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NSW Land and Property Management Authority

Report for

Tweed River Entrance Sand Bypassing Project

Feasibility Study of Sand Placement Options for System Augmentation

February 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Executive Summary

Introduction

The Tweed River Entrance Sand Bypassing Project (TRESBP) is a joint scheme between the NSW and Queensland Governments to establish and maintain a navigable entrance to the Tweed River and to restore and maintain natural sand supply to the southern Gold Coast beaches in perpetuity.

The Governments engaged GHD to undertake a feasibility study of three specific options for enhancing operations of the Tweed River Entrance Sand Bypassing System (TRESBS).

Background

The Tweed River Entrance Sand Bypassing Company operates the TRESBS for the Governments at the mouth of the Tweed River and across the NSW/QLD border. The TRESBS comprises two sand delivery methods:

(1) Pumping by jet pumps mounted on a jetty south of the Tweed River entrance and through a network of buried pipelines to four separate discharge outlets north of the Tweed River entrance; and

(2) Dredging of the Tweed River entrance area by floating dredge and deposition in designated offshore areas north of the Tweed River entrance.

Sand is primarily pumped by the TRESBS to the Point Danger discharge outlet in QLD, from where natural coastal processes transport the sand northwards along the southern Gold Coast beaches.

As intended in the original Project design, large volumes of sand were delivered by the TRESBS in the initial years of operation (2001 – 2006) to develop a sand trap at the jetty; reduce the Tweed entrance bar; and restore the depleted southern Gold Coast beaches. Due to prolonged calm weather conditions over these years, the natural northwards movement of sand through the southern Gold Coast beaches has been slower than predicted. The combination of these events contributed to a large accretion of sand in Coolangatta Bay which resulted in very wide beaches; reduced exposure of Kirra Reef; and the development of a long continuous surfing bank from Snapper Rocks to Coolangatta known as the 'Superbank'.

The dispersal of excess sand out of Coolangatta Bay has increased over the last 2 years, and sand volumes are approaching pre-pumping conditions from Rainbow Bay to Coolangatta. However, there is still a significant build up of sand along Kirra to North Kirra which is perceived by surfers as reducing surf quality at Kirra Point.

Community concern regarding the excess sand in Coolangatta Bay has led to a campaign for changes to the TRESBS operations to overcome the problems caused by the build up of sand in Coolangatta Bay. In response, the Governments have implemented readily available strategies for reducing sand supply into the Bay in order to accelerate the dispersal of the sand build up at Kirra/Central Kirra beaches. The Governments have also agreed to investigate the feasibility of other operational options, to provide longer-term enhancements for achieving a project objective of delivering sand at a rate that is consistent with the highly variable natural supply.

Study Objectives

GHD was engaged to undertake a feasibility study of the following three operational options for enhancing the TRESBS:

1. **North Kirra Outlet**: Extension of the existing sand pumping and delivery capability to a new outlet located at North Kirra;
2. **Additional Dredge Placement Areas**: Development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of dredged sand; and
3. **Kingscliff Sand Delivery**: Consideration of the Tweed River entrance as a one-off source of sand for proposed beach nourishment works at Kingscliff.

Methodology

Following a review of all relevant data, previous studies and the governing legislation, a benchmark condition was defined for each beach within the Project area based on the current coastal condition and expected future trends. An existing conceptual model of sand movement was then updated to reflect the findings of recent investigations and to provide the basis for evaluating beach responses to each operational feasibility option.

In consultation with the project partners LPMA, DERM, GCCC, and TSC, and representatives of the Tweed River Entrance Sand Bypassing Company Pty Ltd, the following tasks were undertaken in the feasibility assessment of the three options:

- Assessment of the natural viability, effectiveness and cost/benefit in terms of
  - Whether they result in a timely and effective response to the current issue of the build up of sand at Kirra and Central Kirra beaches, and
  - Whether they result in improved longer term operation of the system given the natural variability in sand transport conditions along the project area that impact on operations and project objectives;
- Identification of potential adverse impacts, risks/uncertainties and mitigation/management measures; and,
- Recommendation of an environmental planning path to navigate through approvals and permits.

Feasibility Assessment

Over recent years, the jetty operations have been progressively modified to capture and pump sand quantities consistent with natural supply. Dredge placements in outer nearshore reserve placement areas have been trialled and were successful in reducing the sand drift into Coolangatta Bay to promote dispersal of the sand build up at Kirra. Survey results indicate that sand build up from the initial years of operations is dispersing naturally and sand volumes in Coolangatta Bay are approaching pre-pumping conditions under the current sand delivery strategies. However, there is still significant sand build up in the Central/North Kirra Beach areas.

It is noted that the project's EIS stated that substantial variability of beach widths and surfing conditions will always be an inherent natural feature of these beaches. The EIS advised that sand delivery programs should not be reactive in response to short term variations in the beach systems but rather

planned in the context of the longer term operation of the system to best match natural sand supply to the southern Gold Coast beaches.

The following options for alternative sand placement provisions have been investigated to assess their feasibility and potential for addressing issues associated with the sand build up at Kirra/Central Kirra Beaches and potential enhancement of longer term operations to achieve project objectives.

Option 1 – North Kirra Outlet

The construction of an additional outlet at North Kirra physically offers potential for reducing sand drift volumes passing through Kirra by reducing the sand supply to Coolangatta Bay. This could assist in the dispersal of the sand build up at Kirra/Central Kirra and promote improved beach amenity, surfing conditions, and reef health at Kirra. A North Kirra outlet could also provide an operational enhancement that provides some flexibility to better respond to potential sand build up in the future.

However, when undertaking a cost / benefit analysis of a North Kirra outlet, it is important to acknowledge the 'once only' nature of the prolonged and now dispersing sand build up that was due to the additional sand supply to Coolangatta Bay during the initial years of operation of the TRESBP.

While a reduction in sand volume passing Kirra may appear attractive in light of the impacts of sand build up at Kirra/Central Kirra, the implementation of this option is likely to take in the order of two to three years, by which time the need for an additional northern outlet is likely to have diminished given the current trending in sand dispersal from Kirra. Furthermore, the addition of sand through a North Kirra outlet could potentially slow the current sand dispersal process because it is sited in the area where the existing sand build up is most pronounced and hence could delay the transition to 'normal' beach widths in the Central Kirra area.

It is important to note that depending on the selected placement method, location, and timing of sand pumping, a North Kirra outlet could potentially cause a local realignment of the beach south (east) to Kirra, potentially leading to detrimental effects on beach width, surf quality and Kirra Reef.

Routine use of a North Kirra outlet would reduce the available sand supply into Coolangatta Bay over the long term. However, the project's legislation requires volumes of sand to be delivered to these beaches at "…a rate consistent with the natural littoral drift rates…". An ongoing program of delivering sand at rates less than natural supply will contribute to:

1. narrow beaches and reduced surfing shoals that have been depleted of their sand supply;
2. increased storm erosion hazard; and
3. reduced general amenity.

As a result, a North Kirra outlet does not promote the objectives of the TRESBP for the beaches from Rainbow Bay to Kirra.

The beach pipeline infrastructure necessary to make sand placements would impact severely on both the visual values of Kirra to Bilinga and the usability of the beach in the vicinity of the outlet. As a result local community opposition can be expected to this option.

In summary, a North Kirra outlet would have a direct detrimental impact on the local beach amenity where sand is placed. The use of a North Kirra outlet on a routine basis could also seriously starve the southern Gold Coast beaches of their requirements for a restored natural sand supply, contrary to the very objectives that this feasibility study seeks to improve and protect. A North Kirra outlet has one

identifiable benefit ie, the ability to directly nourish the beach at North Kirra following storm erosion, should that need arise in the longer term. However, this should be evaluated against the beach rebuilding that would occur as part of the natural beach cycle under a restored natural sand supply which is an objective of the TRESBS operations. Given the significantly high costs associated with this option and the implementation timeframe of several years, it is difficult to recommend this option as a feasible short-term solution, especially in light of the present sand reduction trend due to natural dispersion in Coolangatta Bay.

Option 2 – Additional Dredged Sand Placement Areas

Option 2A - Bilinga to Tugun Nearshore Areas

The placement of dredged material from the Tweed River entrance in newly defined nearshore sand placement areas in the Bilinga to Tugun area would result in a reduced volume of sand moving through the beaches of Rainbow Bay to Kirra.

Reduction of sand drift into Coolangatta Bay may result in improved beach amenity, surfing conditions and reef health at Kirra. However, it would take some years for the depleted supply condition to impact on the sand build up at Kirra, during which time, the less than natural supply would deplete the beaches and surfing banks from Rainbow Bay to Coolangatta.

While the approval of additional dredge placement areas would improve the flexibility of the sand delivery system, the placement of dredged material in these areas would only be appropriate during periods of high natural sand supply to the southern Gold Coast beaches. It is unlikely to be implemented on a routine basis as it does not promote the objectives of the project that aim at ensuring sustainable and 'natural' beach amenity by requiring full natural sand supply to all southern Gold Coast beaches.

The southern Gold Coast beaches continue to adjust to the 'natural' volumes of sand being targeted by project operations. The sand build up is likely to have substantially dispersed at Kirra during the lead time required to secure approvals and project agreements and realise an impact on the sand drift passing through Kirra. Consequently the cost required to achieve this option should be compared against the limited benefit these additional areas would provide in addressing the current issues at Kirra and in promoting project objectives in the longer term.

Option 2B - Project Area Extended 'Deep Water' Placement Areas

The method of placing dredged sand in deeper water of 10m to 20m depth has been successfully utilised in a previous dredging campaign off Duranbah Beach. The purpose of such placement is to delay the onshore movement of the placed sand if deemed operationally advantageous to do so. It has the benefit, in combination with existing nearshore placement areas, of providing some ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading the sand input over time to better match natural sand supply conditions. As the TRESBP operation reaches its intended operational objectives of delivering 'natural' sand quantities to longer term aligned beaches, the use of new deep water dredging placements seawards of the existing placement areas would likely be less frequently used.

Sand that is placed in deeper water can be considered to remain within the "active sediment system" and will over time move onshore. Such sand is primarily mobilised during higher swell conditions and will otherwise remain undisturbed as an outer nearshore sand reserve.

Although no dredging has been necessary in the last two years, an extension of deep water dredged sand placement areas would provide the TRESBS with additional placement flexibility at generally low cost. In contrast to the other options, it would be more consistent with the project objective of delivering sand consistent with natural supply conditions if managed carefully, and further consideration is justified.

Option 3 – Kingscliff Sand Delivery

The Kingscliff sand delivery option is proposed as a 'once only' opportunity to potentially reduce sand inflow into Coolangatta Bay – through avoidance of dredge sand placement in project areas, while assisting Tweed Shire Council with its foreshore works at Kingscliff Beach.

Feasible methods of placing sand at Kingscliff Beach are likely to involve a large floating dredge with more than three times the sand holding capacity of the dredge used routinely in Tweed River entrance dredging campaigns.

The requirement for a large dredge to achieve sand placement onto Kingscliff Beach means that such a dredge may not be able to dredge sand from the shallower waters of the Tweed entrance bar. Sand that is not captured by the jetty will build up in the entrance and impact on navigation conditions in waters shallower than about 5m in depth at lowest tide. Because of the limitations arising from the greater draft requirement and greater safety distance requirement (from mobile shallow shoals and rock training walls), required by the larger vessel, it is likely that sand can only be dredged from further offshore for this option.

Such a dredging campaign would not avoid the potential for separate entrance maintenance dredging by smaller plant and associated Gold Coast nourishment and will not offer a direct benefit to the TRESBP operation or southern Gold Coast beaches as anticipated. Nevertheless, it would be physically feasible for sand to be taken from deeper water near the entrance to Kingscliff Beach for use in the proposed beach works with minimal or no effect on the TRESBS operations.

The sourcing of sand from the Tweed entrance for Kingscliff nourishment work is likely to have an indirect influence on the natural sand drift to Queensland and is therefore likely to require the support of the Queensland Government. Concurrence should be sought early in the planning process for such a dredging operation.

Indicative costs for sand delivery to the upper beach at Kingscliff Beach are relatively high (up to the order of $25/m3 including set up costs), given that sand would have to be pumped ashore from the dredge. These costs should be assessed early in the planning for further consideration of this option as cost effectiveness will be a key factor in determining the feasibility of sourcing sand from the entrance.

Conclusions

The establishment of new project operations needs to be considered in terms of their location and frequency of use. Long-term use of the options within this report would impact on the southern Gold Coast beaches by altering the current rates of sand delivery. Numerous related issues must also be given consideration in order to achieve balanced economic, social and environmental outcomes.

A North Kirra outlet would have direct and detrimental impacts on the coastline that outweigh any potential benefit. If such an outlet were to be constructed and used regularly in TRESBS operations this would also lead to the coastline from Rainbow Bay to Kirra being undersupplied with sand. The resulting reduction in sand supply would be 'unnatural' and a generally depleted state would develop along this section of coastline not dissimilar to the conditions observed in the decades following the extension of the Tweed River breakwaters in the early 1960s. This would lead to more frequent narrow beaches, reduced nearshore shoals and increased storm hazard. Consequently, routine use of this option would not provide a long-term enhancement to the system operations in terms of achieving project objectives that seek to restore and continue a natural sand supply to all the southern Gold Coast beaches.

Surfing opportunity at Kirra may be improved by use of a North Kirra outlet. However, this would be subject to careful planning and placement of sand, as sand pumping to this location may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surfing and Kirra Reef in the future. Given the significantly high costs and implementation timeframe of several years, this option would not be considered a cost-effective solution to the existing sand build up at Central Kirra when compared to other options, especially in light of the sand reduction that is continuing to occur.

The establishment of additional dredge sand placement areas for project operations needs to be considered in light of their location and frequency of use. Long-term use of Bilinga to Tugun nearshore placement areas would impact on the coastline from Rainbow Bay to Kirra. Similar to the case of a North Kirra outlet, this section of coastline would be denied natural supply of sand. Availability of these placement areas would only be beneficial in terms of promoting project objectives during a period of excess sand supply. However, dredge placement would be more expensive and would not provide any additional benefit compared to the use of optional deep water reserves within the project area.

Addition of deeper nearshore placement reserves seaward of the existing project placement areas would provide worthwhile increases in operational flexibility at relatively low cost and are recommended for consideration.

Supplying sand to Kingscliff Beach from the vicinity of the Tweed River Entrance provides no direct benefit to the TRESBP. The requirement for the use of a large dredge means that the entrance bar, which is the usual dredging location, cannot be dredged and sand would have to be drawn from further offshore.

Delivery of sand from the Tweed River Entrance to Kingscliff Beach appears physically and environmentally feasible with the key feasibility issue likely to be cost. While payment for such a dredging operation is not a matter for TRESBP, the cost to Tweed Shire Council of sand placement on the upper beach may be prohibitive and should be considered by Tweed Shire Council at the initiation of any planning.

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Glossary

AHD	Australian Height Datum
ASP	Association of Surfing Professionals
CA	Concessional Agreement
CSD	Cutter Suction Dredge
DA	Deed of Agreement
DEEDI	Department of Employment Economic Development and Innovation
DERM	Queensland Department of Environment and Resource Management
EMP	Environmental Management Plan
GCCC	Gold Coast City Council
IDAS	Integrated Development Approvals System
ISLW	Indian Spring Low Water
LPMA	Land and Property Management Authority
MDC	McConnel Dowell Constructors (Aust) Pty Ltd
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MSQ	Maritime Safety Queensland
NSW	New South Wales
PTW	Prescribed Tidal Works
QLD	Queensland
SEQRCMP	South East Queensland Regional Coastal Management Plan
SCMP	State Coastal Management Plan
SPA	Sustainable Planning Act 2009
TRESBCo	Tweed River Entrance Sand Bypassing Company
TRESBP	Tweed River Entrance Sand Bypassing Project
TRESBS	Tweed River Entrance Sand Bypassing System
TSC	Tweed Shire Council
TSHD	Trailer Suction Hopper Dredge

1. Introduction

The NSW and QLD Governments have instigated this Project to undertake a feasibility study of three options, for modifying system operations to better respond to the highly variable natural coastal sand supply rates, by the provision of more flexible sand delivery strategies.

To progress this opportunity the LPMA has engaged GHD on behalf of the TRESBP to examine the feasibility, effectiveness and cost/benefit of three additional sand delivery options.

1.1 Background

The Tweed River entrance is located on the NSW / QLD border approximately 900 km north of Sydney and 105 km south of Brisbane. Whilst the primary study area extends from Letitia Spit north to Kirra Beach as shown on Figure 1 (LPMA, 2010), consideration has also been given to the areas of Bilinga and Tugun to the north and Kingscliff to the south.

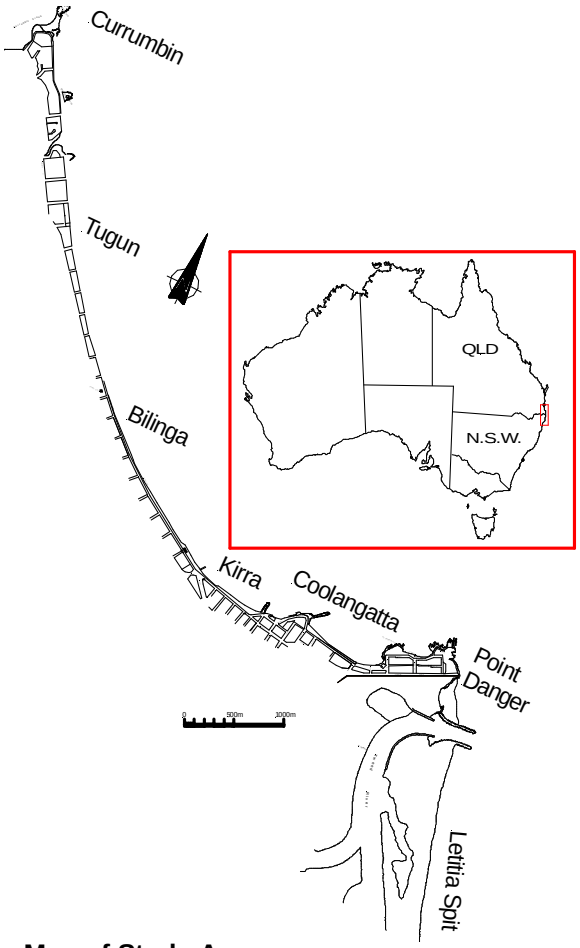

Figure 1 Map of Study Area

This area contains approximately 6 km of coastline which is used for numerous recreational pursuits such as surfing, swimming, kayaking and boating.

The Tweed River Entrance Sand Bypassing Project (TRESBP) is a joint scheme of the NSW and Queensland Governments to establish and maintain a navigable entrance to the Tweed River and to restore and maintain coastal sand supply along the southern Gold Coast beaches.

The project is administered in accordance with matching legislation in Queensland and NSW. An interstate TRESBP Working Group which includes representatives from LPMA, Queensland Department of Environment and Resource Management (DERM), Gold Coast City Council (GCCC) and Tweed Shire Council (TSC), is responsible for the overall implementation of the project.

The average natural net longshore sand drift in the project area is estimated to be in the order of 500,000 cubic metres per year in a northward direction along the NSW north coast into Queensland. The Tweed River Entrance Sand Bypassing Company operates a sand bypassing jetty facility comprised of a 450 m long permanent fixed jetty structure that is sited around 250 m south of the southern Tweed River entrance breakwater and extends offshore to the -5.0m Indian Spring Low Water (ISLW) contour. The jetty supports ten jet pumps installed in series that are buried beneath the seabed. When operational the jet pumps create cones in the sand that intersect each other to form a trench which captures the sand moved by waves and currents along the more active portion of the beach profile, as shown in Figure 2 (DERM, 2010).

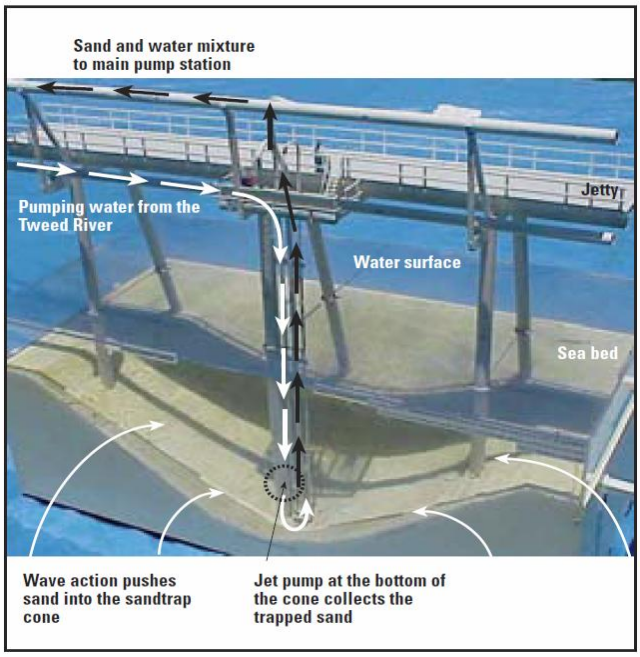

Figure 2 Jetty Pumping Arrangement (DERM 2010)

The sand is pumped hydraulically to a sump located at the onshore end of the structure from where it is again pumped via a slurry pump into a 400 mm diameter discharge pipeline. The discharge pipeline crosses under the Tweed River and directs sand slurry to outlets located at Duranbah beach, Snapper Rocks (East and West) and Kirra Point, as shown in Figure 3 (DERM, 2010). Once discharged the sand is reworked by natural coastal processes across and along the beach profile.

