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BRIBIE ISLAND EROSION AND BREAKTHROUGH

Independent expert review pursuant to the Terms of Reference

PART 4 – FINAL REPORT

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We acknowledge the Traditional Owners and custodians throughout Australia and recognise their continuing connection to land, waters, and community. We pay our respect to them and their cultures and to Elders past and present.

ACKNOWLEDGEMENT OF COUNTRY

PREFACE

Part 4 is the Final report of the independent Review regarding Bribie Island Erosion and Breakthrough, undertaken pursuant to Terms of Reference (**ToR**) issued by the Queensland Government (**Appendix A**).

Prior reports produced under this review, along with this final report, are characterised below:

1. Desktop Review – '***where have we been; what do we know?***'
2. Immediate Recommendations – '***what are the critical issues, and urgent mitigation actions?***'
3. Long Term Recommendations – '***how could the resilience of the coastal system be enhanced?***'
4. Final report – '***what are the key systems – natural and human – governing forward success?***

Part 4 deals with three key issues –

- Sand movement
- Policy frameworks; and
- Administrative arrangements

Sand movement was partially addressed in Part 1, notably reviewing historical investigations regarding coastal processes, both specific to northern Bribie Island and those more regionally focused. Part 4 recaps that advice and expands the discussion, including regarding dredging and shipping channel operations in Moreton Bay, as required by the ToR. Part 1 also considered estuarine processes within Pumicestone Passage, but the historical literature regarding sand movement in the estuary is comparatively sparse. We (the Reviewers) consider this gap seminal and Part 4 attempts to redress that deficiency.

Policy frameworks, including legislative arrangements, are discussed in Part 4 at a conceptual, rather than a prescriptive/detailed level. As noted in Part 1, the Bribie Island erosion and breakthroughs can be characterised as a 'wicked problem'. Erosion, and likely certain breach, has been an acknowledged issue for nearly half a century, and the deliberate policy response has been to allow the matter to progress without intervention. The ToR call for actionable solutions, an implicit intent to alter longstanding historical policy. The path presented in Part 3 calls for enhanced coastal management. This report considers the extent to which that change in orientation aligns or conflicts with existing frameworks, and the changes that may be required to proactively manage this area.

Administrative arrangements are a critical consideration, as foreshadowed in Part 3. There is no clear single entity that possesses the authority or responsibility for progressing the next steps, for doing the detailed planning, including ongoing community engagement, that will be required to action the concepts and recommendations that this collective review provides. Government will determine next steps including any administrative arrangements; however, this report discusses relevant considerations to inform the deliberations that may arise and recommends a possible model.

The Executive Summary and concluding chapter of this report provide a collective summary (Parts 1-4) of the Review process and findings. Overall, our intent has been to assemble a relevant body of knowledge, vet that research with subject matter experts (our technical reviewers from the Queensland Government and Sunshine Coast Council), and share that information and our recommendations with the community as the Review progressed. Part 4 presents a substantial amount of additional information, so it is not simply a summary of Part 1-3; it completes (comprehensive, if not exhaustive) our response to the full scope of the ToR and provides an integrated summary of our advice regarding a path forward towards change.

EXECUTIVE SUMMARY

Why? This is perhaps the earliest question that most of us learn/express. The nature of the answers we receive – simple vs complex, etc. and our satisfaction with the response, whether as individuals we tend to find more questions within answers, exhibit the perpetual curiosity of an inquiring mind, shape and potentially continuously transform our world view.

We have progressed this Review within a particular framework, being our interpretation as independent reviewers of the client brief, as well as our understanding and appreciation of the context for the Review, including the physical environment, governance arrangements, and the equally complex social web – residents, visitors, businesses, and a diverse array of other stakeholders, including the Kabi Kabi people. The assumptions/premises – our *Why?* – applied and tested throughout this review have been:

- Solutions – Actionable in a reasonable time-frame – were expected, including prior to completion
- Complexity – Characterises this 'wicked problem' and that breadth/depth is integral to solutions
- Constraints – Including environmental protections and stakeholders could also be opportunities
- Change – Improvement is possible, through shared vision and integrated management

Time has been a critical element that shaped our approach, including the awareness that it had been more than 3-years since the initial breakthrough and the Queensland Government (**QG**) commitment was to provide the community with a prompt response. In 20-weeks this Review has provided four reports:

Part 1 – Desktop Review

Provides a comprehensive review of relevant literature:

- Commencing with geophysical processes that shaped the landscape and advice that environmental values may have been 'optimal' ~6,000 years ago when sea levels were higher than they are now, there was more rain, but also more vegetation and less catchment erosion and sediment runoff;
- Through to early colonial influences that transformed both terrestrial and marine ecosystems;
- Heightened concern and awareness regarding coastal erosional processes – locally and statewide;
- Comprehensive and consultative investigations, as well as community proposals for solutions;
- Progressive initiatives, leading to protected area declarations, both specific to the project area, and inclusive of the project area and the northern Gold Coast waterways as 'bookends', reflecting their connectedness as part of the larger Moreton Bay estuary; and
- Continuing evolution of management approaches, statewide (e.g. coastal policy), regionally (e.g. sand extraction from the offshore banks) and locally (e.g. planning for climate change adaptation).
- The preface suggested that the long-term erosion and breakthroughs had the characteristics of a 'wicked problem', including lots of reports, but relatively little historical action, absent a consistent policy to not intervene with natural coastal processes.

