTRUCTION DETAILS

DRAWING N° PBPS - 08

REV. B
Overview

Gold Coast Shoreline Management Plan (GCSMP), which commenced in 2005, is a 3-year program aimed at improving our understanding of our beach environments.

The GCSMP focuses research and planning on how we manage our beaches and shoreline. Supporting the sustainability of the natural environment will underpin our lifestyles and economy into the future. In this sense, our goal is to develop coastal protection measures to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions without compromising our way of life.

This information sheet provides an update of a number of the GCSMP research projects.

Gold Coast Healthy Beaches Report

In July 2006, Gold Coast City Council will release its inaugural Healthy Beach Report. The report will focus on 5 key themes:

1. Community values
2. Physical processes
3. Ecological processes
4. Beach management
5. Economic value of beaches

The report will help both Council and the community better understand what constitutes a healthy beach environment. Important issues such as the ability of a beach to withstand and then recover from a major storm event, recreational amenity as well as ecological and biological function will be reported on.

Beach Condition Index Project

This project will provide an assessment of the change that occurs on a beach throughout the day and over a time scale of months and years. Artificial intelligence and numerical modelling techniques are being applied to the data obtained from video images of beach conditions to develop a predictive capability for estimating beach responses to changing wave conditions.

Some of the key indicators for the classification of beach states include the identification of rip currents, unstable bar formations and undertows.

Other indicators being developed by project staff include breaking wave intensity estimation and beach usage assessment. The outcomes will be of benefit to surf lifeguards and beach managers. The study will be completed in late 2006.

Beach Valuation Study

Beaches are a vital asset to the health and well-being of residents and visitors to the Gold Coast. They also play an important biological function. An important component of the GCSMP is the need to fully understand the economic value of beaches on the Gold Coast. This study is gathering data on recreational use, numbers of people on beaches, access and activities and the dollars associated with the use of Gold Coast beaches.

An important component of this study will be an examination in the potential economic risk if beaches are degraded or severely affected by natural conditions. This study will be completed in early 2007.

Surfing Projects

Recreational Value of Surfing Study

The Griffith Centre for Coastal Management (GCCM) is currently conducting a study on the recreational value of surfing to the Gold Coast. The study captures both market and non-market (social) values attributable to surfing. A survey was recently piloted at South Stradbroke Island and surveys will commence at the southern end of the Gold Coast in late February. The study will be completed in July 2006.
Surfers Forum
In the coming months, GCCM will hold a Surfers Forum to address some of the key issues facing surfers and the surfing community on the Gold Coast. Issues include: crowding at surf breaks, artificial reefs, wave quality, competitions and surf schools.

GCCM is currently working with Council and the Surfrider Foundation on the development of a surf awareness and safety education strategy. Surfrider Foundation has previously been involved in the successful implementation of similar ‘surfriders code’ initiatives in Margaret River, Bells Beach, Bondi and Byron Bay.

Surf Break Amenity at Kirra
Over the past 10 years, a combination of factors has resulted in the decline in quality of the wave at Kirra Beach, up to a point today, where the wave seldom breaks. A modification to the groyne in the mid-1990s combined with the effects of the Tweed River Entrance Sand Bypassing Project has significantly modified the local geomorphology resulting in the loss of a significant recreational asset. These changes have had a serious affect on amenity (wave quality and frequency) and safety, not to mention the community well-being and broader economic benefits that ‘Kirra’ delivers.

Surfriders Code (source Surfrider Foundation Australia)

GCCM has recently commenced a study to examine options for improving surf break amenity at Kirra Beach and surrounding surf breaks. The project involves the staging of a series of community and stakeholder initiatives to develop an agreed shortlist of options and approaches that would lead to an anticipated improvement in surf break amenity and safety on the southern Gold Coast, specifically Kirra beach. A key consideration for this project is to combine expert knowledge with community experience and to examine the possible effects that preferred options might have on surrounding surf breaks as well as coastal vulnerability. The study will examine wave quality, wave frequency and surfer safety issues (biological and physical). The study will be completed in July 2006.