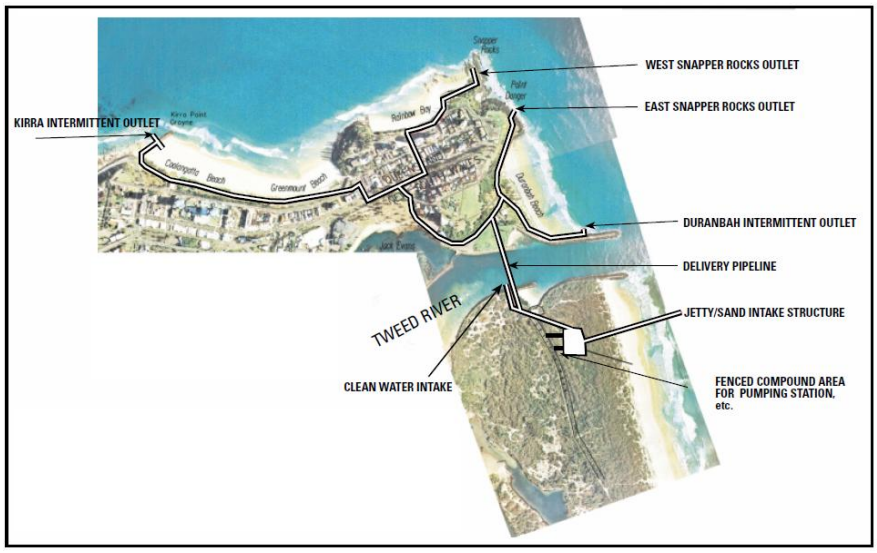

Figure 3 Discharge Pipeline Layout (DERM 2010)

The pumping operation is supplemented by dredging on an as-required basis. In particular, a small trailer suction hopper dredger (TSHD) is periodically required to remove sand that has deposited within the entrance channel. This material is removed from the entrance channel and placed within the subaqueous portion (inner or outer area) of the beach profile, generally off Point Danger.

Since commissioning of the TRESBP system in May 2001, a total of 7.0 M m^3 of sand had been transferred from the entrance area to the Southern Gold Coast and Duranbah beaches to September 2010. Of this total, some 1.5 M m^3 (or around 20%) has been dredged. In the first six years of operation an annual average of around 880,000 m^3 of sand was transferred to the beaches (7% Duranbah). In the last three years, an annual average of around 525,000 m^3 of sand was pumped to the beach outlets (11% Duranbah). This annual average pump delivery was supplemented by an additional 200,000 m^3 of sand that was dredged in 2008. No dredging was undertaken in 2007, 2009 and 2010.

Due to the relative less stormy conditions that have been occurring since commissioning, the natural reworking of sand placed at Snapper Rocks through the beach system to the north has been slower than anticipated. This lag has produced a large accretion of sand and beach widths have increased markedly. An initial positive impact was a continuous surfing break from Snapper Rocks to Kirra known as the "Superbank". However, the continued growth of this sandbank at Kirra is now being perceived by the local surfing community as having an adverse effect on surf quality, as discussed in Section 4.1.5.

In a similar manner, much of the material placed subaqueously by the trailing suction hopper dredge (TSHD) in the nearshore portion of the beach profile has been reworked onshore adding to the accretion at Kirra.

Stakeholder concern over these issues has highlighted a need to investigate options for greater flexibility in the current management of the TRESBP system.

As a result, the LPMA has engaged GHD on behalf of the TRESBP to undertake a feasibility study of three potential options that may provide a more flexible sand delivery system which would be better able to respond to the highly variable natural sand supply rates.

1.2 Project Objectives

Study Objectives

GHD has been engaged to undertake a feasibility study of three options for additional sand placement locations. The primary objective of this study is to investigate the feasibility of modifying the existing sand bypass system to provide more flexible sand delivery such that the system is better able to respond to the highly variable natural sand supply rates.

The three options are as follows:

1. **North Kirra Outlet**: Extension of the existing sand pumping capability to a new sand delivery outlet located at North Kirra;
2. **Additional Dredge Placement Areas**: Development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of dredged sand; and
3. **Kingscliff Sand Delivery**: Consideration of the Tweed River entrance as a one-off source of sand for proposed beach nourishments works at Kingscliff.

The specific objectives of the feasibility study are as follows:

- to review whether the options are consistent with the TRESBP legislation and the extent to which they may promote the achievement of project objectives; and,
- to assess the viability, effectiveness and cost/benefit of options in terms of the following:
    - whether they result in a timely and effective response to the current issue of the build up of sand at Kirra and Central Kirra beaches; and,
    - whether they result in improved longer term operation of the system given the natural variability in sand transport conditions along the project area that impact on operations and project objectives.

TRESBP Objectives

The wider objectives of the TRESBP are as follows:

- "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,
- "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."

2. Review of Existing Information

2.1 Previous Investigations

Much information has been collected on the southern Gold Coast Beaches since the extension of the Tweed River entrance training walls in the early 1960's. A summary of the key studies is provided below, and a full list of the relevant investigations considered during the undertaking of this study is provided in the reference list of this report.

Ongoing erosion problems and questions regarding the impacts of the training walls led to the commissioning of Delft Hydraulics Laboratory in 1968 by the Queensland Government to undertake a comprehensive study of the Gold Coast beaches "Gold Coast Queensland Australia Coastal Erosion and Related Problems" (Delft, 1970). The study provided estimates of sediment transport rates at key points along the Gold Coast. The study overestimated the rate of sediment transport along Letitia Spit, calculating a rate of approximately 625,000 m^3/year. In addition, the rate of sediment transport at Tugun was underestimated at approximately 230,000 m^3/year. This implied that a significant quantity of the sediment transported northwards along Letitia Spit was being lost offshore at Point Danger.

The subsequent report prepared by Delft Hydraulics "Gold Coast Queensland Australia – Southern Gold Coast Littoral Sand Supply" (Delft 1992) contained a number of significant changes to the findings of the earlier report. The study found that while the rate of transport at each location was highly variable in the short-term, the long-term net transport rate at both Letitia Spit and Tugun was estimated to be around 500,000m^3/year. The report also revealed that a significant portion of the sediment transport between Point Danger and areas north of Tugun occurs seaward of the active beach zone. In light of this information, the study concluded that the quantity of sand lost to offshore areas at Point Danger was significantly less than estimated in the earlier report.

Further investigation into the sediment transport processes within the study area was undertaken during the preparation of the Environmental Impacts Assessments associated with Stage 1 (Acer Wargon Chapman, 1994) and Stage 2 (Hyder et al., 1997) of the TRESBP. As part of the Stage 2 EIS/IAS, a model of longshore sand transport was developed using the data from the Brisbane waverider buoy collected between 1989 and 1996. The model revealed that the net transport potential across the study area was about 500,000 to 600,000 m^3/year, averaging about 550,000 m^3/year. However, given that the wave climate during the modelled data period was around 13% higher than the long term average, the study supported the previously determined long-term net transport rate of 500,000m^3/year. In addition, the model provided more detailed estimates of the temporal and spatial variations in sediment transport within the study area.

Since the commencement of sand bypassing operations in 2001, numerous investigations have been undertaken into the response of the southern Gold Coast beaches. These investigations have been reviewed and are discussed in more detail in Section 2.2.

2.2 Beach Responses Since 2000

Since the commencement of full-scale sand bypassing operations in May 2001, numerous investigations and regular beach surveys have been undertaken to determine the responses of southern Gold Coast beaches.

Along with the survey data collected by the TRESBP, the results of previous investigations have been reviewed and the beach responses since 2000 summarised below.

In order to display the evolution of beach profiles since 2000, the results of yearly surveys have been collated by GHD and beach profiles taken at key locations along each beach (refer Appendix A – Figure 01). These survey results are provided in Figure 4 and Figure 5.

2.2.1 Early years of TRESBP Operations 2000 - 2005

Despite the placement of approximately 3 million cubic metres of sand during Stage 1 beach nourishment activities (April 1995 – May 1998) and a further 500,000 m^3 during Stage 2 Pre-commissioning Dredging (April 2000 – April 2001), many of the southern Gold Coast beaches remained in an eroded state at the time of commencement of the sand bypass operations (TRESBP 2010). Consequently, sand was initially pumped to Duranbah Beach, Snapper Rocks and Kirra Point during the first three years of bypassing operations. An average rate of approximately 700,000 m^3/year of sand was pumped from 2001 to 2003, significantly in excess of the natural long term average transport rate, estimated to be approximately 550,000 m^3/year (BMT-WBM, 2010). This initial oversupply of sand was required to replenish the eroded southern Gold Coast beaches, which had not received a full natural sand supply since the extension of the Tweed River entrance breakwaters in the early 1960s (Dyson, 2001). The significant increase in sand supply led to the rapid growth of beach widths from Snapper Rocks to Kirra (Castelle, 2009). Sand reserves within the nearshore area also dramatically increased during this period on account of the Tweed River entrance dredging operations. Material that had accumulated in the river entrance prior to commencement of the sand bypass operations was removed to establish a clear navigation channel and transported to nearshore reserves along the southern Gold Coast beaches at a rate of almost 300,000 m^3/year (TRESBP, 2010).

Material placement operations during the first three years of operation were generally well received by the community and in the main achieved the project objectives. Short-term adverse impacts on surfing sandbanks were experienced at Duranbah (Dyson, 2001), however these were largely overshadowed by the creation of a long straight sandbank between Snapper Rocks and Kirra Point, which produced world class surfing conditions and became internationally known as the “Superbank”.

Sand delivery rates remained high during 2004 and 2005. An average of approximately 610,000 m^3/year was pumped via the bypass system and on average, an additional 180,000m^3/year was dredged from the Tweed River entrance (TRESBP, 2010).

The refraction of the prevailing south-east wave energy around Point Danger into Rainbow Bay provided for reasonably consistent northward sediment transport from the Snapper Rocks TRESBP outlets in the form of episodic sand slugs (Hyder et al., 1997). Transported sand then accumulated within the less active shadow zone of the southern Gold Coast beaches, requiring significant wave energy from the north-east to be transported northwards to Bilinga and Tugun.

The delivery of large quantities of sand during the early years of bypass operations, combined with a period of unusually calm north-easterly wave conditions contributed to the accumulation of excess sand volumes on southern Gold Coast beaches. Volume analysis of beach profiles (Strauss et al., 2009) tracked the slow northerly progress of the accumulating sand which initially peaked at Rainbow Bay in September 2002 shortly after commencement of sand bypassing operations. Beach volumes then peaked at Coolangatta in March 2004 and at Kirra in July 2006 as the sand mass dispersed northward.

Excess sand quantities were of particular concern at Kirra, where the offshore reef was significantly impacted by increased sand levels, raising ecological issues and limiting the recreation potential of the reef for SCUBA diving and fishing (Castelle et al., 2006, Lazarow, 2007). In addition, the once world class surf break to the west of Kirra Point groyne suffered as the previously well aligned sandbanks were buried by excess sand and as a result became poorly aligned to the predominant swells (Lazarow., 2007).

2.2.2 Recent Beach Responses 2006 - 2010

Since 2006 the volumes pumped by the bypass system have more closely matched the natural net littoral drift. From 2006 until 2009 an average of approximately 530,000 m^3/year was pumped via the bypass system (TRESBP, 2010).

Although pumping rates had been greatly reduced, surveys conducted in 2007 revealed that the placement of material dredged from the Tweed River entrance in nearshore reserves was being reworked onto the southern Gold Coast beaches and contributing to the oversupply of sand (Castelle et al., 2009). In order to further reduce the migration of excess sand towards Kirra and promote the dispersal of sand build up in Coolangatta Bay, the material removed from the Tweed River entrance during the 2008 dredging campaign was placed in offshore areas at Duranbah in water depths of up to 20 m below Mean Sea Level (MSL). According to advice provided by TRESBP, this material has remained relatively stable and is expected to be slowly reworked towards the more active nearshore areas over a period of years.

This approach greatly reduced the quantity of sand supplied to the southern Gold Coast beaches which led to a gradual decrease in sand volumes and beach widths from Snapper Rocks to Kirra as the initial sand supply moved slowly northwards under the influence of the predominant wave, wind and current conditions (Castelle et al., 2009).

Between 2006 and 2009 the area between Kirra Point Groyne and the Miles St Groyne experienced a net loss of approximately 280,000 m^3 of sand. The majority of this material was initially lost from the nearshore zone and beach bar, while comparatively little change was experienced in the upper beach profile. However, recent surveys have revealed that significant quantities of sand have now dispersed from the upper beach profile and nearshore zone and beach bar in the area between Kirra Point Groyne and the Miles St Groyne. In addition to the natural loss of sand to northward transport, a further reduction of around 20 m in beach width was achieved as a result of beach scraping works undertaken by GCCC on behalf of DERM in July 2009 (TRESBP 2010). The overall reduction in beach width has been in excess of 100m over the last two years.

During the early years of bypass operations, the long-term depleted areas down-drift from North Kirra experienced little change as a result of sand pumping operations. Recently however, the initial sand supply has been transported beyond Kirra and is spreading out along the stretch of beach between North Kirra Surf Club and the Bilinga Surf Club (TRESBP 2010).

The area from Snapper Rocks to Greenmount Beach has also seen a significant decrease in beach widths and volume since the reduction of sand pumping rates in 2006 and placement of dredged sand in deeper nearshore areas in 2008. Between July 2007 and January 2010 a net loss of approximately 730,000 m^3 of sand was recorded (TRESBP, 2010). The majority of this material was lost from the Rainbow Bay / Coolangatta area, where both beaches have experienced significant shoreline retreat in recent years. Partly as a result of the reduced sand supply, Snapper Rocks experienced severe erosion

during a severe storm in May 2009. Concerns were raised as to whether surfing conditions would improve in time for the Association of Surfing Professionals (ASP) world championship tour event scheduled for February 2010. Although surfing conditions improved prior to the contest, the erosion event served as a reminder of the highly variable nature of the study area.

Shoreline retreat at Duranbah Beach has been less than that predicted in the Stage 2 EIS/IAS (Hyder et al., 1997). However, the Beach has shown an increased potential for erosion since the already restricted natural sand supply around the training walls was interrupted by the commencement of sand bypassing operations in conjunction with regular dredging of the Tweed River entrance shoals. In order to limit erosion, approximately 10% of the sand removed from Letitia Spit has been pumped to Duranbah Beach since 2001. Initial pumping operations led to the accumulation of shallow mounds within the nearshore area along the northern side of the northern entrance training wall, which had an adverse effect on surfing conditions in the short term (Dyson et al., 2001). In recent years the sand placed on Duranbah Beach has been reworked using land based plant and equipment to more evenly distribute the sand supply along the length of the beach.

As was predicted in the Stage 2 EIS/IAS (Hyder et al., 1997), the shoreline along Letitia Spit has undergone significant realignment since the bypass operations commenced removal of downdrift sand which had accumulated at the southern training wall of the Tweed River entrance. The most extensive recession has been recorded in the area immediately surrounding the TRESBP pier where the shoreline has receded by around 120 m since pumping began in 2001 (DERM, 2010). Although shoreline recession was predicted, the high rate of sand removal during the early years of the project combined with a number of storms led to rapid recession of the shoreline and loss of vegetation as the beach system retreated part way between pre-pumping conditions and those observed prior to the extension of the Tweed River entrance training walls. Following the reduction of pumping rates in 2006, Letitia Spit began to stabilise and a revised shoreline has begun to rebuild in the area up to one kilometre south of the TRESBP pier.