Currumbin Entrance Research Program
The recent history of Currumbin Creek entrance has seen rapid growth in the use of the entrance for access to the ocean by fishermen; a popular surfing site, and as a recreational area accommodating still and open water activities. The Volunteer Marine Rescue (VMR) is based at the entrance and data suggests that the entrance is one of the busiest in Queensland for all types of water craft. In addition, development further upstream has meant that there are increasing concerns over water quality and flooding. The entrance is also an integral part of the active littoral sand movement along the southern Gold Coast beaches.

The Currumbin Entrance Research Program aims to develop a sustainable long-term channel maintenance strategy for the lower reaches of Currumbin Creek that addresses the various constraints on the natural characteristics of the estuary and adjacent beaches such as Palm Beach, and on recreational usage of the entrance. Results from this project will be released in late 2006.

More Information
If you would like more information on any of these projects or are interested in participating or contributing to the studies, please contact the Project Manager, Neil Lazarow or visit the website.

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Kirra Beach February 2006 (source WRL, UNSW)

Gold Coast Shoreline Management Review
Information Sheet 4 - February 2006
What is the Gold Coast Shoreline Management Plan (GCSMP)?

The GCSMP, which commenced in 2005, is a 3-year program aimed at improving our understanding of our beach environments. The GCSMP focuses research and planning on how we manage our beaches and shoreline. The management plan includes ecological processes, community values and stakeholder involvement, physical processes, beach management and the economic value of beaches.

Ecological processes

The ecological component of the GCSMP focuses on sandy beach environments. Current management of beaches has been mainly centred on physical aspects such as sand supply, stability and erosion interventions. As we face new challenges such as climate change we believe that the sustainable management of sandy beaches requires an integrated approach that also encompasses the ecological values of these crucial ecosystems.

Why are our beaches important?

Gold Coast City's ocean beaches are its most recognised icon and a fundamental lifestyle asset of the city. Beaches underpin much of the area's economy, they provide much needed recreational amenity for the city's rapidly growing population and are the single most important asset supporting tourism. Wide beaches with healthy dune systems help combat erosion and protect adjacent public and private property. Sandy beaches provide habitat for numerous plants and animals. Beaches are not ecological deserts - a popular misconception. By contrast, sandy beaches harbour unique and diverse species not found in any other marine habitat. The surf zones of beaches are important nursery and recruitment areas for fish that rely on the smaller invertebrates as a supply of food. Beaches also act as enormous sand filters and thus supply ecosystem services such as nutrient processing. Moreover, beaches are an important ecosystem that links the ecology of sand dunes, intertidal zones, the surf zone and nearby rocky reefs.

As part of the ecological component of the GCSMP we are gathering information on all scientific studies that have taken place on Gold Coast beaches, reefs and sand dunes. This information will help us to understand the environmental condition of these environments and will help us identify areas that need research or are under threat from natural or man made activities.

Future actions

We hope to conduct research on biological aspects of our sandy beach environments. This data will be then combined with information on physical aspects (e.g. erosion, sea level rise), human uses and the economic value of beaches. As a result of this project, data on a range of factors will be made available to the general public and decision making authorities. This information could lead to management decisions which take into consideration a range of aspects and as a result, contribute to the sustainable development of our coasts.

Community awareness

In order to raise awareness about our coasts, marine life, beaches and associated fauna we hope to involve the public in the data collection and field work related to the biological research to be undertaken in the area. In this way we expect to provide opportunities and resources for volunteer community groups to directly participate in scientific projects and as a result directly contribute to the management of their local area.

References


Schlacher, T. 2006. Personal Communication
How do humans affect the ecology of beaches?

Sandy beaches are the most popular area of the seashore: more people use sandy beaches than any other type of marine or coastal habitat. The human use of beaches is increasing sharply, mainly as a consequence of burgeoning coastal population growth and an increasing number of visitors. Overtime, global climate change will raise sea levels and increase storminess and beaches will face stronger erosion and landward migration. Direct human impacts on beaches come from many sources, such as recreational activities, coastal development, beach cleaning and beach nourishment.