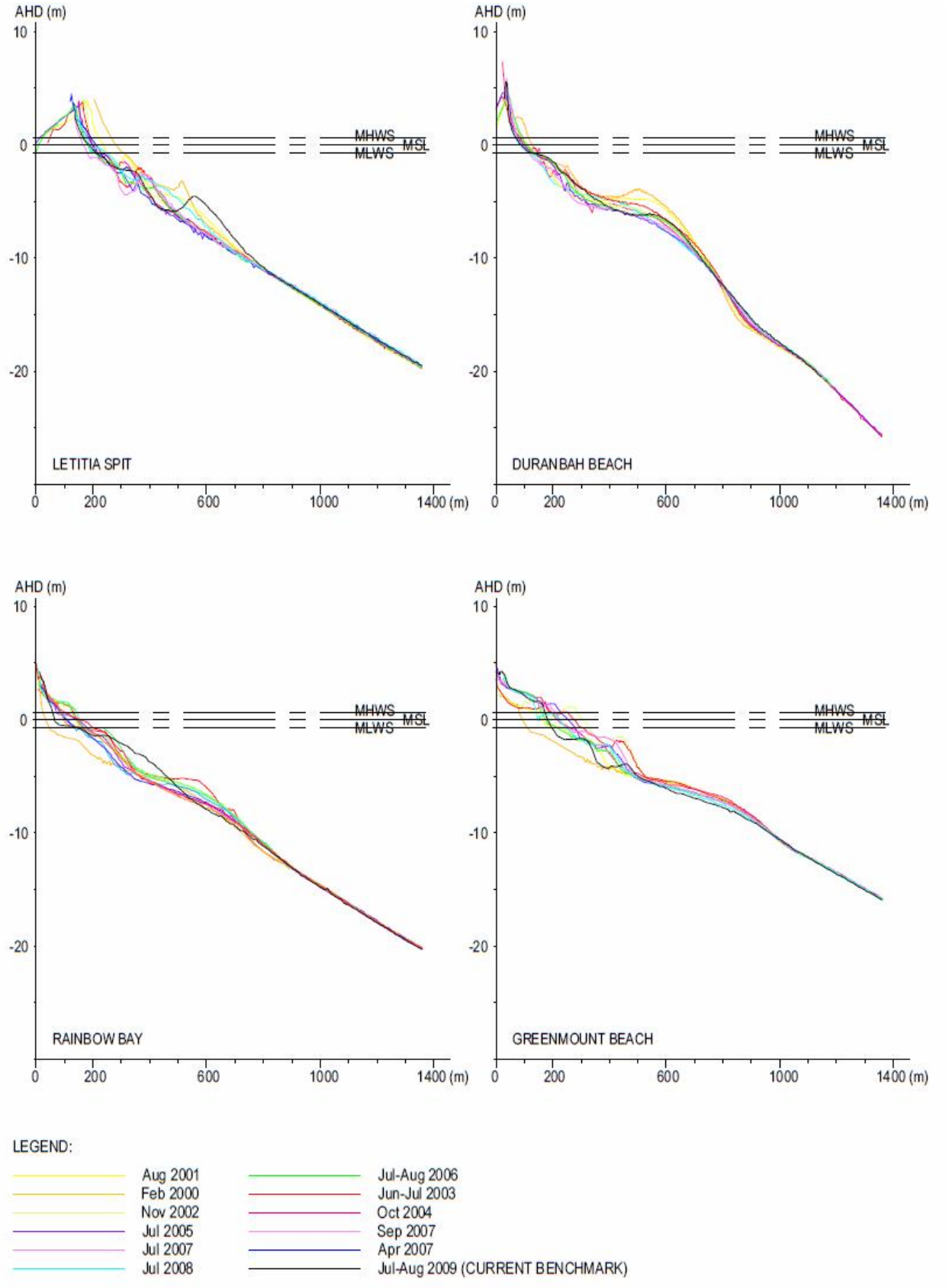

Figure 4 Beach Profile Evolution From Letitia Spit to Greenmount

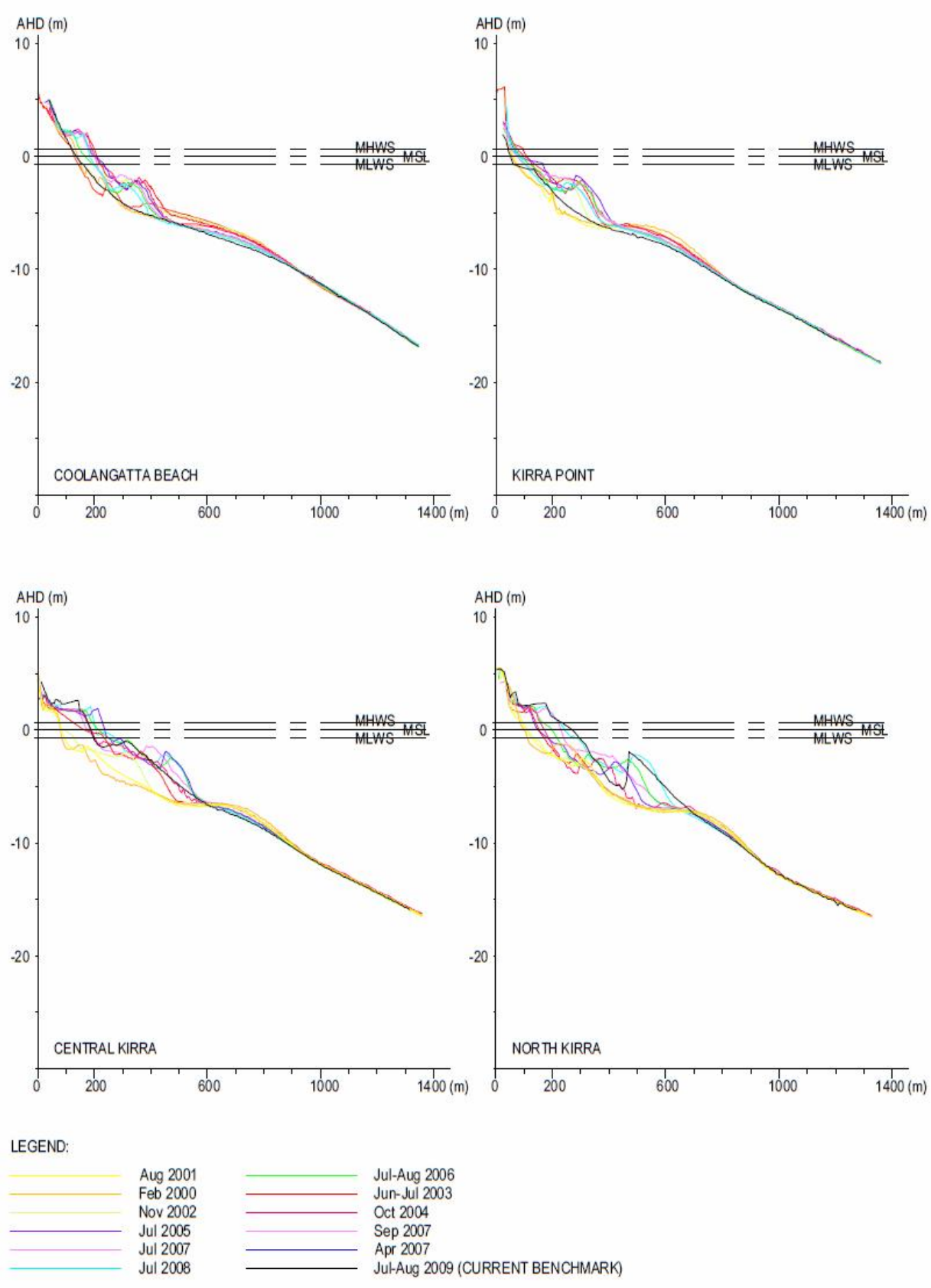

Figure 5 Beach Profile Evolution From Coolangatta to North Kirra

3. Consultation

Consultation with the project partners and the operators of the TRESBP has been undertaken in order to obtain their perspectives on the three proposed options and to identify problem areas and performance shortfalls in the existing system to provide the context for considering the impacts of the three proposed options.

Specifically, consultation has been undertaken with the following project stakeholders:

- The project partners LPMA, DERM, GCCC, and TSC; and
- The representatives of the Tweed River Entrance Sand Bypassing Company Pty Ltd.

3.1 LPMA

Following commissioning of GHD, an inception/start-up meeting was held with LPMA representatives in May 2010 in GHDs Brisbane Office. This meeting was used to confirm/clarify the scope of work, discuss requirements/expectations for the investigation and timing of deliverables.

In addition to providing insight into LPMA's perspectives on the three options and the future needs of the study area, the meeting also provided valuable information on recently processed survey information and recent investigations completed by other consultants.

Consultation has also been undertaken with LPMA's Parramatta Office regarding access to the historical data stored by LPMA. The results of beach and hydrographic surveys, along with recent and historical aerial photos have been provided to GHD to assist in verifying coastal processes and determining the current state of the study area.

3.2 DERM

As the former QLD Environmental Protection Agency (EPA) and current regulator of the Environmental Protection Licence (EPL) held by TRESBCo , DERM has played a significant role in the development and regulation of the TRESBP. In addition, DERM is currently responsible for all medium and long-term management options associated with the Kirra Beach Restoration Project.

In order to establish the views of DERM regarding the performance of the existing system and the future short and long-term needs, a meeting was held with key DERM personnel at the DERM Deagon Facility in April 2010. As the Concurrence Agency for Prescribed Tidal Works (PTW) and the Assessment Manager for Disposal in Tidal Waters applications within the southern Gold Coast beaches, DERM was able to provide detailed information regarding the required approvals associated with Options 1 and 2 and the additional information and investigations required to grant these approvals. DERM revealed that previous discussions between key stakeholders had failed to reach and agreement regarding which group represented the most appropriate applicant for these additional approvals. In the opinion of key DERM personnel, DERM was not the most suitable applicant since this would represent a conflict of interest in light of DERM's existing involvement in the bypass project.

3.3 GCCC

As the agreed service provider for the current Kirra Beach Restoration works, and the council responsible for the management of the southern Gold Coast beaches, it was important for this study to

consider the views of GCCC with respect to the existing system and proposed options for its modification.

A meeting was held at the GCCC Varsity Lakes office in May 2010. During this meeting discussions focused on the approvals processes associated with Options 1 and 2, as well as the recent works undertaken by GCCC within the study area such as beach scraping and excavation.

Through regular historical contact with the local community, GCCC was able to provide information regarding anticipated community support and opposition of each of the three sand placement options.

GCCC confirmed that previous discussions between key stakeholders had resulted in disagreements over the most appropriate applicant for the additional approvals required for Options 1 and 2. In the opinion of key GCCC personnel, these additional approvals should be integrated into the existing project approvals and that consequently, GCCC was not the most suitable applicant since it did not hold these existing approvals.

3.4 TSC

During communication with key TSC personnel in May 2010, discussions primarily related to Option 3 and the effects of the existing TRESBP operations on Duranbah Beach, the Tweed River entrance and Letitia Spit. Having commissioned a number of previous investigations involving beach nourishment works at Kingscliff, TSC was able to provide copies of previous reports and advice on TSC's preferred methodology in relation to Option 3.

Key personnel of TSC stressed the TSC's preference for "rainbowing" over other placement methods, since "rainbowing" could be used to nourish both sub-aerial and subaqueous beach areas and provide an appropriate beach profile in a shorter period of time than other methods such as bottom dumping.

3.5 Consultation with TRESBCo

As the operator of the sand bypass system, TRESBCo is in a unique position, and able to offer valuable insights into the operation of the existing system. During telephone conversations in April and May 2010 TRESBCo representatives provided technical advice on the system's existing capabilities and opinions regarding the feasibility of the three proposed options for modification of the dredging and pumping operations.

Discussions with TRESBCo also touched on the issue of the most appropriate applicant for the additional approvals required for Options 1 and 2. In the opinion of key TRESBCo personnel, TRESBCo was not the most suitable applicant since the additional approvals are outside the original scope of the project and not directly related to achieving the project objectives.

3.6 Site Inspection

In May 2010, GHD personnel undertook an inspection of the study area and existing sand delivery outlets from Kirra to Duranbah. This provided an understanding of the current issues regarding sand build up at Central and North Kirra and beach erosion at Duranbah. The sand placement activities underway at Duranbah at the time of the site inspection also offered an insight into the public access and aesthetic impacts associated with placement of temporary discharge pipelines across popular beaches.

4. Current Benchmark Coastal Condition

For the purposes of assessing the relative benefits of each option, the coastal conditions of each of the beaches in the project area as a result of the option being put in place, has been benchmarked against the current coastal conditions with respect to a range of physical, social and environmental criterion.

In summary, the reduction of sand quantities transported by the TRESBP system since 2006 and the placement of dredged sand in offshore reserves in 2008 have led to significant changes in beach conditions from Letitia Spit to Kirra in recent years. Following a review of recent investigations and survey data, the current benchmark coastal conditions of each of the southern Gold Coast beaches have been summarised and described in Sections 4.1.1 to 4.1.5.

4.1.1 Letitia Spit

As noted in Section 2.2, the erosion of Letitia Spit since commencement of bypass operations in 2001 was expected as the beach adjusted to the removal of a portion of the sand which had accumulated on the southern side of the Tweed River entrance training walls for the development of a sand trap at the jetty. The reduction of sand pumping volumes in recent years has led to stabilisation and rebuilding of the shoreline position along Letitia Spit. It is noted that Letitia Spit beach was severely eroded by major ocean storms in May 2009. As shown in Figure 4, the most recent survey conducted in August 2009 suggests that the general shoreline alignment has begun to stabilise roughly 90 m landward of the 2000 pre-TRESBP position in the vicinity of the pumping jetty. Sand volumes in the area have recovered by more than 30% of the initial losses observed since 2000 (LPMA 2010). However, the majority of the rebuilding has occurred in the nearshore zone. The current benchmark coastal conditions relating to Letitia Spit have been summarised in Table 1.

Table 1 Current Benchmark Coastal Condition – Letitia Spit

Benchmark Criteria	Description
Physical	
Beach Width	Approximately 50m from the vegetation line to MSL at North Letitia Spit. Much narrower than the typical condition observed following the extension of the Tweed River entrance training walls in the early 1960's
Beach Volume	Currently low. Surveys conducted in July 2009 revealed that the volume of sand within the northern portion of Letitia Spit has decreased by approximately 835,000 m^3 since February 2000 but is showing rebuilding over recent years.
Beach Slope	Approximately 1 in 60 to the -12m AHD contour. Significantly steeper in the upper beach zone due to ongoing realignment of the shoreline position. Summarised in Figure 4.
Sediment Characteristics	Pale fawn to fawn-grey, well sorted, clean fine sand with a typical median size of 0.2-0.22 mm with little or no silt (as defined by Hyder et al, 1997).
Social	
Beach Amenity	Large erosion scarp and relatively narrow beach width due to recent erosion events.
Surfing Conditions	Variable conditions largely determined by shifting sand banks, swell size/ direction and winds.
Swimming Conditions	Variable swimming conditions defined by sea state. Frequent rips and treacherous conditions.

Diving Conditions	No known popular dive sites
Fishing Conditions	Typical fishing conditions characteristic of a Transverse Bar and Rip type beach
Aesthetics	Very little foreshore development with the exception of the TRESBP jetty. Large erosion scarp, with some loss of vegetation onto the beach and nearshore area following severe storms.
Environmental	
Storm Erosion Buffer	Minimal storm erosion buffer due to recent storm events and planned shoreline realignment associated with TRESBP operations
Aquatic Ecology	Primarily soft sediment habitat. Some artificial habitat provided by Tweed River entrance training wall and TRESBP Jetty.
Water Quality	Generally very good, low levels of turbidity and suspended solids. Decreases in quality following storms and rain events, particularly adjacent to the Tweed River entrance.
Noise	Minimal noise other than that emitted near the TRESBP pumping station during operational periods.
Terrestrial Ecology	Dunal vegetation in close proximity to the active portion of the beach profile provides terrestrial habitat.

4.1.2 Duranbah Beach

Due to the exposed nature of Duranbah Beach, particularly since the removal of Tweed River entrance sand shoals, the condition of the beach remains highly variable and heavily influenced by swell conditions. Similarly, surfing and swimming conditions at Duranbah Beach are heavily influenced by the wave climate and as a result vary from day to day. At the time of writing this report, sand was being pumped onto Duranbah Beach to replenish the beachfront which had been severely eroded by storms in May 2009 and again in early 2010. During a site visit in May 2010, the northern portion of the Duranbah Beach carpark and footpath was closed due to undermining of the roadway as a result of the storms in May 2009 and early 2010.

Duranbah Beach remains characterised by periods of erosion during inclement swell conditions followed by accretion on account of sand placed via the TRESBP system. As a result of restricted sand supply from the south and the cycle of erosion and controlled accretion, the current condition of Duranbah Beach is heavily influenced by TRESBP operations. The current benchmark coastal conditions relating to Duranbah Beach have been summarised in Table 2.

Table 2 Current Benchmark Coastal Condition – Duranbah Beach

Benchmark Criteria	Description
Physical	
Beach Width	Approximately 40m from the vegetation line to MSL in the centre of Duranbah Beach. Currently undergoing nourishment.
Beach Volume	Low with respect to long term average. Surveys conducted in July 2009 revealed that the volume of sand within Duranbah Beach has decreased by approximately 81,000 m^3 since February 1997.
Beach Slope	Approximately 1 in 60 to the -12m AHD contour. Summarised in Figure 4.
Sediment Characteristics	Pale fawn to fawn-grey, well sorted, clean fine sand with a typical median size of 0.2-0.22 mm with little or no silt (as defined by Hyder et al, 1997).

Social	
Beach Amenity	Narrower beach width due to recent erosion events. Typical of beaches within the area. Currently undergoing nourishment to replenish the upper beach sand store. Occasional disruption during TRESBP sand pumping activities.
Surfing Conditions	Variable conditions largely determined by shifting sand banks, swell size and direction and winds.
Swimming Conditions	Variable swimming conditions defined by sea state. Frequent rips and treacherous conditions.
Diving Conditions	No known popular dive sites
Fishing Conditions	Typical fishing conditions characteristic of a Transverse Bar and Rip type beach
Aesthetics	Little foreshore development with the exception of the Duranbah SLSC and northern carpark
Environmental	
Storm Erosion Buffer	Minimal storm erosion buffer due to recent storm events. Currently undergoing nourishment. TRESBP sand delivery aims to replenish the sand store buffer on a regular basis to accommodate storm erosion.
Aquatic Ecology	Relatively diverse habitat for the area, soft sediment and rocky outcrop habitats. River entrance training wall also provides rocky habitat.
Water Quality	Generally very good, low levels of turbidity and suspended solids. Decreases in quality following storms and rain events, particularly adjacent to the Tweed River entrance.
Noise	Relatively quiet, minimal vehicle traffic, no residential or commercial properties in close proximity.
Terrestrial Ecology	No significant lagoon areas or dunal vegetation

4.1.3 Rainbow Bay

The reduced sand quantities delivered by the TRESBP system in recent years have led to a significant reduction in sand volumes and beach widths within Rainbow Bay, particularly since 2009. Following the May 2009 storm event, sand volumes and beach widths returned to conditions not seen since the commencement of bypass operations in 2001. The May 2009 storm event also demonstrated that Rainbow Bay is now far more vulnerable to erosion during storm conditions. TRESBP surveys of the beach profile following the storm event revealed that between February and May 2009 approximately 70,000 m^3 of sand was lost from the Snapper Rocks area, resulting in adverse surfing conditions. In order to restore the eroded beach profile, sand was pumped via the eastern and western TRESBP outlets at Snapper Rocks in late 2009. This depleted beach condition has been viewed favourably by the local swimming community due to the separation of swimming areas from surfing areas.

Despite localised efforts to return sand to Snapper Rocks, the current volume of sand within Rainbow Bay remains at low levels similar to those recorded prior to commencement of bypass operations in 2001. The current benchmark coastal conditions relating to Rainbow Bay have been summarised in Table 3.

Table 3 Current Benchmark Coastal Condition – Rainbow Bay

Benchmark Criteria	Description
Physical	
Beach Width	Variable though similar to pre 2000 condition. Approximately 25m from the vegetation line to MSL in the centre of Rainbow Bay.
Beach Volume	In line with long term average. Surveys conducted in May 2010 revealed that the volume of sand within Rainbow Bay is approximately equal to that recorded in February 2000.
Beach Slope	Relatively flat through the nearshore zone, approximately 1 in 75 to the -2m AHD contour and 1 in 60 to the -12m AHD contour. Summarised in Figure 4.
Sediment Characteristics	Pale fawn to fawn-grey, well sorted, clean fine sand with a typical median size of 0.2-0.22 mm with little or no silt (as defined by Hyder et al, 1997).
Social	
Beach Amenity	Narrower beach width due to recent erosion events. Generally typical of beaches within the area.
Surfing Conditions	Generally very good, though recent storm events and reduced TRESBP sand placement quantities have resulted in the separation of sandbanks leading to shorter rides.
Swimming Conditions	Favourable swimming conditions within innershore lagoon which is well separated from surfing areas.
Diving Conditions	No known popular dive sites
Fishing Conditions	Generally good fishing conditions though beach fishing and fishing from Snapper Rocks limited by shallow water depths.
Aesthetics	Grassy foreshore reserve backed by significant development including SLSC and road/carpark on eastern foreshore.
Environmental	
Storm Erosion Buffer	Generally adequate though reduced by recent storm events and reduced TRESBP sand placement quantities.
Aquatic Ecology	Primarily soft sediment habitat. Potential rocky outcrop habitat now returning adjacent to Greenmount Hill and Snapper Rocks after previous excess sand supply.
Water Quality	Generally very good, low levels of turbidity and suspended solids. Quality decreases following storms and rain events.
Noise	Moderate to high level noise associated with nearby roads and rainbow Bay SLSC
Terrestrial Ecology	Occasional lagoon areas which provide food and roost site for waterbirds. No significant dunal vegetation

4.1.4 Greenmount / Coolangatta Beach

Efforts to reduce excess sand quantities within Coolangatta Bay have been successful in recent years with significant reductions recorded in beach volume and shoreline width. To date, much of the sand loss has been from the nearshore zone in water depths of 2 – 10 metres, however the upper beach profile is now also adjusting (TRESBP, 2010). Significant shoreline retreat in excess of 100m has occurred along the eastern section of Greenmount Beach to reduce beach width over the last two years to a width that is more consistent with pre-pumping conditions. Surfing conditions remain reasonable at

Greenmount, however ride lengths have been reduced due to the erosion of the sandbank linking the surfing breaks at Greenmount and Rainbow Bay known as the Superbank. Swimming conditions have improved with the reduction of beach widths and separation of surfing and swimming areas. Following storms in May 2009 and early 2010, current conditions within Coolangatta Bay have almost returned to those experienced prior to commencement of sand bypass operations in 2001. The current benchmark coastal conditions relating to the area encompassing Greenmount and Coolangatta Beaches have been summarised in Table 4.

Table 4 Current Benchmark Coastal Condition – Greenmount & Coolangatta

Benchmark Criteria	Description
Physical	
Beach Width	Variable though continuing to readjust and is approaching pre 2000 condition. Approximately 75m from the vegetation line to MSL at Greenmount and around 85m adjacent to the Coolangatta SLSC.
Beach Volume	In line with long term average. Surveys conducted in May 2010 revealed that the volume of sand within Coolangatta Bay is approximately equal to that recorded in February 2000
Beach Slope	Relatively steep through the upper nearshore zone, approximately 1 in 30 and flatter to the -12m AHD contour (1 in 70). Summarised in Figure 5.
Sediment Characteristics	Pale fawn to fawn-grey, well sorted, clean fine sand with a typical median size of 0.2-0.22 mm with little or no silt (as defined by Hyder et al, 1997).
Social	
Beach Amenity	Recently reduced beach width has been viewed favourably by beach users. Generally typical of beaches within the area.
Surfing Conditions	Generally very good, though recent storm events and reduced TRESBP sand placement quantities have resulted in the separation of sandbanks leading to shorter rides.
Swimming Conditions	Favourable swimming conditions within innershore lagoon which is well separated from surfing areas.
Diving Conditions	No known popular dive sites
Fishing Conditions	Generally good fishing conditions though beach fishing limited by shallow water depths.
Aesthetics	Grassy foreshore reserve backed by significant development including SLSC and roads/carparks.
Environmental	
Storm Erosion Buffer	More than adequate, particularly adjacent to the Coolangatta SLSC where the beach is wider.
Aquatic Ecology	Primarily soft sediment habitat. Potential rocky outcrop habitat now returning adjacent to Greenmount Hill after previous excess sand supply.
Water Quality	Generally very good, low levels of turbidity and suspended solids. Quality decreases following storms and rain events.
Noise	Moderate to high level noise associated with nearby roads, and residential and commercial properties including Coolangatta SLSC.
Terrestrial Ecology	Frequent lagoon areas adjacent to Greenmount Hill which provide food and roost site for waterbirds. No significant dunal vegetation

4.1.5 Kirra Beach and Kirra Reef

Recent efforts to reduce excessive sand quantities at Kirra have also begun to show significant progress, particularly in the area between Kirra Point groyne and the Miles Street groyne. Following the May 2009 storm event, sections of rocky foreshore were uncovered that had not been seen since the commencement of sand bypassing operations in 2001. Recent surveys have revealed that significant quantities of sand have now dispersed from the upper beach profile and nearshore zone and beach bar in the area between Kirra Point Groyne and the Miles St Groyne. A survey conducted in October 2009 showed that sand volumes have continued to decrease as sand progresses northwards. This reduction in sand volumes has seen a progressive uncovering of Kirra Reef, which is expected to continue as sand continues to disperse. The dispersal of sand has also seen improvements to surfing conditions associated with the deepening of nearshore areas to the west of Kirra groyne.

Similarly, recent TRESBP surveys revealed that in the year prior to the August 2009 survey, Central Kirra has lost approximately 80,000 m^3 of material, primarily from the nearshore zone. Results of the October 2009 survey reveal significant seaward cross-shore transport has been occurring as the beach profile adjusts to the recent sand loss from within the nearshore zone.

North Kirra Beach remains significantly wider than could be expected naturally due to the movement of the initial sand supply through Kirra. Recent surveys have shown that North Kirra has also begun to erode, however the reductions in volume and beach width are far less than the changes experienced between Kirra Point and the Miles Street groyne. The beach width at North Kirra is expected to continue to decrease as the initial sand mass continues to disperse northwards along the stretch of beach between North Kirra Surf Club and the Tugun Surf Club. The dispersal of this sand will greatly benefit the down-drift areas to the north of Kirra, which have remained in a depleted condition since the extension of the Tweed River entrance training walls in the early 1960s.

The current benchmark coastal conditions relating to Kirra Beach have been summarised in Table 5.

Table 5 Current Benchmark Coastal Condition - Kirra

Benchmark Criteria	Description
Physical	
Beach Width	Kirra Point (adjacent to Kirra Groyne) - Similar to pre 2000 condition, exposed rocks and very little beach. Central Kirra - Approximately 100m from the vegetation line to MSL North Kirra - Approximately 160m from the vegetation line to MSL
Beach Volume	High compared to long term average. Surveys conducted in August 2009 and May 2010 revealed that the volume of sand at Kirra reduced by more than 200,000 m^3 from 2008 to 2009 but is still approximately 165,000 m^3 higher than that recorded in February 2000. The volume at Central/North Kirra remains significantly in excess of that recorded in February 2000.
Beach Slope	Approximately 1 in 70, as shown in Figure 5. Relatively flat, particularly at North Kirra where the beach is much wider
Sediment Characteristics	Pale fawn to fawn-grey, well sorted, clean fine sand with a typical median size of 0.2-0.22 mm with little or no silt (as defined by Hyder et al, 1997).
Social	
Beach Amenity	Beach amenity has improved over the last 12 months between Kirra Point and the Miles St Groyne, however beaches remain very wide at Central/North Kirra.

Surfing Conditions	Surfing conditions at Kirra Point remain poor compared to pre-TRESBP conditions.
Swimming Conditions	Favourable swimming conditions within innershore lagoon which is well separated from surfing areas.
Diving Conditions	Poor diving conditions due to the inundation of Kirra Reef by excess sand build up.
Fishing Conditions	Beach fishing at Central/North Kirra limited by shallow water depths. Fishing from Kirra Point Groyne has improved in the last year.
Aesthetics	Groynes, road and commercial developments at Kirra Point and Central Kirra. Residential developments at North Kirra set back from dunal vegetation. Beach at Central/North Kirra generally considered too wide.
Environmental	
Storm Erosion Buffer	More than adequate, particularly at Central/North Kirra where the beach is much wider
Aquatic Ecology	Relatively diverse habitat for the area, soft sediment and rocky outcrop habitats. Kirra Reef is currently experiencing adverse impacts as a result of excess sand volumes
Water Quality	Generally very good, low levels of turbidity and suspended solids. Decreases in quality following storms and rain events, particularly adjacent to the Coolangatta Creek outlet.
Noise	Higher noise levels at Kirra Point and Kirra/Central Kirra associated with road and commercial developments. Low levels noise at North Kirra associated with residential developments which are set back from dunal vegetation.
Terrestrial Ecology	Tidal lagoon areas provide food and roost site for waterbirds. Works are currently being undertaken by GCCC/DERM along Central Kirra to establish a vegetated dune, which has not been present since the early 1960s. Existing vegetated dune along North Kirra.

5. Conceptual Model of Coastal Processes

As discussed in Section 2.1 a number of previous studies have developed conceptual models of coastal processes within the study area that identify the sediment pathways for the movement of material onshore/offshore and alongshore. These conceptual models include the various mechanisms that affect the sediment balance in this coastal area.

Typically, a coastline can be subdivided into cells in which the supply, loss and thus balance of sediment follows an identifiable model. Waves, tidal currents, winds and river floods are among the main natural forcing mechanisms in a model describing a sediment cell on the coastline as shown in Figure 6.

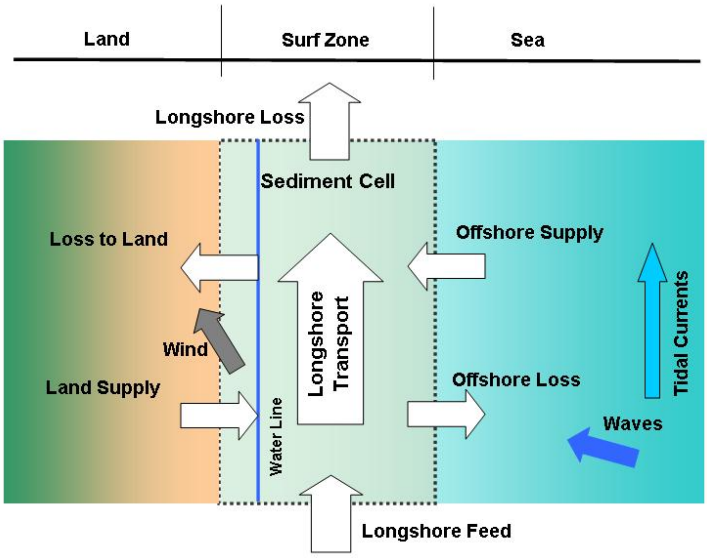

Figure 6 Conceptualising Sediment Movement

On the sandy beaches typically occurring on this coastline, there is an onshore/offshore movement of material associated with the occurrence of storms and the subsequent recovery period. This is superimposed on the net northerly movement of sand in response to the prevailing south-easterly wave climate. However, in the case of the study area there are the additional factors (not shown in Figure 6) of the removal and transport of sand along the coast by the sand bypassing plant, dredging and beach scraping operations.

As discussed in Section 2.1, the existing understanding of coastal processes prior to construction of the bypass system was summarised in the form a conceptual model during the preparation of the Environmental Impacts Assessments associated with Stage 2 of the TRESBP (Hyder et al., 1997, Druery, B. and Wright, M., 1997).

The model revealed the following salient points:

- the beach system begins at the dunes and extends across the beachfront, through the surfzone and into water depths of 20 to 25 m;
- long-term net transport rate across the study area is in the order of 500,000m^3/year;

- the majority of longshore sediment transport occurs in water depths between 2 and 4 m; and,
- the longshore sediment transport varies substantially over time, particularly between Point Danger and west of Snapper Rocks, where sediment transport is characterised by the episodic movement of large sand slugs during high energy storm events.

The previously developed conceptual model has been reviewed by GHD in light of the wealth of information that has been co llected since the commencement of Stage 2 of the project and updated through consideration of the following issues:

- The extent to which Kirra acts as a sediment sink;
- The potential for rapid erosion of Snapper Rocks and Duranbah Beach following the removal of the Tweed River entrance shoals;
- The erosion impacts on Letitia Spit arising from removal of sand by the TRESBP jetty;
- The effects of beach scraping operations along Kirra Beach; and,
- The potential for storage of dredged material in offshore areas between Duranbah and Point Danger in water depths of up to 20 m.

While many of these processes were investigated during previous studies, in some cases the impact on the study area in conjunction with sand pumping operations was not fully considered.

The updated conceptual model summarising the sediment transport processes within the study area is presented in Appendix A - Figure 02.

6. Sand Placement Scenarios and Predicted Beach Responses

So as to ensure that the most suitable approaches are developed and carried forward to the feasibility stage, a number of sand placement scenarios have been considered for each of the three sand placement options. Prediction of the beach responses within the project area to these placement scenarios has been undertaken based on consideration of the coastal processes identified in the conceptual sediment transport model discussed in Section 5.

The placement scenarios and responses described below have been selected in consultation with key stakeholders and developed through workshops with senior GHD personnel experienced in coastal management, and dredging and beach nourishment operations.

It should be noted that the beach responses described below are based on the assumption that the TRESBP system will continue to receive and deliver sand at a rate close to the long-term net littoral drift, which has been estimated to be about 550,000 m^3/year. In reality, the conditions of the project beaches will be heavily influenced by the highly variable natural sediment transport rate within the study area, which has been estimated to vary between 350,000 m^3/year and 750,000 m^3/year since 2000 (LPMA 2010). In addition, the episodic nature of sediment transport northwards around Point Danger contributes to the short term variations in southern Gold Coast beach conditions. Consequently the beach responses described below should be viewed as long-term trends expected to occur over the next 10 years. During this time there are likely be significant variations in beach conditions due to the highly variable nature of sand transport conditions within the study area.

6.1 Option 1 – North Kirra Outlet

6.1.1 Sand Placement Scenarios

The permanent sand bypassing system currently in place delivers sand to Duranbah and as far north as Kirra Point Groyne. Option 1 comprises the extension of the existing system with the incorporation of a supplementary sand delivery outlet located at Coolangatta Creek to nourish Central/North Kirra and areas further north.

In order to extend the pumping distance of the existing underground sand pumping capabilities Option 1 would require the incorporation of an additional booster pump at Greenmount Beach to pump the sand an extended distance of approximately 1200m from Kirra Point Groyne. Alternatively, two additional booster pumps could be incorporated into the system, one at Greenmount and one at Kirra Central, to pump an extended distance of 2400m allowing an outlet to be placed as far north as Graham Street, Bilinga.

In order to minimise the potential for the sand discharged via an additional outlet to contribute to the current build up of sand at North Kirra, any additional outlets would need to be sited such that material is discharged within the active portion of the beach profile. This approach would minimise impacts in the discharge area since the deposited sand would be more readily transported from the discharge point.

However, unlike the existing outlet locations at Snapper Rocks and Kirra Point, there are no suitable discharge locations within the active portion of the beach profile, such as rocky headlands or groynes. In addition, the beach in the vicinity of the proposed additional outlets is currently very wide as discussed in

Section 4.1.5. Consequently, any additional outlets at North Kirra could potentially require significant additional pipework and support structures to reach an appropriate discharge point near the active portion of the beach profile, which is currently between 200 and 300m seaward of the beach vegetation line.

Various scenarios developed around Option 1 have been investigated and are highlighted below. The location and required pipeline extensions are shown in
Figure 03 in Appendix A.

6.1.1.1 Scenario 1A – Fixed Jetty Structure

The permanent sand bypassing system currently in place would be extended to pump sand as far north as the Coolangatta Creek Outlet, approximately 1200m further than the existing system. Scenario 1A would incorporate a fixed jetty structure and discharge pipe extending out into a water depth of one to five metres. The quantity of material pumped will be dependant on beach conditions at the time of operation as much of the area is currently not in need of further nourishment.

6.1.1.2 Scenario 1B – Buried Pipeline

Scenario 1B is similar to 1A and would include an additional 1200m of a buried pipeline discharging at Coolangatta Creek however the discharge would be through a gooseneck in one to five metres of water rather than by an above ground fixed jetty structure as per scenario 1A.

6.1.1.3 Scenario 1C – Temporary Flexible Pipeline

A temporary flexible pipeline discharging in the nearshore zone adjacent to Coolangatta Creek Outlet would be implemented as Scenario 1C. The temporary pipeline would be similar to that used in TRESBP sand placement activities at Duranbah and would connect to a permanent pipeline extension at the rear of the beach near Coolangatta Creek. This permanent section of pipeline would link the temporary pipeline with the existing bypass system at the shoreward end of the Kirra Point groyne. The temporary nature of the pipeline would enable its removal should the outlet become redundant. Redundancy of the pipeline may occur as a result of the beach reaching an equilibrium state and thus not requiring future nourishment. The quantity of material to be pumped would be as per the scenarios above.

6.1.1.4 Scenario 1D – Multiple Temporary Outlets

Scenario 1D is similar to scenario 1C, and would include an additional 2400m of pipework onto the existing system allowing slurry to be discharged as far north as Graham Street, Bilinga. The scenario would call for the incorporation of two booster pumps, one at Greenmount the other at Kirra Central to pump the required distance. This scenario would incorporate a number of potential outlets in series along the one discharge pipeline located at the rear of the beach. This scenario has been developed to offer greater flexibility in the system allowing for a spot method of nourishment. The discharge outlet could be selected based on the area of the beach that is in need of nourishment rather than having one outlet pumping to the same location potentially over nourishing the beach profile. Temporary pipelines could be used to target specific portions of the beach profile. The quantity of material to be pumped could be distributed between the different outlets along the discharge pipeline allowing a more even distribution of sand nourishment.

6.1.2 Predicted Beach Responses – North Kirra Outlet

The predicted beach responses associated with the placement of sand in the nearshore zone adjacent to Coolangatta Creek (Scenarios 1A, 1B, 1C and 1D) has been summarised below and in Table 6, which provides a snapshot of the positive and negative changes associated with this option.

The construction of an additional outlet at North Kirra offers potential for decreasing sand accumulation at Kirra by reducing the sand supply to Coolangatta Bay. This could be expected to accelerate the dispersal of the sand build up at Kirra/Central Kirra and potentially promote improved beach amenity, surfing conditions, and reef health at Kirra. However, the implementation of this option is likely to take in the order of two to three years, by which time the impact of an additional northern outlet on the sand build up at Central Kirra is likely to have diminished given the current trending in sand dispersal from Kirra/Central Kirra Beach.

An additional outlet would result in the beaches of Bilinga and Tugun receiving increased sand volumes, leading to a rapid response in the nearshore beach profile and shoreline as the placed material is reworked northward via the affects of the prevailing wind, waves and currents.

However, it is important to note that depending on the selected placement method, location, and timing of sand pumping, the addition of sand through a North Kirra outlet could potentially slow the current sand dispersal process because it is sited in the area where the existing sand build up is most pronounced, and hence could delay the transition to 'normal' beach widths in the Central Kirra area. In addition, a new outlet may also cause a seaward realignment of the beach south (east) to Kirra, to the detriment of Kirra surf quality and Kirra Reef.

Routine use of a North Kirra outlet would reduce the available sand supply into Coolangatta Bay over the long term. This reduction in sand supply could potentially lead to the following impacts within Coolangatta Bay:

- narrow beaches and reduced surfing shoals that have been depleted of their sand supply;
- increased susceptibility to storm erosion; and
- reduced general amenity.

Table 6 Summary of Beach Responses – Option 1, Scenarios A, B, C & D, North Kirra Outlet

Benchmark Criteria	Letitia Spit & Duranbah	Rainbow Bay	Coolangatta & Greenmount	Kirra Beach
Physical				
Beach Width	🟡	🔴	🔴	🔴
Beach Volume	🟡	🔴	🔴	🔴
Beach Slope	🟡	🔴	🔴	🔴
Sediment Characteristics	🟡	🟡	🟡	🔴
Social				
Beach Amenity	🟡	🔴	🔴	🔴
Surfing Conditions	🟡	🔴	🔴	🔴
Swimming Conditions	🟡	🔴	🔴	🔴
Diving Conditions	🟡	🟡	🟡	🔴
Fishing Conditions	🟡	🟢	🟢	🔴
Aesthetics	🟡	🔴	🔴	🔴
Environmental				
Storm Erosion Buffer	🟡	🔴	🔴	🟢
Aquatic Ecology	🟡	🟡	🟡	🔴
Water Quality	🟡	🟡	🟡	🔴
Noise	🟡	🟡	🟡	🔴
Terrestrial Ecology	🟡	🔴	🔴	🔴

🟢 Potential positive changes to Benchmark Condition

🟡 No significant changes to Benchmark Condition

🔴 Potential Negative changes to Benchmark Condition

Refer to preceding text for explanation of positive and negative changes expected with this option.

6.2 Option 2 – Additional Dredge Placement Areas

Option 2 entails the development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of the sand dredged from the entrance to the Tweed River. The proposed locations of the additional placement areas are shown on Figure 04 in Appendix A and are described as the Bilinga & Tugun Dredge Placement Areas and the Deepwater Dredge Placement Areas. Other areas between the Bilinga and Deepwater placement areas have been identified by previous studies, however these have not been considered in this study due to their proximity to Kirra and the risk of oversupply of sand to Kirra and Kirra Reef, from onshore reworking of sand.

It should also be noted that TRESBP pumping operations generally play a greater role in determining the condition of the southern Gold Coast beaches than do dredging and deposition operations. This is due to the larger volume of material placed via the pipeline system.

When considering beach responses to placement of dredged material it is important to consider the sediment transport system as a whole, including proposed discharge operations and the current condition of the beaches within the study area.

6.2.1 Sand Placement Scenarios

During the early years of the TRESBP, dredging campaigns were undertaken on an annual basis. From 2001 to 2006 an average of approximately 240,000 m^3/year was removed from the Tweed River entrance channel. As the entrance channel and area surrounding the sand extraction jetty began to stabilise, dredging of the Tweed River entrance was required less frequently and is currently undertaken only every two years. Around 200,000 m^3 was removed during the 2006 and 2008 dredging campaigns, however no dredging was undertaken in 2007 or 2009. In keeping with previous dredged volumes, the sand placement scenarios associated with Option 2 have been developed based on the dredging and disposal of an average of 200,000 m^3 per dredging campaign.

Historically dredging of the Tweed River entrance has been undertaken during winter months (typically May to September). Sea conditions are most favourable at this time and disruption to boating traffic using the Tweed River entrance channel which is generally less during the winter months, is minimised. The dredging activities associated with Option 2 would most likely be undertaken between May and September, depending on plant and equipment availability.

In reality it is likely that the dredged material would be distributed across a number of placement areas, including the proposed additional areas and deposition boxes. As in previous dredging campaigns, hydrographic survey data would be used to determine the most appropriate deposition box at the time of dredging. This approach minimises the potential for deposited material to accumulate in any one deposition box and allows eroded areas to be targeted during deposition activities.

6.2.1.1 Scenario 2A – Bilinga & Tugun Dredge Placement Areas

The material removed during the dredging of the Tweed River entrance channel would be placed in nearshore areas to the north-west of the existing nearshore dredge placement areas. Previous studies have identified potential placement areas seaward of Bilinga and Tugun in water depths of around 7 – 12 metres which would be the areas targeted in this Scenario. The quantity of material to be placed within these areas would be determined during dredging planning workshops and would be no greater than 200,000 m^3. As in previous campaigns the dredging would likely be undertaken by a small TSHD, which would transport the dredged material in hopper loads of around 350 - 400 m^3 from the river entrance to the placement areas approximately 6 to 8 km north. Material would be placed by slowly opening the bottom hopper doors while drifting through the placement area. This approach has been shown to spread the material evenly through the placement area and minimise adverse impacts on surfing conditions (Boswood 2001a).

6.2.1.2 Scenario 2B – Deepwater Dredge Placement Areas

The material removed during the dredging of the Tweed River entrance channel would be placed in deeper nearshore storage reserves seaward of the existing dredge deposition boxes from Point Danger to Coolangatta. Previous studies have identified potential placement areas beyond the existing dredge deposition boxes to the -15 m AHD contour.

Depending on the state of the southern Gold Coast beaches at the time of dredging, material could also be placed in water depths similar to those utilised during the 2008 dredging campaign, which placed

material in the Duranbah placement area between the -15 m and -20 m AHD contours. This would provide a stable storage location for excess sand during times when it may be undesirable to introduce additional sand to the southern Gold Coast beaches. Although large swell events may result in slow northerly transport and some smearing of the stockpile, it is expected that the majority of the deposited material would remain within the placement area. Material could also be retrieved at a later date for beach nourishment campaigns elsewhere on the Gold Coast.

As in previous campaigns, dredging of the Tweed River entrance would be undertaken by a small TSHD, which would transport the dredged material in hopper loads of around 350 - 400 m^3 to the placement areas 1 to 3 km north of the river entrance. Material would be placed by slowly opening the bottom hopper doors while travelling through the placement area. This approach has been shown to spread the material evenly through the placement area and minimise impacts on wave propagation, thereby keeping adverse impacts on surfing conditions to a minimum (Boswood 2001a).

6.2.2 Predicted Beach Response – Additional Dredge Placement Areas

Deposition of dredged sand within additional nearshore placement areas along the southern Gold Coast beaches is expected to have immediate impacts within the zone of material placement and longer term effects on the southern Gold Coast beaches as the littoral system adjusts to the introduced material. Predicted beach responses to the potential scenarios adopted around Option 2 are discussed below in general terms. It should be noted that the specific beach responses associated with each placement scenario would depend upon the location and profile of the placed material with respect to the following parameters:

- depth;
- width/length relative to wavelength;
- orientation relative to predominant swell direction;
- slope of the leading edge; and,
- smoothness / uniformity of thickness.