Erosion and changes to beach shape

The profile of eroding beaches is frequently changed by importing sand from elsewhere (‘nourishment’) or shifting sand from the lower to the upper beach (‘reprofiling’). This is common practice on the Gold Coast when our beaches face erosion from large storm events. Both activities aim to provide recreational amenity, safety and protection from storm events. They can also have impacts on the beach fauna, potentially lowering the number and biodiversity of animals substantially. Natural storm events such as Tropical Cyclones or East Coast Lows may have similar impacts. Both forms of disturbance may have effects on the fauna but it is not known how long it takes for the environment to recover. Given the long term effects on beach ecology of constructed solutions to erosion (e.g. seawalls, groynes etc) beach nourishment is the preferred method to deal with erosion on Gold Coast beaches.

Mechanical beach cleaning methods

Mechanical cleaning of beaches provides a beach free of rubbish and natural debris to improve safety and aesthetic appeal for people. It also severely disrupts the natural ecological processes and modifies the function and structure of the beach ecosystem. Cleaning machines can kill organisms near the sand surface and can crush deeper-living invertebrates inside their burrows. Wrack (the build-up of debris consisting of seagrass/weed, marine organisms and other material deposited on the beach with the tides and waves), which is removed by beach cleaning, is a vital element in maintaining the ecology of sandy beaches. Wrack provides essential habitat for intertidal organisms and is an important food source for many animals. Wrack lines may also help to stabilise wind blown sand and start the growth of dunes. In essence, beach cleaning reduces the number and type of organisms living in the beach. These environmental impacts need to be considered along with public expectations of a safe and clean beach environment.

Human trampling

Dunes are highly sensitive to trampling associated with recreational activities. Gold Coast City Council spends
hundreds of thousands of dollars each year maintaining dedicated public access ways to direct beach users away from damaging the dune vegetation. This involves building new fences as the dunes build up and replacing older and broken fences. This is an expensive operation but essential for dealing with the very high levels of beach usage on the Gold Coast. Humans walking in the fragile dunes cause strong negative effects: a few passes can destroy the vegetation and the fauna. Also the physical characteristics of dune sands are changed through compaction, which influences soil moisture, run-off, erosion, vegetation and the micro-organisms. Many animals of the beach itself appear more resilient to human trampling, but this is poorly understood. Certainly, birds are highly sensitive to intense human use of beaches, and frequent disturbance of birds results in lower survival of chicks, reduced feeding times and ultimately population declines.

Next to the destruction of habitat through development, driving of 4WD vehicles is the most harmful of all human activities on sandy beaches. Cars dramatically change the physical properties of beaches leading to deep rutting. Fragile dune vegetation is easily destroyed by vehicles. Animals inhabiting beaches are highly susceptible to vehicle impacts: 4WDs can destroy nests and kill chicks of shorebirds, turtle hatchlings show lower survival rates on beaches open to 4WD vehicles, and ghost crabs are crushed in large numbers by night traffic. Many other smaller, buried invertebrates of the beach may also be impacted by beach traffic. A recent study on beaches in South-East Queensland showed that beaches open to 4WD vehicles have substantially fewer species of invertebrates and these occur at much reduced densities.

Gold Coast beaches (with the exception of South Stradbroke Island) are not open to recreational four wheel driving. Only emergency vehicles or those related to beach dependent activities such as life saving, beach management and limited commercial fishing licenses are allowed on our beaches. There are designated vehicle access points that restrict the damage to dune vegetation. Vehicle speeds are restricted to ensure safety of other beach users.

References

Authors: R. Noriega and T. Schlacher
Contributor: G. Stuart
What lives in, on or under the sand?

To the casual observer, beaches may simply appear as barren stretches of beautiful sand, largely devoid of obvious signs of life. In reality, hundreds of species inhabit sandy beaches, and careful examination of sandy beaches reveals a hidden world of great animal diversity. We don’t see this world because most organisms are quite small (a centimetre long or less) and live buried in the sand. Inhabitants of sandy beaches include representatives from all major groups in the food web such as decomposers (bacteria and fungi), plants (mostly small diatom algae), filter-feeding organisms (e.g. clams), scavengers (e.g. ghost crabs) and predators.