These parameters would be determined by the following issues:

- area of placement;
- quantity of material placed; and,
- placement method.

6.2.2.1 Scenario 2A – Bilinga & Tugun Dredge Placement Areas

The response of the Bilinga and Tugun beaches to the placement of dredged material in adjacent nearshore areas has been summarised in Table 7, which provides a snapshot of the positive and negative changes associated with this option.

It is expected that the beach response will be more gradual than that associated with pumping of material directly into the active beach zone via pipelines. While the impacts in nearshore areas would be almost immediate, changes in the beach profile and shoreline would occur gradually as the placed material is reworked onshore under the influence of the predominant wave, wind and current conditions.

Given the greater exposure of Bilinga and Tugun to the predominant south east swells and resulting high rate of sediment transport (Delft, 1992), it is expected that the placed material will disperse from the placement areas more rapidly than previous nourishment campaigns at Kirra and Greenmount. The lack of obstructions to sediment transport along this stretch of beach (such as groynes and headlands) is expected to result in an even spreading of placed material along this stretch of coast, leading to a more uniform seaward movement of the current shoreline position. It is important to note that these responses will be heavily influenced by the position of the current sand build up at the time of placement operations.

The removal of material from the Tweed River Entrance and placement adjacent to the stretch of beach from Bilinga to Tugun, would reduce the quantity of sediment transported through the beach systems from Duranbah to North Kirra. Beach responses to this approach would vary depending on the current condition of each beach.

As noted in Section 4, Duranbah and Rainbow Bay (particularly Snapper Rocks) are currently in a depleted condition and at the time of writing this report, were undergoing nourishment via the TRESBP system. The removal of material from the Tweed River Entrance and downdrift sand placement at Bilinga and Tugun would further reduce the littoral supply of sediment to Duranbah Beach and Rainbow Bay. As a result these beaches would continue to erode and require ongoing nourishment via the TRESBP system.

Beaches such as Coolangatta and Kirra, which have experienced a surplus of sand, would experience shoreline recession and decreases in beach volume as the littoral sand supply is reduced, allowing dispersal of the existing build up of sand, particularly along Kirra to North Kirra. The reduction of sand volumes from offshore areas adjacent to Kirra/Central Kirra could be expected to result in increased exposure of Kirra Reef and provide significant benefits to reef health. However, it would take some years for the depleted supply condition to impact on the sand build up at Kirra, during which time, the less than natural supply would deplete the beaches and surfing banks from Rainbow Bay to Coolangatta.

Table 7 Summary of Beach Responses – Option 2, Scenario A Bilinga & Tugun Dredge Placement Areas

Benchmark Criteria	Letitia Spit	Duranbah Beach	Rainbow Bay Coolangatta Greenmount	Kirra Beach	Bilinga & Tugun Beaches
Physical					
Beach Width	🟡	🔴	🔴	🟢	🟢
Beach Volume	🟡	🔴	🔴	🟢	🟢
Beach Slope	🟡	🔴	🔴	🟢	🟢
Sediment Characteristics	🟡	🟡	🟡	🟡	🔴
Social					
Beach Amenity	🟡	🔴	🔴	🔴	🟢
Surfing Conditions	🟡	🔴	🔴	🟢	🟡
Swimming Conditions	🟡	🔴	🔴	🟢	🟢
Diving Conditions	🟡	🟡	🟡	🟢	🟡
Fishing Conditions	🟡	🟡	🟢	🟢	🟡
Aesthetics	🟡	🔴	🔴	🔴	🟢
Environmental					
Storm Erosion Buffer	🟡	🔴	🔴	🔴	🟢
Aquatic Ecology	🟡	🟡	🟡	🟢	🔴
Water Quality	🟡	🟢	🟢	🟡	🔴
Noise	🟡	🟡	🟡	🟡	🔴
Terrestrial Ecology	🟡	🟡	🟡	🟡	🟢

🟢 Potential positive changes to Benchmark Condition

🟡 No significant changes to Benchmark Condition

🔴 Potential Negative changes to Benchmark Condition

Refer to preceding text for explanation of positive and negative changes expected with this option.

6.2.2.2 Scenario 2B – Deepwater Dredge Placement Areas

Beach responses to the placement of dredged material in deeper nearshore storage reserves are expected to be similar to those experienced following previous placement campaigns within the existing dredge deposition boxes. These responses have been summarised in Table 8,which provides a snapshot of the positive and negative changes associated with this option.

Excluding issues associated with the oversupply of sand to southern Gold Coast beaches and mounding of deposited material, no major changes in beach conditions were associated with previous placement campaigns, which deposited dredged material from the Tweed River entrance landward of the - 8 and - 12 m AHD contours.

It is therefore expected that the removal of similar quantities of material from the Tweed River entrance and placement in deeper nearshore areas will result in less pronounced changes to southern Gold Coast beach conditions.

The method of placing dredged sand in deeper water depths of 10 m to 20 m depth has been utilised in a previous dredging campaign off Duranbah Beach. The purpose of such placement is to delay the onshore movement of the placed sand if deemed operationally advantageous to do so. This approach provides the ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading over time to better match natural sand supply conditions.

Sand that is placed in deeper water can be considered to remain within the “active sediment system” and will over time move onshore. Such sand is primarily mobilised by large swell events and will otherwise remain undisturbed as an outer nearshore sand reserve.

In general terms, the placement of dredged material in deeper nearshore areas, would see beaches such as Kirra/Central Kirra, which have experienced a surplus of sand, experience shoreline recession and decreases in beach volume as the littoral sand supply is reduced, allowing dispersal of the existing build up of sand, particularly at Central Kirra and North Kirra. The reduction of sand volumes from offshore areas adjacent to Kirra/Central Kirra could be expected to result in increased exposure of Kirra Reef and provide significant benefits to reef health.

It is also important to note that reduced rates of littoral sand supply to Duranbah Beach, Rainbow Bay and Coolangatta Beach could be expected to reduce the storm buffer of these beaches, making them more vulnerable to erosion.

Beach responses would be driven by changes in wave propagation due to the localised areas of reduced depth within the placement areas. This could potentially create a lens effect, which would lead to superposition of wave sets and focusing of wave energy onto areas of the southern gold coast beaches. Depending on the water depth in which the material is deposited, and the time required for the placed sand to dissipate, longer term impacts associated with variations in wave energy could include localised areas of erosion and accretion along the southern Gold Coast beaches. The specific areas of erosion and accretion would be primarily driven by the quantity of material deposited within each placement area and the method of placement.

It is important to note that there is a substantial outer nearshore area in water depths of -12 to -20m AHD seawards of the existing placement areas to spread the dredged sand as a relatively thin layer (up to approximately 0.3m thick). It is unlikely that placement in this manner would have a significant impact on wave propagation in these water depths if spread uniformly and implemented on an infrequent basis.

In addition, part of the material placed in deeper nearshore storage reserves would be reworked landward contributing to the accretion of the nearshore shoals. Placed material would also be distributed northwards by the natural littoral drift, though at a much slower rate than that placed within the more active portion of the beach profile. It has the benefit in combination with existing nearshore placement areas of providing some ability to gradually incorporate dredged sand into the longshore sand drift, ie spreading over time to better match natural sand supply conditions. The rate at which the material moves shoreward and northward will depend largely on the depth of water in which the material is deposited.

Table 8 Summary of Beach Responses – Option 2, Scenario B Deepwater Dredge Placement Areas

Benchmark Criteria	Letitia Spit	Duranbah Beach	Rainbow Bay	Coolangatta & Greenmount	Kirra Beach
Physical					
Beach Width	🟡	🔴	🔴	🔴	🟢
Beach Volume	🟡	🔴	🔴	🔴	🟢
Beach Slope	🟡	🔴	🔴	🔴	🟢
Sediment Characteristics	🟡	🟡	🟡	🟡	🟡
Social					
Beach Amenity	🟡	🔴	🔴	🔴	🔴
Surfing Conditions	🟡	🔴	🔴	🔴	🟢
Swimming Conditions	🟡	🔴	🔴	🔴	🟢
Diving Conditions	🟡	🟡	🟡	🟡	🟢
Fishing Conditions	🟡	🟡	🟢	🟢	🟢
Aesthetics	🟡	🔴	🔴	🔴	🔴
Environmental					
Storm Erosion Buffer	🟡	🔴	🔴	🔴	🔴
Aquatic Ecology	🟡	🟡	🟡	🟡	🟢
Water Quality	🟡	🟢	🟢	🟢	🟡
Noise	🟡	🟡	🟡	🟡	🟡
Terrestrial Ecology	🟡	🟡	🟡	🟡	🟡

🟢 Potential positive changes to Benchmark Condition

🟡 No significant changes to Benchmark Condition

🔴 Potential Negative changes to Benchmark Condition

Refer to preceding text for explanation of positive and negative changes expected with this option.

6.3 Option 3 – Kingscliff Sand Delivery

Option 3 includes consideration of the Tweed River entrance as a 'once only' source of sand for proposed beach nourishment works by Tweed Shire Council at Kingscliff. The location of the proposed dredge and nourishment areas is shown on Figure 05 in Appendix A.

6.3.1 Sand Placement Scenarios – Kingscliff Sand Delivery

In each of the three sand placement scenarios discussed below, sandy material would be removed from the Tweed River entrance and transported roughly 10 km south to Kingscliff. TSC has previously determined that the required initial nourishment volume would be in the order of 250,000 m^3 with an ongoing nourishment requirement of around 5,000 m^3/year to be placed every 5 to 10 years (WP, 2008). However, in keeping with previous volumes dredged from the Tweed River entrance, the sand placement

scenarios associated with Option 3 have been developed based on the 'once only' dredging and disposal of 200,000 m^3.

The placement scenarios described below have been developed based on the dredging and material placement operations being undertaken by a 1250 m^3 TSHD or similar with the capacity to place material at Kingscliff Beach using the following methods:

- bottom dump material in the nearshore zone;
- rainbow material onto the beach and nearshore zone; and,
- pump material onto the beach via a submerged or floating pipeline.

As discussed below, each of these placement methods target a specific area of the beach profile. Consequently, it would be preferable to use all three methods to achieve total nourishment of the beach profile.

Due to the relatively large transport distances involved, it would be economically unfeasible to complete this work using a small TSHD such as the *Port Frederick*, which would require a high number of dredge/deposition cycles per week. In addition the *Port Frederick* does not have "rainbowing" capabilities, which would limit the placement of material in shallower nearshore areas.

A TSHD with a capacity of around 1,250 m^3 would provide a more economical and practical solution by reducing the required number of transport cycles between the Tweed River and Kingscliff. While an even larger dredge would further reduce cycle times and operational costs per cubic metre, the mobilisation costs are likely to be much greater, meaning the total cost per cubic metre would be greater for a dredging campaign to remove a total volume in the order of 200,000m^3. In addition, consideration has been given to the operational constraints of the Tweed River entrance such as shallow water depth, limited turning areas and the proximity of preferred dredge areas to nearshore shoals and the river entrance training walls. Depending upon the dimensions and capabilities of the TSHD commissioned to undertake these works, it is likely that dredging of some areas may be restricted because of the limitations arising from the use of a larger TSHD, such as greater draft requirement and greater safety distance requirement (from mobile shallow shoals and rock training walls). Whilst a larger TSHD could source material from the deeper portions of the Tweed River bar and entrance area, it is possible that separate entrance maintenance dredging by smaller plant would be required.

6.3.1.1 Scenario 3A – Bottom Dumping

The TSHD would travel slowly through the nearshore zone in water depths of around 5 to 12 m before gradually opening the bottom hopper doors to spread the material throughout the deposition area. This approach allows nourishment of the deeper nearshore areas and represents a cost effective option for beach nourishment. However, sand placement would be limited to deeper areas meaning that the shoreline could be very slow to respond as the placed material is reworked shoreward and onto the beach. The placed material would also create short-term irregularities in seabed levels which could affect wave propagation until the material is smoothed by wave action and currents. The material placed in the nearshore area would also reduce the potential for direct wave attack of the upper beach area.

6.3.1.2 Scenario 3B - Rainbowing

The TSHD would anchor in the nearshore zone to employ the "rainbowing" method to spray sand slurry over the bow onto the beach and nearshore zone. A TSHD of this size would be capable of casting material around 50 to 70 m, which would allow nourishment of shallower nearshore areas and more even placement of dredged material. This approach would provide a more rapid response in beach widths

and seaward shoreline movement, however the additional pumping costs associated with “rainbowing” would increase the cost of the nourishment campaign.

6.3.1.3 Scenario 3C – Pump Ashore

The TSHD would pump material ashore through floating or submerged pipelines whilst anchored in the nearshore zone. Depending on the desired beach profile and the existing areas of erosion, material could be pumped into bunded areas or allowed to flow across the beach. In both cases land based plant and equipment would be required to manage onshore pipelines and rework the placed material to achieve an acceptable beach profile. This approach would result in immediate shoreline accretion and increases in beach width, however there would also be significant additional costs associated with the additional pumping and land based plant requirements.

6.3.2 Predicted Beach Response – Kingscliff Sand Delivery

While the beach response at Kingscliff will vary depending on the method of placement, the response of the beaches from Duranbah to Kirra to each of the three scenarios associated with Option 3 will essentially be the same.

As this response has been discussed in detail in Section 8.2.1, a brief summary of the beach responses has been provided below for completeness and further summarised in Table 9, which provides a snapshot of the positive and negative changes associated with this option.

Feasible methods of placing sand at Kingscliff Beach are likely to involve a large floating dredge (for operational efficiency and costing reasons) with more than three times the sand holding capacity of the dredge used routinely in Tweed River entrance dredging campaigns. Depending on the capabilities of the available dredging equipment at the time of construction, separate entrance maintenance dredging by smaller dredging plant may also be required in order to dredge some of the shallower parts of the entrance bar which may not be accessible by a larger dredge. Assuming this is the case, it would be necessary to source sand from the deeper parts of the Tweed entrance, which would be likely to have only an indirect influence on the natural sand drift to Queensland and on southern Gold Coast beaches.

Sand would be gradually reworked into the deeper parts of the entrance area that had been dredged. It is expected that it would take a significant number of years for the rebuilding of the dredged area during which time the natural bypassing of sand across the entrance would be reduced somewhat. Duranbah would likely experience gradual minor sand loss from nearshore shoals requiring some additional sand delivery to compensate. However, this additional delivery is likely to be available from within the existing project provisions for delivery of sand to Duranbah. The impact on the natural bypassing of sand across the border into Queensland would likely be minor but would need to be managed to maintain natural supply conditions to southern Gold Coast beaches over the longer term.

If however a larger hopper dredge was able to access and dredge the shallower parts of the Tweed entrance, the impacts on the southern Gold coast beaches would be more pronounced. Specifically, beaches that are currently in a depleted condition, such as Duranbah and Rainbow Bay (Snapper Rocks) will experience further sand loss from nearshore shoals, thereby reducing the storm buffer of these beaches and making them more vulnerable to erosion.

On the other hand, beaches that have retained excess sand volumes in recent years, such as Kirra and Coolangatta, are expected to decrease in width and volume in response to reduced sand feed from nearshore areas to the south. This reduced sand supply rate will lead to shoreline recession as the existing sand surplus disperses under the effect of prevailing winds, waves and currents.

It is important to note that the responses of the southern Gold Coast beaches will depend upon the dredge removal area. Removal of sand from deeper areas will have a reduced impact when compared to removal from shallower areas in the active portion of the littoral system.

The response of the proposed beach nourishment location at Kingscliff is expected to be increased beach width, seaward migration of the current shoreline position and the development of a flatter, more linear beach slope as the beach profile adjusts to the nourishment campaign. While the long-term beach response will be relatively similar for each sand placement scenario associated with Option 3, the short-term beach response will be heavily influenced by the method of placement. The specific response to each placement method at Kingscliff is outside the scope of this study and has not been considered in detail. An EIS was commissioned by TSC in 2008 to investigate the effects of proposed beach foreshore protection works, including beach nourishment using material dredged from the Tweed River entrance. The EIS report (WP, 2008) provides a detailed description of the coastal processes within the proposed nourishment location, potential impacts and proposed mitigation strategies.

Table 9 Summary of Beach Responses – Option 3 Kingscliff Sand Delivery

Benchmark Criteria	Letitia Spit	Duranbah Beach	Rainbow Bay Coolangatta Greenmount	Kirra Beach	Kingscliff Beach
Physical					
Beach Width	🟡	🔴	🔴	🟢	🟢
Beach Volume	🟡	🔴	🔴	🟢	🟢
Beach Slope	🟡	🔴	🔴	🟢	🟢
Sediment Characteristics	🟡	🟡	🟡	🟡	🔴
Social					
Beach Amenity	🟡	🔴	🔴	🔴	🟢
Surfing Conditions	🟡	🔴	🔴	🟢	🟡
Swimming Conditions	🟡	🔴	🔴	🟢	🟢
Diving Conditions	🟡	🟡	🟡	🟢	🟡
Fishing Conditions	🟡	🟡	🟢	🟢	🟡
Aesthetics	🟡	🔴	🔴	🔴	🟢
Environmental					
Storm Erosion Buffer	🟡	🔴	🔴	🔴	🟢
Aquatic Ecology	🟡	🟡	🟡	🟢	🔴
Water Quality	🟡	🟢	🟢	🟡	🔴
Noise	🟡	🟡	🟡	🟡	🔴
Terrestrial Ecology	🟡	🟡	🟡	🟡	🔴

🟢 Potential positive changes to Benchmark Condition

🟡 No significant changes to Benchmark Condition

🔴 Potential Negative changes to Benchmark Condition

Refer to preceding text for explanation of positive and negative changes expected with this option.

7. Feasibility Assessment

The tasks to be undertaken in the feasibility assessment of the three options have been grouped into the following sections as specified in the Study Brief.

Assess the feasibility of each of the three options in terms of viability, effectiveness and cost/benefit

- Potential improvement to the longer term operation of the system
- Benefits compared to the benchmark outcomes
- Consistency with or promotion of the achievement of project objectives
- Expected timeframes required to achieve the development, installation and benefit (including an allowance for the potential lag in the response of the natural system)
- Breakdown of costing (development, construction, operation and maintenance)

Identify potential adverse impacts, risks/uncertainties and mitigation/management measures

- Adverse Impacts on Kirra Reef, Kirra surf quality and the beach width at Kirra
- Risks/Uncertainties
- Mitigation/Management Issues

Recommend environmental planning path to navigate through approvals and permits

- Compliance with the relevant legislation
- Required planning approvals and the time needed to obtain these approvals

The salient points related to the feasibility of each option have been summarised in Table 10.

Table 10 Feasibility Summary of Sand Placement Options

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT - OPTIONS FEASIBILITY ASSESSMENT - FEBRUARY 2011

Assessment Key:	Unfavourable	Neutral/Caution	Favourable

	ASSESSMENT CRITERIA	OPTIONS			
		NORTH KIRRA OUTLET	EXTENDED DREDGE PLACEMENT AREAS		KINGSCLIFF BEACH SAND DELIVERY
			Bilinga – Tugun Nearshore Area	Project Area - Deep Water Extension	
1	Impact on: Kirra Reef Kirra Surf Quality Kirra Beach Width	**MINIMAL DIRECT BENEFIT** **Unlikely a North Kirra Outlet can be installed and have an impact before sand build-up has effectively dispersed from Kirra. Discharge pipework would have significant impact on Central/North Kirra beach amenity. Potential to cause detrimental re-alignment of Kirra Beach, and delay dispersal of sand build-up from Kirra.**	**MINIMAL DIRECT BENEFIT** **Provides improved longer term control in matching natural sand movements, however it is unlikely any benefit can be achieved prior to natural dispersion of sand build up from Kirra.**	**LONGER TERM BENEFIT** **Addition of deep-water placement opportunities provides improved longer term control in matching natural sand movements and in beach nearshore profiling.**	**NO DIRECT BENEFIT** **Requires large dredge restricted to dredging deeper parts of entrance. This would not avoid the need to dredge from shallower waters to maintain an entrance navigation channel. Sand taken from outer entrance bar in 'once only' operation has no significant direct impact at Kirra Beach, or southern Gold Coast beaches.**
	Kingscliff Beach	**N/A**	**N/A**	**N/A**	**High cost of direct sand placement to upper Kingscliff Beach is a major feasibility issue. Operation is physically possible and would achieve the desired extent of beach nourishment at Kingscliff.**
2	Impact on Existing Benchmark Conditions	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Provides unnatural depleted sand supply to Rainbow Bay, Coolangatta & Kirra beaches. Causes beach retreat and reduced storm resilience.**	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Provides unnatural depleted sand supply to Rainbow Bay, Coolangatta & Kirra beaches. Causes beach retreat and reduced storm resilience.**	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Rainbow Bay to Kirra: Improved nearshore profiling and 'natural' sand supply.**	**Nil**
3	Long Term Improvement to Operations	**MINIMAL BENEFITS** **Impacts as above plus increased energy usage.**	**MINIMAL BENEFITS** **Impacts as above plus increase in energy usage**	**YES** **Improved volume control and beach profiling.**	**MINIMAL BENEFITS** **Insignificant impact on TRESBP operations.**
4	Consistent with Project Objectives	**NO** **Does not restore natural sand supply to Coolangatta Bay.**	**NO** **Does not restore natural sand supply to Coolangatta Bay.**	**YES**	**Has minor indirect impact on the natural sand flow to Queensland and Tweed River entrance navigability.**
5	Time for Approvals	**1 to 2 Years ***	**1 Year***	**1 Year***	**1 Year**
6	Time for Installation	**2 to 3 Years ***	**Possibly 2-3 years depending on need for dredging***	**Possibly 2-3 years depending on need for dredging***	**1 Year***
7	Time until Benefit	**At least 3 and up to 4 years for impact at Kirra* Excess sand likely to have dispersed**	**No immediate impact at Kirra Excess sand likely to have dispersed**	**No immediate impact at Kirra though flexibility improved immediately**	**Immediate at Kingcliff**
8	Additional Set-up Cost	**$4.6M to $7.6M**	**$100,000**	**$100,000**	**$100,000**
9	Additional Operations Cost	**$125,000 to $250,000 pa**	**$1.05M to $1.5M per dredge campaign**	**$100,000 per Dredge campaign**	**$2.5M to $5.1M (nil TRESBP)**
10	Adverse Impacts or Risks	**Rainbow Bay-Coolangatta beaches, Kirra Beach environment. Plus additional energy usage.**	**Rainbow Bay-Coolangatta beaches, Kirra Beach environment. Plus additional energy usage.**	**Slightly increased energy usage. Requires careful management to achieve benefits**	**Nil**

7.1 OPTION 1 – North Kirra Outlet

The following paragraphs outline the assessment of the various Option 1 scenarios, as outlined in Section 6.1, in terms of the feasibility of each option and the above mentioned factors.