Beach animals are remarkably well adapted to this harsh environment: almost all animals show great mobility, can burrow quickly into the sand when dislodged, are apt in orientating with the aid of the sun and moon, and display amazingly accurate rhythms of activity in relation to tides and waves.

Why is this environment important?

Sandy beaches provide habitat and support a great variety of living organisms. They are key ecosystems that link the sand dunes with the surf zone through a constant interchange of sand, organic matter and nutrients. The surf zones of beaches are an important nursery and recruitment area for fish that rely on the smaller invertebrates as a supply of food. For example, prey organisms (e.g. invertebrates) that live in the intertidal zone support fish populations and it is these fish that recreational fishermen target. Beaches are also home to a variety of shorebirds and the essential nesting habitat for turtles.

Food chain of sandy beaches

The constantly shifting sands of beaches do not support large plants with roots that are the base of all life on land. Yet, an amazing variety of life does flourish on our beaches. These animals are fuelled by inputs from the ocean that delivers plankton to the beaches’ consumers. The sea also casts ashore larger dead organisms such as fish, jellyfish and other invertebrates which are eaten by the scavengers like ghost crabs and birds. Some beaches naturally accumulate considerable amounts of seaweed and seagrass on the upper shore near the dunes. This material often collects as a distinct “drift line”. It may be unsightly to the casual observer, but such organic material is a vital food source and habitat to many animals.

What can you do to help?

Here are some ideas about how you can get more involved in caring for our beaches.
Getting to the beach

• Stick to public access tracks. Don’t damage the dunes by walking across the plants to get to the beach.
• Don’t drive across the sand dunes, stick to the designated parking areas.

On the beach

• Get involved in a BeachCare group to look after your local beach.
• Enter your beach in the Clean Beach Challenge.
• Use the beach not the sand dunes when sunbathing or playing.
• Leave shells on the beach for use by other animals for shelter.
• If you have carried it in ... carry it out. Go one step further: remove rubbish left by others.

In the water

• Know the regulations that apply to collecting animals including fish, abalone, crayfish, pippies and other shellfish.
• Bin unwanted or tangled fishing lines, nets and bait packages as they can be lethal to fish, marine mammals, birds and reptiles.
• Collect only the bait that you need. Some bait species are protected. Know the regulations on bait collection.

At your house and at work

Most coastal pollution originates on land. Rubbish thrown onto streets or oil on the road is washed into storm water drains and eventually into the sea. Sea currents can bring this rubbish and pollutants on to the beach. Here are some ideas to minimize pollution.
• Put waste fats and oils into a container for recycling or use on the garden.
• Remember that the drains are only for rain water. Don’t let rubbish get washed down the gutter into a drain. Make sure all rubbish goes into bins for correct disposal or recycling.
• Engine oils must not be poured into drains but returned to a garage for recycling.
• Fix up oil leaks on your car.
• Dispose of unwanted chemicals responsibly. Petrol, paints, thinners, pharmaceutical drugs, and garden pesticides and herbicides, must not go into the sewers or drains.
• Use cleaning products that have minimum impact on the environment by breaking down quickly. Check the packet to see if it is environmentally friendly and has little or no phosphate content.

How do I get more information?

More information is available online at:

Gold Coast Shoreline Management Plan
www.griffith.edu.au/centre/gccm/gcsmp

BeachCare Program
www.griffith.edu.au/centre/gccm/beachcare

Clean Beach Challenge
www.keepaustraliabeautiful.org.au/qld

Or contact:

Griffith Centre for Coastal Management
Griffith University Gold Coast Campus
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References

Authors: R. Noriega and T. Schlacher
Contributor: G. Stuart
**What is a reef?**

A subtidal reef is any solid surface under water that provides a home to a range of organisms. Reefs are one of the world’s most diverse ecosystems and provide habitat for a huge number of marine animals and plants. Reefs may be found in both tropical and temperate areas of the world. Rocky reefs are usually found in temperate areas and are formed by existing rocky outcrops. On the other hand, coral reefs are found in the tropics and are built by small coral polyps which, once established, can grow and expand the size of the reef.

**What type of animals and plants live on Gold Coast reefs?**

Our reefs provide habitat for many different kinds of plants and animals, from the very small, such as single-celled algae, to larger animals, such as sharks, rays and dolphins. The rocky reefs of the Gold Coast are home to many encrusting organisms (such as sponges, hydroids, anemones, worms and soft and hard corals) as well as to a host of colourful mobile animals (such as shells, sea-slugs, crabs, crayfish and sea-stars).

**Why are our reefs important?**

- Rocky reefs provide habitat and shelter for many plants, invertebrates and fish communities.
- Reefs protect our coasts from strong currents and waves by slowing down the water before it gets to the shore. They provide a barrier between the ocean and the shore.
- Rocky reefs are important for commercial and recreational fisheries. A variety of fish depend on reefs for food, shelter and spawning sites at some stage during their lives. While fish communities on rocky reefs may not be as diverse as their coral reef counterparts, individual fish species may be just as numerous as in the tropics.
- Rocky reefs are popular spots for diving and snorkelling.

**What are some of the threats to the health of reefs?**

Because many of the Gold Coast’s reefs are located close to shore, they are often the first diverse marine habitat to be affected by human activities on land or in nearshore areas. Human activities that are known to have an impact on reefs include:

- Beach nourishment practices;
- Alteration of coastline habitats (seawall construction, removal of mangroves);
- Urbanisation and coastal development;
- Destructive fishing techniques;
- Domestic and agricultural pollution;
- Oil pollution from boats;
- Stormwater runoff, especially where this carries debris and pollutants;
- Boat anchoring; and
- Overfishing.

In addition, there are a number of natural threats such as cyclones and storms that often have an effect on reefs located near shore.

**Our main reefs and their residents**

**Palm Beach Reef**

Palm Beach Reef is made up of a series of rocky ridges and gullies covered by extensive growths of hard and soft coral, anemones, ascidians and sponges. This reef is also home to Wobbegong sharks and a range of other fishes and invertebrates. Palm Beach Reef is a popular site for fishing and diving and ranges in depth from 8-24 metres.

**Palm Beach Bait Reef**

Palm Beach Bait Reef is located very close to shore and, as the name suggests, often supports large schools of bait fish. For this reason, it is popular with local fishers. The marine life on the reef includes a range of animals...
that thrive where there are lots of suspended food particles (hydroids, sponges and sea-squirts) as well as large patches of seaweeds and the small animals associated with them.

**Narrows Reef**
This artificial reef was initially designed as a coastal erosion protection structure but has also proved to be an ideal surface for brown seaweeds to become established. The habitat in the more sheltered sections of the reef, and in the crevices between the large sand-filled containers, is home to a range of colourful invertebrates and small fish. The diversity of life associated with this "young", easily accessible reef includes nudibranchs, shrimps and crabs, crayfish, wobbegong and nurse sharks, pineapple fish, lionfish, and cardinal fish. Further out from shore, and in the large sand patch between the two sections of the reef, shovelnose rays, cow tail rays, bull rays and turtles are commonly observed.

**Gretas Reef**
Gretas Reef is 30-50m long and has an average depth of 20 metres. It is located about 200 metres from the sand collection jetty at Southport. The reef is covered by soft corals, sponges, anemones and colourful molluscs including nudibranchs.

**Mermaid Beach Reef**
This reef is located off Mermaid Beach and the deepest section is approximately 27 metres. The reef is covered by organisms such as ascidians, tunicates, nudibranchs, sea stars and feather stars.

**Kirra Reef**
Kirra Reef is by far the most threatened and damaged reef in the Gold Coast region. Most of the reef is currently under sand which has been pumped for beach nourishment purposes from south of the Tweed River. Prior to sand-inundation, Kirra Reef supported a high diversity of marine life, especially of fish and molluscs. The more elevated sections of the reef also provided habitat from corals and large, colourful sponges. Its close proximity to shore made Kirra Reef a popular site for snorkellers and divers.