7.1.1 Viability, Effectiveness and Cost/Benefit

7.1.1.1 Potential improvement to the longer term operation of the system

The potential improvements to the system with the implementation of either of the Option 1 scenarios are as follows:

- Greater flexibility following periods of severe erosion through the provision of additional sand placement areas. Option 1 offers a rapid and effective method of nourishment in emergency situations provided material is not needed in other locations;
- The incorporation of flexible outlet locations allows greater flexibility when selecting where on the beach to nourish.
- Potential to reduce the quantity of sand being transported to Kirra Beach by pumping it either 1200m or 2400m further north which will reduce the problem of over nourishment that has occurred in the past; and
- Potential to improve surfing conditions at Kirra. However, this would be subject to careful planning and placement of sand, as sand pumping to this location may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surfing and Kirra Reef in the future.

7.1.1.2 Benefits compared to the current benchmark outcomes

In addition to the improvements to the system that have been identified above, the sand placement scenarios associated with the North Kirra outlets proposed under Option 1 could directly benefit those beaches further north of the proposed outlet location as the material is dispersed.

As noted in Section 2.2, the beaches of Bilinga and Tugun have remained in a depleted state since the extension of the Tweed River entrance training walls in the early 1960s. These beaches are expected to benefit from Sand Placement Option 1, as the placed material is gradually reworked northward via the affects of the prevailing wind, waves and currents. This benefit needs to be assessed in light of the fact that these beaches have recently began to increase in width as the existing build up of sand moves northwards from Kirra.

7.1.1.3 Consistency with or promotion of the achievement of project objectives

As noted above, material could be directly pumped onto North Kirra Beach during periods of severe erosion, should that need arise in the longer term. However, this should be evaluated against the beach rebuilding that would occur as part of the natural beach cycle under a restored sand supply along all the southern Gold Coast beaches, which is the objective of the TRESBS operations.

However it should be noted that the development of strategies that result in depleted beaches from Duranbah to Kirra is not consistent with, and is contrary to, the project objectives that seek to restore and continue a natural sand supply to all the southern Gold Coast beaches.

7.1.1.4 Expected timeframes required to achieve the development, installation and benefit (including an allowance for the potential lag in the response of the natural system)

It is anticipated that it would take at least 12 weeks to prepare the technical design details for the relevant approvals and at least a further 12 weeks for completion of associated environmental assessment studies. Securing the appropriate statutory approvals could then be expected to take between 26 to 39 weeks because there is likely to be significant impact on visual amenity and beach usage which is likely to complicate the approval process. This would depend on the time taken by the applicant to respond to requests for information (RFI's) and the community consultation process.

Following completion of the approvals process, construction of the additional pipeline and outlet structures could be expected to take approximately 12 months.

Depending on the frequency of use, the beach system adjacent to the outlet sites could be expected to respond within days of commencement of pumping operations. At Kirra and the beaches to the south, the benefits are not expected to be recognizable for at least 1 year and would depend primarily on the occurrence of storm events.

7.1.1.5 Breakdown of costing (development, construction, operation and maintenance)

The estimated probable cost breakdown relating to the base extension of the pumping system to North Kirra (Option 1) is summarised in Table 11. The largest cost associated with the Option 1 Scenarios is the cost to construct the additional pipework needed to extend the existing bypass pipeline network. In addition, it should be noted that the existing pipeline between the Boundary St junction and Kirra has been designed to accommodate a maximum discharge rate of 70,000 m^3/year for 20 years[1] and is therefore unable to deliver the additional sand volumes required.

Consequently the costs provided in Table 11 allow for the installation of an further length of 1200m of pipeline to provide a connection to the existing pipe network at Boundary Street rather than at the Kirra outlet to overcome the limitations described above. The costs provided in Table 11 assume material is discharged at the rear of the beach in the upper beach profile as undertaken by TRESBP at Duranbah.

Extending the sand discharge capabilities by a distance of 1200m (Scenarios 1A-1C) is expected to have a base establishment cost of $4,400,000. This establishment cost includes for steel pipes and components, valve sets, Y pieces, earth works, pipe laying, boosters in concrete housing, as well as investigations and approvals. The base establishment cost of extending the sand discharge capabilities by 2400m (Scenario 1D) is estimated to be approximately $7,400,000.

Depending upon the additional pumping length and outlet infrastructure, total costs for Option 1 range from $4.6M to $7.6M as shown in Table 12.

[1] Based on advice provided by Ian Taylor during telephone conversations in September 2010

Table 11 – Costing Breakdown - Option 1 – North Kirra Outlet Base Extension

Cost Description	Scenario 1A-1C Extra Distance 1200m	Scenario 1D Extra Distance 2400m
400 mm Steel Pipe in 12m Lengths	$725,000	$1,090,000
Valve Sets	$80,000	$105,000
Y Pieces	$20,000	$25,000
Earthworks and Pipe Laying	$150,000	$225,000
Electric Booster Stations & Concrete Housing	$1,200,000	$2,400,000
Earthworks for Booster Stations	$30,000	$50,000
Approvals	$250,000	$250,000
Project Management & Other Project Costs	$590,000	$990,000
Sub-Total	$3,050,000	$5,140,000
Contractor's Mark-up of 20%	$610,000	$1,030,000
Contingency of 20%	$730,000	$1,230,000
Total Base Establishment (nearest $0.1M)	$4,400,000	$7,400,000
Additional Operating Cost ($/$m^3$)	$0.50	$1.00
Additional Pumping Cost (250,000m^3)	$125,000	$250,000

In each case, the costs provided in Table 11 cover the base extension of the discharge pipeline. However, as noted above, the additional outlet must deliver sand to the active portion of the beach profile in order to provide favourable outcomes. Unless the construction of the additional outlet is delayed until after the excess sand build up has dissipated from North Kirra, significant additional outlet infrastructure would be required to reach the active portion of the beach profile. Approximate estimates of the construction costs associated with this additional infrastructure and resulting total establishment costs are provided in Table 12.

Table 12 – Costing Breakdown Option 1 – Outlets and Total Establishment Cost

Option	Outlet Description	Cost per metre	Additional Cost*	Total Cost[+]
A	Fixed Jetty Structure	$4500.00	$1,575,000	$6,000,000
B	Buried Pipeline	$790.00	$280,000	$4,700,000
C	Temporary Pipeline[#]	$710.00	$250,000	$4,600,000
D	Multiple Temporary Outlets[^#]	$710.00	$250,000	$7,600,000

[+] Total costs reported to nearest $0.1M.

* Additional costs based on a current distance of 350m from upper beach to active portion of the beach profile.

[#] Allows for procurement of necessary infrastructure and initial deployment.

[^] Assumes only one pipeline, which would be moved between multiple locations.

These preliminary estimates of probable cost have been developed for the purposes of comparing options and may be used for evaluation of options. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. A more detailed functional design is recommended to provide more accurate costs estimates prior to the development of Option 1.

7.1.2 Adverse Impacts, Risk/uncertainties and Mitigation/management Measures

7.1.2.1 Adverse Impacts on Kirra Reef, Kirra surf quality and the beach width at Kirra

Of particular concern to the project are the potential affects of each placement scenario on the Kirra area. One of the key drivers behind the need to investigate additional placement areas is the need to restore and maintain the recreational and ecological benefits of Kirra Point and Kirra Reef.

All of the scenarios developed around Option 1 could potentially impact on Kirra Reef, Kirra surf quality and the beach width at Kirra. Based on a review of the available information, past research and understanding of the subject site, the potential impacts of the Option 1 scenarios are outlined below:

- If the occurrence of storms is lower than the predicted average or if the use of the outlet is not carefully managed, then the outlet could contribute to the existing build up of sand thus impacting on surfing quality, general beach amenity and aesthetics;
- Over supply of sand could also result in smothering of Kirra Reef with sand, leading to damage of the marine ecology present on the reef thus reducing it's recreational appeal for divers;
- Potential conflicts with commercial fishing operations could arise during construction since the protected shoreline to the west of Kirra point groyne is used as a vessel launching site during the mullet fishing season, which typically starts in April and extends for four months;
- Interruption to recreational use of the beach during construction and times of slurry discharge; and,
- Adverse affects on the aesthetic appeal and visual amenity of Kirra Beach to Bilinga Beach with the addition of a new outlet structure.

7.1.2.2 Risks/Uncertainties

In addition to the risks relating specifically to Kirra (Section 7.1.2.1) and the general risks associated with sand bypass operations identified in the Stage 1 (Acer Wargon Chapman, 1994) and Stage 2 EIS/IAS process (Hyder et al, 1997), the additional risks and uncertainties associated with the extension of pumping operations to North Kirra are described below.

Erosion of exposed beaches

The removal of material from the active beach profile at Letitia Spit and placement at North Kirra would reduce the quantity of sediment transported through the active portion of the beach systems from Duranbah to Kirra. Whilst Kirra would benefit from this approach due to the current build up of sand, beaches such as Duranbah and Snapper Rocks would become more susceptible to erosion.

Given that the beaches of Duranbah and Rainbow Bay (particularly Snapper Rocks) are currently in a depleted state, placing material at North Kirra would contribute to the following:

- further narrowing of beaches and reduction of surfing shoals,
- increased storm erosion hazard, and
- reduced general amenity.

Other Users

Given that the pipeline installation would be need to cross a highly developed area of significant social value between the Boundary St junction and Kirra, it is expected that conflicts with local residents and businesses could arise during construction.

Suitability of Existing Infrastructure

As previously noted, the existing pipeline between the Boundary St junction and Kirra has been designed to accommodate a maximum discharge rate of 70,000 m^3/year for 20 years[2]. Whilst the costing provided in Section 7.1.1.5 allows for this limitation, the suitability and condition of the system as a whole would require more detailed investigation prior to development of this option.

7.1.2.3 Mitigation/Management Issues

The scenarios of Option 1 developed above could all potentially provide improvements to the system however there are a number of risks and uncertainties associated with the adoption of the Option 1 scenarios. These include the following issues which would require development of management strategies to avoid adverse impacts:

- surplus sand accumulation at Kirra and associated effects on beach width, Kirra Reef health as well as surfing and swimming conditions
- potential erosion at more exposed locations between Duranbah and Kirra and associated effects on beach width, surf quality and swimming conditions;
- interfacing with other users of the beach, such as commercial fisheries as well as the wider public during the construction and operational phases; and,
- Additional wear and tear placed on existing infrastructure.

[2] Based on advice provided by Ian Taylor during telephone conversations in September 2010

In order to manage and mitigate these issues, the current TRESBP Environmental Management Plan (EMP) must be expanded to include consideration of any additional sand placement options adopted. Similarly, the existing monitoring and consultation programs should be expanded to provide accurate inputs to the management decision making process relating to the additional areas and issues. In addition to expanded survey and beach profiling activities, this should include increased frequency of routine condition assessments, to ensure TRESBP infrastructure can accommodate the revised pumping requirements.

7.1.3 Environmental Planning Path

7.1.3.1 Compliance with the relevant legislation

This option will involve the construction of a buried pipeline on land under existing roads, pathways, and / or reserves, connecting the new outlet to the existing pipeline infrastructure. In order to deliver the sand to the beach, a structure will be required to be built in the coastal tidal zone, the form of the structure being dependent on the Option chosen.

The statutory approvals required come under the umbrella of the Integrated Development Approvals System (IDAS) with the governing legislation being the Sustainable Planning Act 2009 (SPA) (replacing the Integrated Planning Act 1997). The approvals requirements of other Queensland legislation are called up through Schedules in the SPA. For activities on the coastal zone, the principal pieces of legislation that will apply are the Coastal Protection and Management Act 1995 (Coastal Act), Environmental Protection Act 1994 (EPA), and the Fisheries Act 1994.

For the pipeline on land, approval under the Coastal Act will be required for that part of the pipeline that traverses the coastal management district, being the area of jurisdiction of the Coastal Act, in addition to any planning and/or building works approvals required to be submitted to the Gold Coast City Council.

For that part of the option that involves structures below high water mark (specifically Mean High Water Spring tide level), a prescribed tidal works application will be required with justification of the works and the suitability of the location being assessed against the State Coastal Management Plan (SCMP) and the South East Queensland Regional Coastal Management Plan (SEQRCMP) policies, particularly those relating to coastal processes.

The Assessment Manager for the application will be the Gold Coast City Council and the Concurrence Agencies (with the ability to approve, approve with conditions, or refuse the application) will be the Department of Environment and Resource Management (DERM) for matters related to coastal management and the environment, the Department of Employment Economic Development and Innovation (DEEDI) for matters related to fisheries and marine plants, and Maritime Safety Queensland (MSQ) for matters related to marine safety.

An important issue that will need to be resolved is to determine who will be the owner of the approval. The owner must be a legal entity and is responsible for the construction and maintenance of the works. In this instance the owner could be the joint proponents of the Tweed River Entrance Sand Bypassing Project (TRESBP), being the NSW Minister for Lands and the State of Queensland represented by DERM, or the Gold Coast City Council, or the Queensland Government represented by DERM.

Other issues that will arise in the submission of a development application relate to permission from the landowner to make the application (Resource Entitlement if the land is State land), allocation of quarry material if material is to be removed from below high water mark, and approval to conduct the

environmentally relevant activity for dredging if more than 1000 tons of material is to be removed as part of the construction. The first two of these need to be obtained prior to the submission of the development application under the SPA.

Depending on the location of the additional outlet and the proposed discharge quantities, compliance with the current Deed of Agreement may also require consideration. The project agreement for the sand bypassing system provides for sand delivery to Kirra Point or its vicinity. Consideration is required whether a new North Kirra outlet located 1.2 to 2.4 kilometres to the north of Kirra Point complies with the current Deed of Agreement. If the quantity of sand stays within the 'Kirra Contract Quantity' as specified within Section 12.2.7 (d) of the Deed of Agreement then pumping under Option 1 may be considered to be in accordance with the specified sand quantity provisions for delivery under the current Deed of Agreement. However, the delivery of larger quantities would be outside the current provisions and would likely require legislative changes.

7.1.3.2 Required planning approvals and the time needed to obtain these approvals

It is anticipated that it would take at least 12 weeks to prepare the technical design details for the relevant approvals and at least a further 12 weeks for completion of associated environmental assessment studies. Securing the appropriate statutory approvals could then be expected to take between 26 to 39 weeks because there is likely to be significant impact on visual amenity and beach usage which is likely to complicate the approval process. This would depend on the time taken to respond to RFI's and not allowing for mutually agreeable extensions of time and the community consultation process.

7.2 OPTION 2 – Additional Dredge Placement Areas

The following sections outline the assessment of Option 2 which comprises development of additional near shore placement areas along the southern gold coast beaches.

7.2.1 Viability, Effectiveness and Cost/Benefit

7.2.1.1 Potential improvement to the longer term operation of the system

- Greater flexibility through provision of additional placement locations during times when it may be undesirable to introduce additional sand directly to the southern Gold Coast beaches.
- Additional placement areas would afford greater flexibility when selecting the areas of the southern Gold Coast beaches requiring nourishment. Currently the TRESBP system is unable to directly target these areas, which are not easily reached by the existing TRESBP outlets and existing dredge deposition boxes.
- Potential to improve surfing conditions through careful consideration of the effects of material deposition on wave propagation through the southern Gold Coast beaches.

7.2.1.2 Benefits compared to the current benchmark outcomes

In addition to the improvements to the operational flexibility of the TRESBP system listed above, the sand placement scenarios associated with Option 2 would directly benefit selected areas of the southern Gold Coast beaches as described below.

Subject to the risks discussed below in Section 7.2.2, the scenarios associated with Option 2 could benefit the stretches of beach between Greenmount and North Kirra by reducing the migration of sand

into the area and promoting the ongoing dispersion of the existing sand build up within the area, particularly at Central Kirra and North Kirra. As the prevailing wind, waves and currents disperse the accumulated sand, the following benefits could be expected:

- beach narrowing;
- reef enlargement; and
- improved surfing and swimming conditions.

However, the sand build up is likely to have substantially dispersed at Kirra during the lead time required to secure approvals and project agreements and realise an impact on the sand drift passing through Kirra. The provision of Bilinga to Tugun nearshore areas for future dredge placement would promote dispersal of possible sand build up further to the north over coming years, particularly at North Kirra.

As noted in Section 2.2, the beaches of Bilinga and Tugun have remained in a depleted state since the extension of the Tweed River entrance training walls in the early 1960s. These beaches are expected to benefit greatly from Sand Placement Scenario 2A, which is expected to result in a uniform seaward movement of the current shoreline position, as the placed material is gradually reworked onshore. It should be noted that as the existing build up of sand at Central / North Kirra continues to move northwards, the beaches of Bilinga and Tugun will naturally receive similar benefits to those provided by Option 2A.

7.2.1.3 Consistency with or promotion of the achievement of project objectives

Additional placement areas will allow direct deposition of dredged sand within nearshore areas of the southern Gold Coast beaches requiring nourishment.

Under Option 2A, the placement of dredged material from the Tweed River entrance in newly defined nearshore sand placement areas in the Bilinga to Tugun area would result in a reduced volume of sand moving through the beaches of Rainbow Bay to Kirra. However, it could take some years for the depleted supply condition to impact on the sand build up at Kirra, during which time, the less than natural supply would deplete the beaches and surfing banks from Rainbow Bay to Coolangatta.

While the approval of additional dredge placement areas would improve the flexibility of the sand delivery system, the placement of dredged material in these areas would only be appropriate during periods of excess sand supply to the southern Gold Coast beaches. It is unlikely to be implemented on a routine basis as it does not promote the objectives of the project that aim at ensuring sustainable and ‘natural’ beach amenity by requiring full natural sand supply to all southern Gold Coast beaches.

Under Option 2B, sand that is placed in extended deep water placement areas offshore of Point Danger to Coolangatta can be considered to remain within the “active sediment system” and will over time move onshore. Such sand is primarily mobilised in higher swell conditions and will otherwise remain undisturbed as an outer nearshore sand reserve. The purpose of such placement is to delay the onshore movement of the placed sand if deemed operationally advantageous to do so. It has the benefit in combination with existing nearshore placement areas of providing some ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading over time to better match natural sand supply conditions.

An extension of deep water sand placement areas would provide the TRESBS with additional placement flexibility and would be more consistent with the project objective of delivering sand consistent with natural supply conditions if managed carefully, in contrast to the other options.

Under the present arrangement, dredging of the Tweed River entrance is potentially limited during periods of sand excess by the capacity of the southern Gold Coast beaches to accommodate the dredged sand. The ability to place dredged material beyond the active portion of the beach profile would reduce this potential restriction by providing additional deposition areas, thereby promoting the project objective to maintain a navigable water depth in the approach to and within the entrance channel to the Tweed River.

7.2.1.4 Expected timeframes required to achieve the development, installation and benefit (including an allowance for the potential lag in the response of the natural system)

It is unlikely that the required environmental and planning approvals could be secured prior to the commencement of the next dredging campaign of the Tweed River entrance which is anticipated to be sometime during 2011. Consequently material placement in additional near shore placement areas along the southern gold coast beaches could not be undertaken until commencement of the dredging campaign following the 2011 campaign, which is expected to be required sometime in 2012/13.