**What can we do to protect our reefs?**

There are a number of things we can all do to protect our reefs.

1. Get to know and respect the regulations that apply to collecting animals including fish, crayfish and shellfish.  
2. When on a boat try to anchor over clear sandy patches and avoid the use of heavy sinkers in order to minimize damage to corals and other marine organisms. 
3. You can also concentrate on simple things like putting your litter in the bin and using good household and garden practices (e.g. reducing the use of fertilisers and detergents).  
   - Plastic material, cigarette butts and other items of rubbish can be mistaken for food by some marine organisms causing stress and often death. If you see plastic on your beach pick it up and bin it. 
   - Detergents containing phosphorus pollute our oceans. When possible, choose environmentally friendly laundry/dishwashing detergents. 
4. Remember that stormwater ends up in the ocean and can severely affect reefs. 
   - Leaking oil from your car will finds its way into stormwater drains. This can cause harm to reef organisms in both the short and long term. 
   - Remember stormwater drains are only for rain water. 

If you are worried about the health of our reefs, tell the appropriate government agencies and your elected officials. In this way you can help to influence decision-making processes and environmental management.

**How do I get more information?**

More information is available online at:

Griffith Centre for Coastal Management  
Griffith University Gold Coast Campus  
PMB 50  
Gold Coast Mail Centre, Qld 9726  
P: (07) 5552 8506  
F: (07) 5552 8067

References
Ian Banks. 2007. Personal communication.
Authors: R. Noriega and S. Smith
Kirra Surf Study

Overview
The Griffith Centre for Coastal Management (GCCM) has recently commenced a study to examine options for improving surf break amenity at Kirra Beach and surrounding surf breaks. The project involves the staging of a series of community and stakeholder initiatives to develop an agreed shortlist of options and approaches that would lead to an anticipated improvement in surf break amenity and safety on the southern Gold Coast, specifically Kirra beach.

A key consideration for this project is to combine expert knowledge with community experience and to examine the possible effects that preferred options might have on surrounding surf breaks as well as coastal vulnerability. The study will examine wave quality, wave frequency and surfer safety issues (biological and physical). The study will be completed in July 2006.

Background information
For over 40 years, Kirra Surf Beach has been the bastion of surfing on the Gold Coast. The wave at Kirra, both before the groyne was built in the early 1970’s and subsequently, has regularly been rated as being the best surfing wave in the world. Around this and other waves, surfing has grown to become a major recreational and commercial activity in South-East Queensland. Many thousands of surfers live on the Gold Coast and many more intrastate, interstate and overseas travellers visit and enjoy our beaches each year. Surfing forms major pillar of the Gold Coast culture, is a major community asset and is also a significant contributor to the local economy.

Over the past 10 years, a combination of factors has resulted in the decline in quality of the wave at Kirra Beach, up to a point today, where wave seldom produces the waves and recreational amenity it became world famous for. A modification to the groyne in the mid-1990s combined with the effects of the Tweed River Entrance Sand Bypassing Project has significantly modified the coastal landscape resulting in the loss of a significant recreational asset.

Surfing is at an all-time level of popularity and record numbers of surfers of all levels and ability (both local and visitors) are utilising the breaks of the southern Gold Coast. At the same time, this area has witnessed not only the loss of Kirra, but also of waves at surrounding surf breaks. Kirra no longer serves the surfing community as a high quality recreational asset and the effects of this loss both in the economy and in terms of community-well being are starting to be felt throughout the southern Gold Coast.

Project goals
1) Develop and run a series of community and stakeholder initiatives to develop an agreed shortlist of options and approaches that would lead to an anticipated improvement in surf break amenity and safety on the southern Gold Coast, specifically Kirra beach. Initiatives include:
   a. Historical review - interviews with key personalities involved in surfing and coastal management at Kirra (reviews to be made public).
   b. Experts Panel - a half day conference where community, academic and
government experts provide input and opinion on Kirra (event open to the public). Experts Panel will also include discussion of legal and planning aspects.

c. Focus groups – independent meetings with key stakeholder groups to gather data on the project.

d. Site visit / field trip to the sand bypass jetty.

e. Surfers Forum - to address some of the key issues facing surfers and the surfing community on the Gold Coast. Issues include: crowding at surf breaks, artificial reefs, wave quality, competitions and surf schools.

2) Project researchers will undertake detailed computer based modelling for each of the short-listed options to determine which would be the best possible approach to improving wave quality at Kirra, while at the same time not having a net detrimental affect on coastal protection and surrounding waves.

3) Review and finalisation of modelling options.
   a. Findings presented to community at a public meeting.
   b. Findings sent to key stakeholder groups for comment.
   c. Finalisation of findings.

4) This project and the activities will be documented (filmed) with the purpose of creating a short documentary of the process. The documentary will be made available for education and commercialisation purposes, including a public film night.

Project benefit
At this stage, the project outcome is an unknown and no guarantee can be given that the outcomes from this project will be adopted by the relevant government authorities. A key outcome for this project is the sharing of information between technical experts and the local community with the aim of developing a preferred option(s) for beach management which can then be included in the management process for the beaches of the Southern Gold Coast.
Introduction

Did you ever think that good waves only depended on Mother Nature? A cyclone, a solid groundswell, favourable winds, the right tide, a bit of topography like a headland or reef and maybe a quick prayer to Huey (the god of waves) used to be all the elements a surfer needed to think about when it came to wave quality.

But that was then and this is now. Here on the Gold Coast, our coastline has been heavily modified over the past 100 years. In geological timeframes this doesn’t mean much at all but what about right now? Unlike most of the rest of the surf breaks in the world that rely totally on mother nature to create the waves that we surf, wave quality on the Gold Coast is also strongly influenced by coastal engineering works. Traditionally, coastal engineering was used to protect the coast or to ensure safe and reliable access for boating. It is complete fluke that coastal engineering has also created some pretty awesome surf breaks.

Natural or engineered?

The two most consistent surf breaks on the Gold Coast are relatively new beaches. Duranbah (Dbah) was created in the early 1960s when the walls of the Tweed River were extended to assist with navigation. South Stradbroke Island (Straddie) as we know it today was created in the mid-1980s when the entrance to the Broadwater was modified. At Straddie, using a sand bypass pumping system, sand is periodically pumped from south of the Broadwater across to the island. At Dbah, a similar situation exists where a temporary pipe is laid over the northern wall of the Tweed River and sand is pumped as needed from the Tweed River Entrance Sand Bypass Project (a maximum of 10% of the annual sand pumping budget for the project is available for Dbah).

Pumping at East Snapper (Froggies) (source TRESBP)

Just round the corner from Dbah is of course the Superbank and the breaks of Coolangatta Bay, which include Snapper, Little Mali, Rainbow Bay, Greenmount, Coolangatta, Spot X, Big Groyne, Kirra Point, Little Groyne and the Creek. Big Groyne and Little Groyne were created in the early 1970s in an attempt to capture sand that was moving north to stop erosion that was caused by the extension of the Tweed River walls a decade earlier. Coastal protection measures have been undertaken in this area for decades with the purposes of protecting built assets (public and private property), ensuring safe navigational access and creating or retaining beaches for recreational purposes. The massive storms of the late 1960s and early 1970s succeeded in stripping the beach at Coolangatta to reveal bits of old cars and concrete that was used to secure the coastline after the storms of the 1930s.

Tweed River Entrance Sand Bypassing Project (source TRESBP)

All of these waves are heavily affected by the Tweed River Entrance Sand Bypassing Project, which commenced operations in 2001 which transports sand north by dredge and through the bypass system. Sand is cleared from the mouth of the Tweed River by a barge and deposited in Coolangatta Bay. The sand bypass system picks up sand from the area immediately south of the southern wall of the Tweed River. This sand is then piped in a slurry form (80% water and 20% sand) to 4 outlets - Dbah, East Snapper (Froggies), West Snapper and Kirra (Big Groyne). The outlets at West Snapper and Kirra have seldom been used.