The dredging and disposal campaigns associated with Option 2 are expected to require longer timeframes than previous years due to the increased time spent sailing between the dredge and deposition sites. Although the increase associated with deposition immediately adjacent to the existing dredge deposition boxes would be negligible, Scenario 2A is expected to require an additional 2 to 3 weeks to complete.

The beach responses to Scenarios 2A and 2B would be expected to occur in the months and years following the 2012/13 campaign respectively, depending upon the wave climate and the sand placement scenarios adopted. It is anticipated that the effects of placement of dredged material adjacent to Bilinga and Tugun (Option 2A) on the shoreline position of these beaches would start to become recognisable within 6 to 12 months of completion of placement activities. It is expected that impacts associated with Option 2B would take significantly longer to be realised.

7.2.1.5 Breakdown of costing (development, construction, operation and maintenance)

The fees associated with the preparation of documentation and approvals are estimated to be in the order of $100,000. This does not include any offset costs that may be imposed under the Fisheries Act.

There are no additional construction or maintenance costs associated with the Option 2 sand placement scenarios.

Due to the relatively small capacity of the *Port Frederick* and the high number of dredge/deposition cycles per week, the operational costs associated with each of the Option 2 placement scenarios will be largely controlled by the distance between the dredge and deposition areas. Since the proposed deeper areas associated with Scenario 2B are immediately adjacent to the existing deposition boxes, the difference in operational costs is expected to be relatively low and an allowance of $100,000 is noted for additional operational costs per dredge campaign. However the disposal areas proposed under Scenario 2A are located significantly further north than those utilised in previous dredge campaigns. Consequently, the operational cost required to place material in the areas adjacent to Bilinga and Tugun would be significantly higher than that associated with placement in the existing deposition boxes.

These additional costs relative to placement by the *Port Frederick* within the existing deposition boxes adjacent to Snapper Rocks have been developed in consultation with a specialist dredging advisor, and based on extrapolation of recent similar projects and recent discussions with a dredging contractor

experienced in TRESBP dredging operations. These estimates of probable costs have been summarised in Table 13.

Table 13 – Costing Breakdown Relating to Option 2A – Additional Placement Areas

Placement Area	Additional Cost per cubic metre	Total additional cost*
Bilinga	$5.26	$1,050,000
Tugun	$7.54	$1,500,000

* Total dredging costs based on removal and deposition of 200,000 m^3.

These preliminary estimates of probable cost have been developed for the purposes of comparing options and may be used for evaluation of options. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD.

7.2.2 Adverse Impacts, Risk/uncertainties and Mitigation/management Measures

7.2.2.1 Adverse Impacts on Kirra Reef, Kirra surf quality and the beach width at Kirra

Of particular concern to the project are the potential effects of each placement scenario on the Kirra area. One of the key drivers behind the need to investigate additional placement areas is the need to restore and maintain the recreational and ecological benefits of Kirra Point and Kirra Reef.

The scenarios associated with Option 2 are expected to benefit the Kirra area by reducing the migration of sand into the area and promoting the ongoing dissipation of the existing sand build up within the area. Adverse impacts on the Kirra area that may result from the implementation of the scenarios associated with Option 2 are discussed below.

7.2.2.2 Risks/Uncertainties

Further to the issues identified in the Stage 1 (Acer Wargon Chapman, 1994) and Stage 2 EIS/IAS process (Hyder et al, 1997), the additional risks and uncertainties associated with the development of additional placement areas are described below.

Erosion of exposed beaches

The removal of material from the Tweed River Entrance and placement either downdrift or offshore from the southern Gold Coast beaches, as is proposed by Scenarios 2A and 2B respectively, would reduce the quantity of sediment transported through the active portion of the beach systems from Duranbah to North Kirra. As noted in Section 7.2.1 beaches such as Kirra, which have experienced a build-up of excess sand in recent years, would benefit from this approach, while beaches such as Duranbah and Snapper Rocks would become more susceptible to erosion.

Historically the material removed from the Tweed River entrance has been deposited in nearshore deposition boxes from Duranbah to Coolangatta. Regular survey data was collected and used to determine the most appropriate deposition box at the time of dredging. This approach ensured that the deposited material did not accumulate in any one deposition box and allowed eroded areas to be targeted during deposition activities.

Given that the beaches of Duranbah and Rainbow Bay (particularly Snapper Rocks) are currently in a depleted state, placing material outside the existing deposition boxes would increase the susceptibility of these beaches to erosion

A similar situation occurred in May 2009 when Snapper Rocks and Duranbah Beach were severely depleted during a storm event following the placement of dredged material in deepwater storage reserves offshore from Duranbah. The material removed during the 2008 dredging campaign could have been placed in nearshore reserves adjacent to Point Danger to increase the storm buffer and limit erosion of the nearby beaches.

Prior to placement of material in additional placement areas, consideration should be given to the current state of the southern Gold Coast beaches with respect to both surplus sand accumulation at sheltered beaches and erosion potential at more exposed locations

Impacts of changes to wave propagation

While the placement of material in water depths greater than 7 m is not expected to cause shoaling of waves under normal conditions, previous investigations have shown that the placement of material in nearshore areas, as proposed by Scenarios 2A and 2B, has influenced the propagation of waves within the study area. As noted in Section 6.2.2, this could cause focusing of wave energy into some areas of the southern Gold Coast beaches leading to increased sediment transport and potential erosion, while other areas may experience a decrease in wave energy and sediment transport leading to accumulation of excess sand volumes.

Similarly, changes to wave propagation could also result in the reshaping of nearshore sand bars, which play a pivotal role in determining surfing and swimming conditions on the southern Gold Coast beaches. Previous placement campaigns, particularly those completed using larger dredges such as the Pearl River, have resulted in an uneven seabed in the area of deposition which resulted in reports of adverse surfing conditions (DYSON et al., 2001). It noted that there is a substantial outer nearshore area in water depths of -12 to -20m AHD seawards of the existing placement areas to spread the dredged sand as a relatively thin layer (up to approximately 0.3m thick). It is unlikely that placement in this manner would have a significant impact on wave propagation in these water depths if spread uniformly and implemented on an infrequent basis.

Other Users

Potential conflicts with commercial fishing operations could arise during deposition activities since both activities are undertaken within the study area. The protected shoreline to the west of Kirra point groyne is used as a vessel launching site during the mullet fishing season, which typically starts in April and extends for four months. The increased distance between the dredge and deposition sites would lead to longer cycle times between dredging and disposal activities, which would increase the total duration of the dredging campaign. This increases the potential for conflict with commercial and recreational users of the Tweed River entrance

7.2.2.3 Mitigation/Management Issues

The increase in the number of potential placement areas offers improved flexibility, however it is accompanied by increased management requirements. As discussed above, there are a number of risks and uncertainties associated with the adoption of the Option 2 scenarios. These include the following issues which would require development of management strategies to avoid adverse impacts:

- surplus sand accumulation at sheltered beaches and potential erosion at more exposed locations;
- managing placement quantity and location to maintain sand supply conditions to Queensland beaches;
- the effects of material deposition on wave propagation and in particular the associated impacts on surfing and swimming conditions;
- dredge size and placement capabilities;
- interfacing with other users of the dredging and deposition areas, such as commercial fisheries; and,
- increased risk of encountering cetaceans while depositing material in deeper waters.

In order to manage and mitigate these interrelated and potentially conflicting issues, the current TRESBP Environmental Management Plan (EMP) must be expanded to include consideration of any additional sand placement options adopted. Similarly, the existing monitoring and consultation programs should be expanded to provide accurate inputs to the management decision making process relating to the additional areas and issues.

7.2.3 Environmental Planning Path for Option 2 – Additional Placement Areas

7.2.3.1 Compliance with the relevant legislation

This option will involve the placement of dredge material dredged from the Tweed River entrance channel into nearshore areas offshore of Bilinga and Tugun and in deepwater areas between Point Danger and Coolangatta. The areas being considered are seaward of the areas covered by existing approvals and the existing approvals cannot be amended to include the new areas as the existing approvals were granted under now repealed legislation.

Depending on the location of the additional nearshore placement areas, compliance with the current Deed of Agreement may also require consideration. The use of Bilinga to Tugun nearshore placement areas is outside the project scope as defined within legislation and changes to the interstate Deed of Agreement is expected to be required for the use of these areas. The use of extended reserve areas offshore of existing placement areas lies within the general project area specified in legislation and the use of these areas for placement would comply with the current Deed of Agreement.

The applicable legislation is as discussed previously and the application required is for disposal of dredge material in tidal water under the Coastal Act with DERM as the Assessment Manager for the application, and DEEDI as a Concurrence Agency for fisheries and marine plants matters. Compliance with the National Guidelines for Ocean Disposal will also be required and the application will need to be justified against the relevant policies of the SCMP and the SEQRCMP, particularly those dealing with coastal processes.

An important issue that will need to be resolved is to determine who will be the owner of the approval. The owner must be a legal entity and is responsible for the construction of the works covered by the approval. In this instance the owner could be the joint proponents of the Tweed River Entrance Sand Bypassing Project (TRESBP), being the NSW Minister for Lands and the State of Queensland represented by DERM, or the Gold Coast City Council, or the Queensland Government represented by DERM.

The total fees for the above approvals will be approximately $10,000. This does not include any offset costs that may be imposed under the Fisheries Act.

7.2.3.2 Required planning approvals and the time needed to obtain these approvals

It is anticipated that it would take at least 12 weeks to prepare the technical design details for the relevant approvals and at least a further 12 weeks for completion of associated environmental assessment studies. Securing the appropriate statutory approvals could then be expected to take between 16 to 26 weeks depending on the time taken to respond to RFI's and not allowing for mutually agreeable extensions of time.

7.3 OPTION 3 – Kingscliff Sand Delivery

7.3.1 Viability, Effectiveness and Cost/Benefit

7.3.1.1 Potential improvement to the longer term operation of the system

The Kingscliff sand delivery is proposed as a 'once only' opportunity to potentially reduce sand inflow into Coolangatta Bay when it may be undesirable to introduce additional sand, whilst assisting Tweed Shire Council with nourishment works at Kingscliff Beach. This option would not provide a significant direct benefit for the longer term operation of the system.

7.3.1.2 Benefits compared to the current benchmark outcomes

As mentioned previously the level of benefit will depend on the amount of sand taken that would, under normal circumstances, be transported to the southern Gold Coast beaches. As noted above, some of the sand to be transported to Kingscliff may need to be dredged from deeper areas due to the difficulties in getting the larger dredge into the shallower areas and the proximity of the training walls and the bypass jetty.

Feasible methods of placing sand at Kingscliff Beach are likely to involve a large floating dredge with more than three times the sand holding capacity of the dredge used routinely in Tweed River entrance dredging campaigns.

The requirement for a large dredge to achieve sand placement onto Kingscliff Beach means that such a dredge may not be able to dredge sand from the shallower waters of the Tweed entrance bar. Sand that is not captured by the jetty will build up in the entrance and impact on navigation conditions in waters shallower than about 5m in depth at lowest tide. Because of the limitations arising from the greater draft requirement and greater safety distance requirement (from mobile shallow shoals and rock training walls), required by the larger vessel, it is possible that sand could only be dredged from further offshore for this option. Such a dredging campaign may not avoid the need for separate entrance maintenance dredging by smaller plant and associated Gold Coast nourishment. Assuming this is the case, it would be necessary to source sand from the deeper parts of the Tweed entrance, which would be likely to have only a minor indirect influence on the natural sand drift to Queensland and no significant direct benefit for the sand build up issues at Kirra or southern Gold Coast beaches.

If however a larger hopper dredge was able to access and dredge the shallower parts of the Tweed entrance, the impacts on the southern Gold Coast beaches would be more pronounced. The benefits to the stretches of beach between Greenmount and North Kirra would be the same as those related to Option 2A for each of the scenarios considered in Option 3. In each case, the longshore sediment

transport reaching Kirra would be reduced as described in Section 6.2.2. The stretches of beach between Greenmount and North Kirra would be expected to experience beach narrowing, reef enlargement and improved surfing and swimming conditions.

7.3.1.3 Consistency with or promotion of the achievement of project objectives

Although the project objectives do not consider the state of Kingscliff Beach, the option to use dredged material from the Tweed River entrance to nourish Kingscliff beach would promote the project objective to maintain a navigable water depth in the approach to and within the entrance channel to the Tweed River. Specifically, the dredging of the Tweed River entrance would no longer depend on the capacity of the southern Gold Coast beaches to accommodate the sand removed from the river entrance during periods of sand excess, as the dredged material could be transported south to Kingscliff Beach.

However, the removal of sand from the Tweed entrance for nourishment works at Kingscliff has the potential to adversely impact on project objectives which include the future supply of sand to Queensland at natural littoral drift rates, depending on the circumstances at the time that the works may be proposed to be carried out.

7.3.1.4 Expected timeframes required to achieve the development, installation and benefit (including an allowance for the potential lag in the response of the natural system)

It is unlikely that the required environmental and planning approvals associated with beach nourishment at Kingscliff could be secured prior to the commencement of the next dredging campaign of the Tweed River entrance which is anticipated to be sometime during 2011. Consequently nourishment of Kingscliff Beach using material removed from the Tweed River entrance could not be undertaken until commencement of the dredging campaign following the 2011 campaign, which is expected to be required sometime in 2012/13. Undertaking these dredging activities as a separate activity outside of TRESBP operations would address this constraint as dredging could be undertaken at any point sufficient material was available and the relevant approvals were in place.

Depending on the size of the TSHD and the preferred method of placement, the dredging campaign would be expected to take around 6 to 8 weeks to remove and place approximately 200,000 m^3 of material, as shown in Table 14.

Table 14 – Duration relating to Option 3 – Kingscliff Sand Delivery

Placement Scenario	Placement Method	Duration (weeks)
3A	Bottom Dumping	6
3B	Rainbowing	7
3C	Pumping Ashore	8

* Durations based on removal and deposition of 200,000 m^3.

The beach responses along the southern Gold Coast beaches would be expected to occur in the months and years following the 2012 campaign depending upon the wave climate during this period.

The beach response at Kingscliff is expected to occur shortly after commencement of deposition activities, depending upon the placement methods selected. In each case the response within the area

of placement would be immediate, with adjacent areas responding in the weeks and months following deposition of the material, depending on their proximity to the primary placement area.

7.3.1.5 Breakdown of costing (development, construction, operation and maintenance)

As discussed in Section 6.3.1, A TSHD with a capacity of around 1,250 m^3 would represent the most economical and practical means of dredging the Tweed River and transport to Kingscliff.

Estimates of the probable costs associated with each of the options for dredging of material from the Tweed River entrance and transport to Kingscliff by a TSHD with a capacity of 1,250 m^3 are provided in Table 15. These estimates have been developed in consultation with a specialist dredging advisor, and are based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience.

As shown below the estimated costs associated with each option vary greatly depending on the placement method. Bottom dumping of material within the nearshore zone (Scenario 3A) is by far the most economical method of placement, since it allows rapid deposition of material without requiring the dredged material to be mixed into a slurry and pumped a second time. Scenarios 3B and 3C both require the use of the dredge pumps to create a slurry and deposit the material. This adds to the operational costs and the overall campaign duration. In addition, Scenario 3C also requires the use of additional pipelines as well as land based plant and equipment to rework the material onshore. As a result Scenario 3C is significantly more expensive than Scenarios 3A and 3B. Consideration should be given to the required placement profile at Kingscliff in light of the placement capabilities and accompanying costs associated with each Placement Scenario.

Table 15 – Costing Breakdown relating to Option 3 – Kingscliff Sand Delivery

Placement Scenario	Placement Method	Mobilisation & Demobilisation	Cost per metre	Total cost*
3A	Bottom Dumping	$750,000	$8.68	$2,500,000
3B	Rainbowing	$750,000	$12.04	$3,200,000
3C	Pumping Ashore	$1,000,000[+]	$20.15	$5,100,000

* Total Costs based on removal and deposition of 200,000 m^3.

[+] Mobilisation and Demobilisation costs include an additional $250,000 for land based plant and pump ashore equipment.

These preliminary estimates of probable cost have been developed for the purposes of comparing options and may be used for evaluation of options. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD.

7.3.2 Adverse Impacts, Risk/uncertainties and Mitigation/management Measures relating to Option 3 – Kingscliff Sand Delivery

Depending on the capabilities of the selected dredge, separate entrance maintenance dredging by smaller dredging plant may also be required in order to maintain the required navigable depth within the entrance channel with associated delivery of the dredged sand to southern Gold Coast beaches. If this

was the case, these operations would provide no direct benefit to the TRESBP and insignificant impact on the southern Gold Coast beaches.

If however a larger hopper dredge was able to dredge the shallower parts of the Tweed entrance to maintain navigable depths in the entrance channel and deliver dredged sand to Kingscliff, the impacts on the southern Gold Coast beaches are discussed further below together with issues relating to Kingscliff Beach.

7.3.2.1 Adverse Impacts on Kirra Reef, Kirra surf quality and the beach width at Kirra

Of particular concern to the project are the potential effects of each placement scenario on the Kirra area. One of the key drivers behind the need to investigate additional placement areas is the need to restore and maintain the recreational and ecological benefits of Kirra Point and Kirra Reef.

As discussed in Section 6.3.2, the scenarios associated with Option 3 are expected to benefit the Kirra area by reducing the migration of sand into the area and promoting the ongoing dissipation of the existing sand build up within the area. No adverse impacts to the Kirra area are expected to occur as a result of the sand placement scenarios associated with Option 3.

7.3.2.2 Risks/Uncertainties

As noted in Section 6.2, TRESBP pumping operations play a greater role in determining the condition of the southern Gold Coast beaches than do dredging and deposition operations. This is due to the larger volume of material placed via the pipeline system. Therefore when considering beach responses to placement of dredged material it is important to consider the sediment transport system as a whole, including proposed discharge operations and the current condition of the beaches within the study area.

Further to the issues associated with the removal of material from the Tweed River entrance, as identified in the Stage 1 (Acer Wargon Chapman, 1994) and Stage 2 EIS/IAS process (Hyder et al, 1997), the additional risks and uncertainties associated with the use of this material for proposed beach nourishment works at Kingscliff are described below.

Erosion of exposed beaches

The removal of material from the Tweed River Entrance and transport to Kingscliff, as is proposed by Scenarios 3A, B and C, would reduce the quantity of sediment transported through the active portion of the beach systems from Duranbah to North Kirra. As noted in Section 7.2.1 beaches such as Kirra, which have experienced a build-up of excess sand in recent years, would benefit from this approach, while beaches such as Duranbah and Snapper Rocks would become more susceptible to erosion.

Given that the beaches of Duranbah and Rainbow Bay (particularly Snapper Rocks) are currently in a depleted state, placing material outside the existing deposition boxes would increase the susceptibility of these beaches to erosion, leading to increased sand delivery requirements from the TRESBP outlets.

As has occurred in the past, placement of sand to the south east of Point Danger to limit erosion of exposed areas such as Snapper Rocks may be at the expense of sheltered areas to the north west which inadvertently receive a potentially deleterious supply of excess sand as a result of downdrift nourishment activities.

Prior to use of dredged material for beach nourishment at Kingscliff, consideration should be given to the current state of the more exposed southern Gold Coast beaches.

Extended duration of dredging and disposal activities

The increased distance between the dredge and deposition sites will lead to longer cycle times between dredging and disposal activities, which will increase the total duration of the dredging campaign. This increases the potential for conflict with commercial and recreational users of the Tweed River entrance and coastline. In addition, the vessels involved are more likely to encounter marine life such as cetaceans due to the increased transport distance and extended duration of dredging and disposal activities.

Availability of suitable dredging equipment

As discussed in Section 6.3.1, it would be economically unfeasible to complete this work using a small TSHD such as the previously utilised *Port Frederick*, which would require a high number of dredge/deposition cycles per week. In addition the *Port Frederick* does not have "rainbowing" capabilities, which would limit the placement of material in shallower nearshore areas.

A TSHD with a capacity of around 1,250 m^3 with "rainbowing", and pump ashore capabilities would provide a more economical and practical solution by reducing the required number of transport cycles between The Tweed River and Kingscliff.

Should a dredge of this nature not be available at the time of dredging, consideration should be given to the following scenarios which may arise:

- Delays in commencement of the nourishment campaign;
- Inability of a larger dredge to meet the operational constraints of the Tweed River entrance;
- Increased duration and cost required to undertake the nourishment campaign using a smaller, less economical dredge; and,
- Difficulties in achieving the required nourishment profile using a dredge without pump ashore and "rainbow" capabilities.

In addition, it is important to note that the requirement for a large dredge to achieve sand placement onto Kingscliff Beach means that such a dredge may not be able to dredge sand from the shallower waters of the Tweed entrance bar. Sand that is not captured by the jetty will build up in the entrance and impact on navigation conditions in waters shallower than about 5m in depth at lowest tide. Because of the limitations arising from the greater draft requirement and greater safety distance requirement (from mobile shallow shoals and rock training walls), required by the larger vessel, it is possible that sand can only be dredged from further offshore for this option.