Approximately 1 million cubic metres of sand is moved each year through the bypass and dredging operations (the estimated yearly average for sand pumping over the life of the project is 500 000m³ which is said to be equivalent to the estimated natural longshore transport).

As a direct result of the sand bypass and dredging program (and the fact that there haven’t been any major cyclonic events this decade) Coolangatta Bay is 2-3m shallower than it was 4 years ago, so much so, that Kirra Reef has been completely covered over. As well as this, the beaches from Coolangatta through to North Kirra are significantly wider.
Where did the surf go?

What has this done to the surf? Snapper has become the Superbank, a good wave has been turned into a great wave that has received incredible media attention all over the world and is a drawcard to surfers and tourists alike. What can be said about the breaks of Coolangatta Bay? Remember that 30m was shaved off Big Groyne in the mid-90s. Council argues that the removal of the section of the groyne was initiated by the surfing community in an attempt to improve surf quality. May surfers wholeheartedly disagree with this statement and there is heated debate between some in the surfing community that they weren’t consulted over this issue and that private interests ruled the day.

From a surfers’ perspective, the interpretation mostly comes in one of two ways. One point of view is that these waves have for the most part dried up. The shape and depth of the bay and the beaches has been significantly altered as a direct result of the sand bypass project and this has resulted in a significant loss of quality surf at all of these breaks except Snapper. For example, on all except the most exceptional days, Kirra has become a mushy longboard wave with a section breaking on the outer sandbank. Another point of view might suggest that the Superbank has kind of adsorbed the surrounding waves, and extended the length of the wave that starts at Snapper. We can now take off and ride past Rainbow Bay and Greenmount and through Coolangatta.

The Act of Parliament that governs the Tweed River Entrance Sand Bypass Project states that the purpose of the Act is to provide for a sand bypassing project to improve and continuously maintain—
(a) the amenity of the southern Gold Coast beaches; and
(b) the navigability of the Tweed River entrance.

What does the future hold?

How do we reconcile the need for coastal protection and the sustainable management of our marine environment with our desire for the best waves as often as possible?

Gold Coast City Council with assistance from the Qld and NSW Governments (for the Tweed project) spends many millions of dollars each year on coastal protection and management on the Gold Coast. These efforts can and have had a serious positive (Superbank) and negative (Kirra and the possible loss of the wave South Stradbroke Island as a result of the cruise ship development) on waves and wave quality in the region. Would the surf quality decrease if this money wasn’t spent? YOU BET!

Much more than Mother Nature is responsible for wave quality on the Gold Coast and surfing is only one of many competing interests. If wave quality decreases and conditions become dangerous for all surfers, business will slow down and maybe dry up alongside the dreams and expectations of so many local and visiting surfers. For all its hype, surfers and the surf industry need waves to survive. If wave quality reduces significantly then Surfers Paradise will just become paradise and paradise will be a sad place for surfers.

What can you do?

Imagine a surfer having a say in when the sand is pumped or dredged. Imagine being able to link in long term swell forecasts with sand pumping or dredging with tide and moon cycles. Imagine being able to tweak that bank to get it just right. Who controls wave quality on the Goldie? We all know Huey does, but there’s heaps we can do to help the old out.

What will the beaches of the Gold Coast look like in 10 years time? For some, the vision involves a string of artificial reefs along the coastline, some used for coastal protection, some to create fish habitat and others dedicated to the creation of surfing.

What have you done to save a wave today?

Current projects

The Griffith Centre for Coastal Management has recently commenced a project to model options for improving the surf at Kirra, so we’ll know the answer to this question sometime later this year. Refer to the information sheet on Surf Research Projects for more information about the current study at Kirra Surf Study and the Recreational Value of Surfing Study.

More Information

If you surf or you’re interested in surfing on the Gold Coast then you have a responsibility to get involved in this research. We want to hear from you!

A project update will be released in mid-March detailing dates and times for upcoming events. Contact the Project Manager to register to receive this update.

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