Such a dredging campaign would not avoid the need for separate entrance maintenance dredging by smaller plant and associated Gold Coast nourishment and will not offer a direct benefit to the TRESBP operation or southern Gold Coast beaches as anticipated. Nevertheless it is physically feasible for sand to be taken from deeper water near the Tweed River entrance to Kingscliff Beach to assist the proposed beach works.

Issues associated with the nourishment of Kingscliff Beach

The majority of these issues and management initiatives have been previously identified in an EIS which was commissioned by TSC in 2008 to investigate the effects of proposed beach foreshore protection works at Kingscliff, including beach nourishment using material dredged from the Tweed River entrance. The EIS report (WP, 2008) provides a detailed description of the coastal processes within the proposed

nourishment location, potential impacts and proposed mitigation strategies. A summary of the issues for consideration is provided below:

- water quality impacts;
- changes to sediment transport pathways and wave propagation;
- disturbance of foreshore fauna and burial of benthic organisms in the nearshore zone;
- increased vehicle traffic associated with land based plant requirements;
- noise impacts associated with pumping operations and land based plant;
- dust and wind blown sand associated with “rainbowing” and land based operations;
- restricted beach access; and,
- disruption of businesses along the foreshore such as the Holiday Park and Bowling Club.

7.3.2.3 Mitigation/Management Issues

As discussed above, there are a number of issues associated with the removal of sand from the southern Gold Coast sediment transport system as is proposed by Option 3. The existing EMP developed during the Stage 1 (Acer Wargon Chapman, 1994) and Stage 2 EIS/IAS process (Hyder et al, 1997) should be expanded to include management initiatives which minimise the adverse impacts listed below:

- potential erosion at more exposed locations such as Duranbah and Snapper Rocks and the associated impacts on surfing and swimming conditions;
- Extended duration of dredging activities and increased interfacing with commercial and recreational users of the Tweed River entrance due to the longer dredge / deposition cycle time;
- Requirement to dredge areas of the Tweed River Entrance Bar which are not required to be dredge regularly, and may not be adequately addressed by the existing monitoring and management plans ; and,
- increased risk of encountering marine life such as cetaceans due to the increased transport distance and extended duration of dredging and disposal activities.

In addition, the issues associated with the nourishment of Kingscliff Beach will also require the development of management initiatives to avoid adverse impacts. A separate EMP should be developed to address these potential impacts in association with an appropriate monitoring program to provide feedback to the management decision making process.

7.3.3 Environmental Planning Path for Option 3 – Kingscliff Sand Delivery

The environmental planning approval ‘pathway’ for Option 3 is complicated somewhat by the numerous relevant legal instruments in force, such as the Tweed River Entrance Sand Bypassing Act 1995 and Coastal Protection Act 1979, and the recently announced proposed changes to the relevant suite of NSW coastal protection legislation, in particular, the State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) under the Environmental Planning and Assessment Act 1979 (EPA Act). However, dependant on the outcome of recent NSW State government initiatives, the approval would most likely remain an environmental impact assessment (EIA) under the EPA Act.

7.3.3.1 Compliance with the relevant legislation

The proposed works associated with Option 3 would potentially include land controlled by Tweed Council and the NSW State Government. Regardless, Division 25 of the ISEPP provides for works defined as "waterway or foreshore management activities" to be undertaken by, or on behalf, of a public authority without development consent. Assuming the works are to be undertaken by, or on behalf of a public authority, Option 3 clearly fits within this definition, in accordance with clause 129 of the ISEPP. Accordingly, environmental planning approval would be sought under the EPA Act (as previously stated) as the Tweed River Entrance Sand Bypassing Act 1995, through clause 10, does not appear to override the EPA Act in regard to approvals for such works.

In addition it is important to consider the implications of the proposed nourishment of Kingscliff Beach with respect to the Concessional Agreement and the Deed of Agreement.

Under the Concessional Agreement, there are no clauses that assign rights to the proposed dredged sand within the Tweed River entrance. The removal of large quantities of sand, such that the Operator could not source required sand quantities, could be considered as a "Supervening Event". However, given the quantities proposed for removal this would seem unlikely. Consequently the Concessional Agreement would not prevent the use of material from the Tweed River entrance for nourishment of Kingscliff Beach as proposed in Option 3.

Similarly, the Deed of Agreement confirms that sand within the Tweed River entrance is not considered as an asset of the Project, nor is it the property of QLD (Refer Clause 20). However, the Deed of Agreement requires that the States should not take actions that are detrimental to the achievement of project objectives which include the future supply of sand at natural littoral drift rates. Removal of sand from the Tweed entrance for nourishment works at Kingscliff has the potential to impact on these objectives depending on the circumstances at the time it is proposed to be carried out. As such the Deed of Agreement would require approval from the QLD Government. In considering the likelihood of approval, it is important to note the "one-off" nature of the dredging, and that material would be placed "updrift" and would thus remain within the wider sediment transport system.

7.3.3.2 Required planning approvals and the time needed to obtain these approvals

The level of detail and length of the process is dependant on the environmental significance of the proposed works. The required environmental impact assessment (EIA) would be conducted under Part 5 of the EPA Act. The EIA could potentially take the form of a Review of Environmental Factors (REF). However, should the potential for significant environmental impact or significant public interest exist, combined with the fact that the proponent of the works would be the State Government, the EIA would then need to be considered as a Major Project under the EPA Act (under Part 5 Order of 2005), and require an Environmental Assessment (EA) to be prepared pursuant to Part 3A of the EPA Act. The determining authority of the above would be the relevant State Minister, or, in light of recent State government initiatives, potentially a Joint Regional Planning Panel.

It is anticipated that it would take a few months to prepare the technical detail for the relevant EIA documentation. However the process, and hence timeframe, associated with a REF versus an EA are considerably different, due largely to public reporting requirements and government processes. The timeframe to gain approval through the Part 3A EA process is likely to take several months more than that of a REF and the total period required to complete technical and environmental assessment studies and the approval process expected to take from 9 to 12 months.

8. Conclusions

It is important to note that each of the three options discussed below were devised during a period when the southern Gold Coast beaches were oversupplied with sand due to the TRESBP start-up operations coinciding with a period of low north-easterly wave energy.

While each of these options would allow the existing sand bypass system to provide more flexible sand delivery, consideration must be given to the long-term benefits to the TRESBP in light of the recent survey results which indicate that the excess sand volumes are dispersing naturally and can be expected to continue to do so.

Based on the current rate of sand loss from Kirra, and the required timeframes for approvals and construction, it is possible that shortly after being put into operation, these options will no longer represent the most appropriate solution to the problem of excess sand build up, and indeed they may no longer be required at all.

As discussed below, the costs and potential negative impacts associated with each option must be considered against the benefits of additional sand placement options, which are primarily focused on reducing sand supply to the southern Gold Coast beaches.

In addition, it is important to note that due to the wide range of potentially conflicting views and interests of the various stakeholder groups, no one option will please all individuals.

Option 1 – North Kirra Outlet

The construction of an additional outlet at North Kirra could potentially reduce sediment transport to Kirra from the south, thereby facilitating the dispersal of excess sand and resulting in improved beach amenity, surfing conditions and reef health. However, consideration must be given to the high construction and operational costs, along with the potentially deleterious effects on physical, social and environmental conditions. A North Kirra outlet would have a direct detrimental impact on the local beach amenity where the sand delivery outlet infrastructure is located. The use of a north Kirra outlet on a routine basis could also seriously starve the southern-most Gold Coast beaches of their requirements for restored sand supply. Consequently, routine use of this option would not provide a long-term enhancement to the system operations in terms of achieving project objectives that seek to restore and continue a natural sand supply to all the southern Gold Coast beaches. In addition, the required approvals process is expected to take at least 12 months, while the construction of the additional pipeline and outlet infrastructure would take a further 12 months. Given the current rate of sand dispersal from Kirra, the need for an additional northern outlet is likely to diminish in the next two to five years, meaning that the benefits of the additional outlet could be limited in the longer term.

Option 2 – Additional Dredge Placement Areas

The placement of dredged material within additional nearshore dredge placement areas would be expected to result in reduced sand volumes being reworked onshore and contributing to the oversupply of sand. In the case of Option 2A, additional dredge placement areas adjacent to Bilinga and Tugun would not only facilitate the dispersal of excess sand but would also offer a more economical method of supplying sand to these beaches than extension of the existing pipeline system.

The establishment of additional dredge sand placement areas for project operations needs to be considered in light of their location and frequency of use. Long-term use of Bilinga to Tugun nearshore placement areas would impact on the coastline from Rainbow Bay to Kirra. Similar to the case of a North Kirra outlet, this section of coastline would be denied natural supply of sand. While the approval of these additional dredge placement areas would improve the flexibility of the sand delivery system, the placement of dredged material in these areas would only be appropriate during periods of excess sand supply to the southern Gold Coast beaches. Consequently, the costs required to progress this option should be weighed up against the limited long term benefits these additional areas would provide.

Addition of deeper nearshore placement reserves seaward of the existing project placement areas would provide worthwhile increases in operational flexibility at relatively low cost and are recommended for consideration.

Option 3 – Kingscliff Sand Delivery

The requirement for the use of a large dredge means that dredging of the entrance bar, which is the usual dredging location, may not be possible and sand could have to be drawn from further offshore. Under such circumstances, supplying sand to Kingscliff Beach from the vicinity of the Tweed River Entrance provides no direct benefit to the TRESBP.

If however a larger dredge was able to access the shallower parts of the Tweed entrance then the Kingscliff sand delivery option would provide an opportunity to prevent dredged material being reworked onto the southern Gold Coast beaches by redirecting this material 10 km south to Kingscliff. As with Option 1 and 2, the benefit of Option 3 to the southern Gold Coast beaches is heavily dependent on these areas receiving an oversupply of sand. Option 3 however, also addresses the long term erosion issues at nearby Kingscliff Beach. The anticipated beach nourishment requirements at Kingscliff (approx. 250,000 to 300,000 m3) would only permit placement of material from one dredging campaign over the next ten years. Consequently, Option 3 would not improve the flexibility of the existing delivery system in the long term.

It should be noted that, given the current rate of sand dispersal from North Kirra, it is possible the TRESBP may only require disposal capacity for one dredging campaign before excess sand volumes disperse.

9. References

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Appendix A

Figures

0 100 200 300 400 500m

SCALE 1:10,000 AT ORIGINAL SIZE

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LAND AND PROPERTY MANAGEMENT AUTHORITY
TRESBP FEASIBILITY STUDY OF SAND PLACEMENT OPTIONS FOR SYSTEM AUGMENTATION

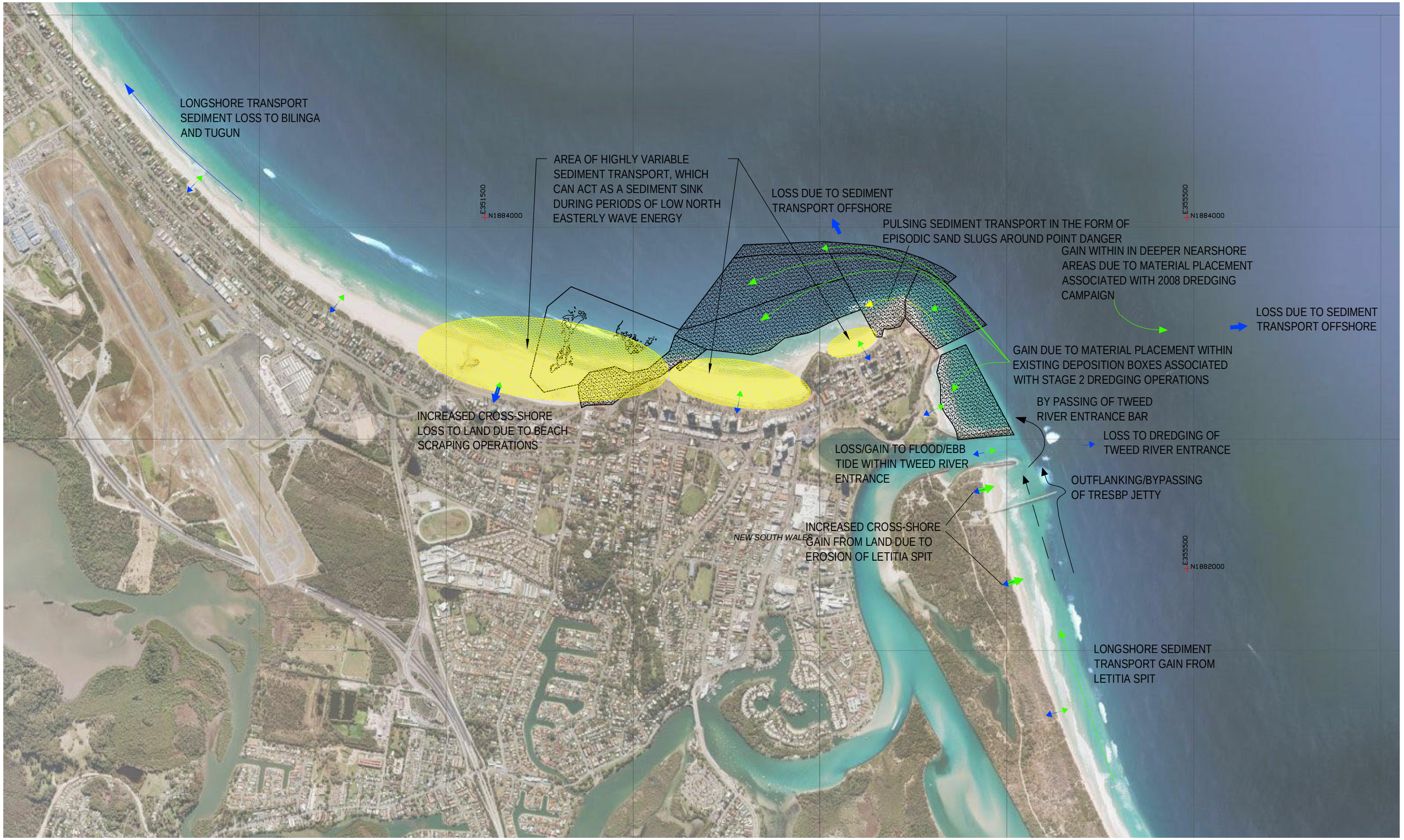
SITE PLAN & BEACH PROFILE LOCATIONS

Job Number 21-19493
Revision A
Date June 2010

Figure 01

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Plot Date: 9 July 2010 - 3:28 PM Plotted by: Peggy Lin/Sydney/GHD/AU Cad File No: G:\21\19493\CADD\Drawings\21-19493-FIG001.dwg



0 200 400 600 800 1000m

SCALE 1:20,000 AT ORIGINAL SIZE

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LAND AND PROPERTY MANAGEMENT AUTHORITY Job Number 21-19493

TRESBP FEASIBILITY STUDY OF SAND PLACEMENT OPTIONS FOR SYSTEM AUGMENTATION Revision A

Date June 2010

UPDATED CONCEPTUAL MODEL OF COASTAL PROCESSES

Figure 02

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Plot Date: 5 July 2010 - 2:41 PM Plotted by: Peggy Lin/Sydney/GHD/AU Cad File No: G:\21\19493\CADD\Drawings\21-19493-FIG002.dwg

LEGEND:

- SCENARIO 1A
- SCENARIO 1B
- SCENARIO 1C
- SCENARIO 1D

0 100 200 300 400 500m

SCALE 1:10,000 AT ORIGINAL SIZE

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LAND AND PROPERTY MANAGEMENT AUTHORITY
TRESBP FEASIBILITY STUDY OF SAND PLACEMENT OPTIONS FOR SYSTEM AUGMENTATION

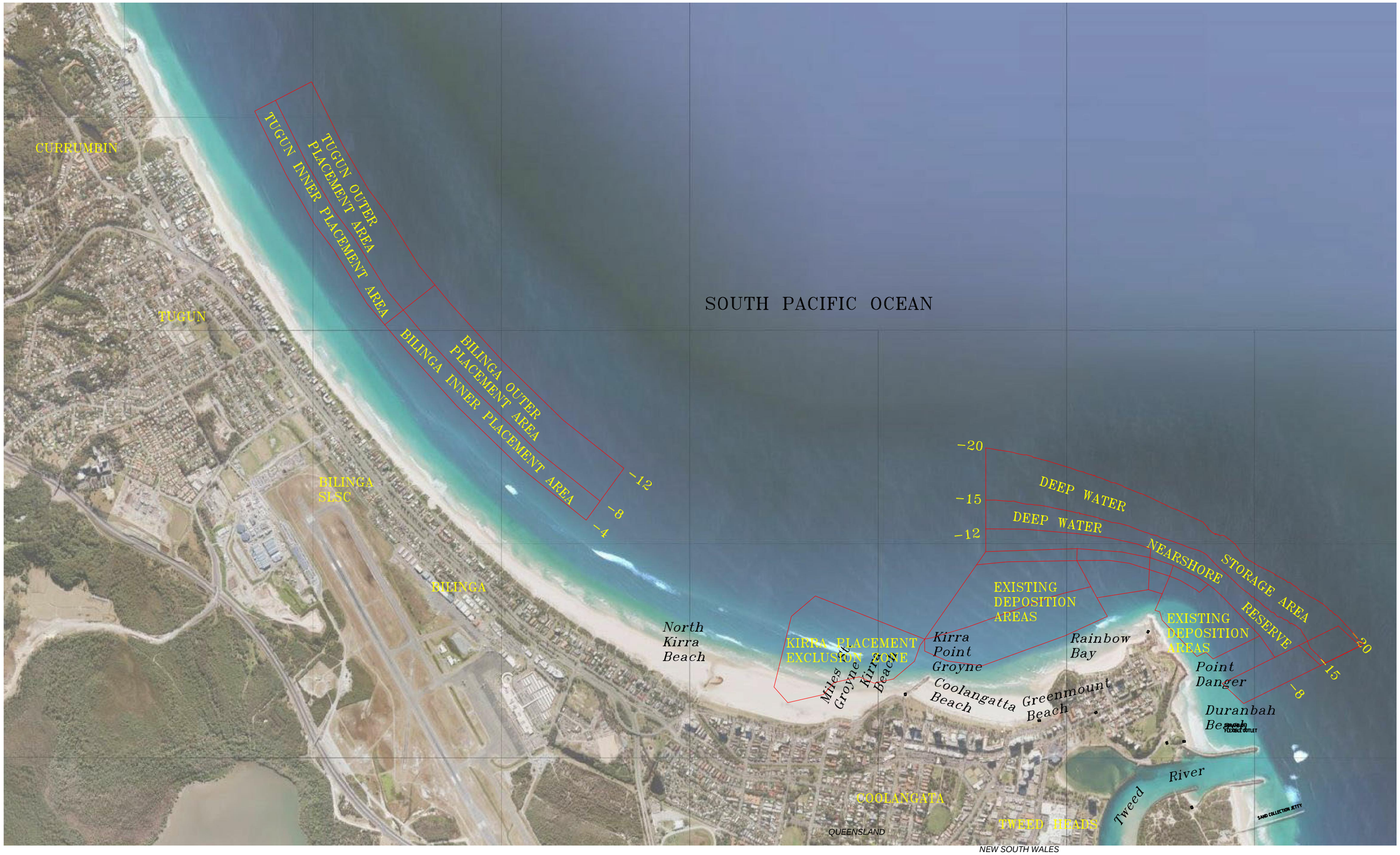
PROPOSED EXTENSION TO SAND DELIVERY PIPELINE - OPTION 1

Job Number 21-19493
Revision A
Date June 2010

Figure 03

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Plot Date: 5 July 2010 - 5:37 PM Plotted by: Peggy Lin/Sydney/GHD/AU Cad File No: G:\21\19493\CADD\Drawings\21-19493-FIG003.dwg



0 200 400 600 800 1000m

SCALE 1:20,000 AT ORIGINAL SIZE

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LAND AND PROPERTY MANAGEMENT AUTHORITY Job Number 21-19493
TRESBP FEASIBILITY STUDY OF SAND PLACEMENT OPTIONS FOR SYSTEM AUGMENTATION Revision A
Date June 2010

PROPOSED ADDITIONAL DREDGE PLACEMENT AREA - OPTION 2

Figure 04

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0 500 1000 1500 2000 2500m

SCALE 1:50,000 AT ORIGINAL SIZE

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TRESBP FEASIBILITY STUDY OF SAND PLACEMENT OPTIONS FOR SYSTEM AUGMENTATION
KINGSCLIFF SAND DELIVERY OPTION 3

Job Number 21-19493
Revision A
Date July 2010

Figure 05

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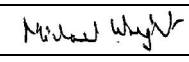
1	C Dengate	P O'Keeffe		M Wright		02/2011