Part 2 – Recommended Immediate Options

Documents the breakthroughs and issues, discusses options, and recommends immediate actions:

- Breakthrough #1 (BT#1) in January 2022 (TC Seth), BT#2 in March 2025 (TC Alfred), and potential BT#3 (TC Oswald, January 2013 origins) profoundly altered conditions in Pumicestone Passage;
- Including amplified wave energy and increased tide levels (>0.23m MHW), triggering implementation of 2041 actions under Sunshine Coast Council's Coastal Hazard Adaptation Strategy) [162].
- Progressive and continuing issues include: severe erosion; large-scale sand migration; tidal and storm surge inundation and debris deposition; infrastructure issues; dune and vegetation loss and ongoing deterioration; water quality concerns; and navigational access, including for emergency services, compounded by increased hazards, risks and continuously changing and unpredictable conditions.
- Options, including 'do nothing' were discussed, in the context of both short-term needs (urgent) and long-term objectives, with recommendations provided including closure of BT# 2 & 3, as well as other works to address water quality, navigational access, and additional mitigation of foreshore issues, with delivery of that package of works prior to the forthcoming storm season, approximately December 2025.

Part 3 – Long Term Recommendations

Provides a strategic framework of practical options for proactive, enhanced coastal management:

- Part 2 recommendations focused on returning conditions to post-BT#1 (pre-TC Alfred);
- Pre-BT#1 conditions included long-standing concerns around sea-level rise, sediment transport, navigation, and foreshore protection.
- Long term solutions should both stabilise and improve – enhance – that earlier state.
- Re-instating the Island, closing BT#1, and reopening the former Caloundra bar entrance provides the lowest risk, practical and actionable option as it relies on moving towards known (historical) conditions.
- A combination of natural and 'soft' engineering solutions provides the optimal conditions – including proven effectiveness and synergy with environmental and social values – for rapidly progressing remedial works and realising an enhanced coastal environment.
- Ten integrated potential solutions to improve resilience, biodiversity, sediment stability, and water quality, including multipurpose reefs, artificial headlands, buried walls, ecological restoration, channel realignment, and dune buffers, are presented and discussed.
- Part 3 explicitly advises that further planning and design is required and that those potential solutions are conceptual options, some of which may ultimately be deemed unnecessary; and that
- Long term success requires more than engineering; it must be accompanied by a shift towards and commitment to collaborative, integrated and proactive management.

Part 4 – Final Report

Provides supplementary review and recommendations about long term management considerations:

- Sand movement in this area is subject to complex dynamics – natural and human contributions.
- Early investigations provide partial answers and recommend further studies.
- Subsequent decisions relegated local issues to natural causes and promoted non-intervention; and
- Decisions to extract Moreton Bay sand resources did not adequately consider local issues.
- Coastal erosion was accompanied by adjacent erosion of inner Bribie Island; and
- Accretion – Intertidal areas, available as habitat and for tidal conveyance, became land.
- That extension of the tip of Bribie Island (west & north) constrains tidal flows and entrance dynamics.
- Intertidal areas are fundamental to both tidal conveyance and recognised environmental values.
- Ramsar provides a potential guide to enhancement (wise management), rather than a constraint.
- It is clear that the breakthroughs have disrupted natural processes;
- Those disruptions are ongoing, and the effects will be difficult to assess for some time;
- It is unclear whether pre-breakthrough values were better or worse than when protections were declared.
- National Park/Recreation Area and adjoining land that was intertidal should be 'levelled' to reinstate historic tidal processes and entrance dynamics; enhancement, even via 'soft' infrastructure solutions, is incompatible with existing management planning, which favours passive, non-intervention approaches.
- Fisheries Habitat Area provisions are incompatible with proactive management, effectively prohibiting all dredging and nourishment; abandoned oyster leases should be appropriately de-commissioned, on principle (restoration) as well as due to their potential contribution to inner Bribie Island erosion.
- Restoration, including proactive management, is a bold course that presents unavoidable risk and uncertainty, is likely to attract criticism, but could also enhance local values, including collaboration.
- The local circumstances – problem – include an opportunity to pilot initiatives that may provide learnings that can be transferred, within Queensland and potentially internationally.
- This suggested possible future requires new administrative arrangements and that entity will need to transform the concepts this Review presents into a detailed, integrated, collective reality.

Final Report Recommendations

Recommendations arising from Part 4 are presented below at a summary level; each of these recommendations is included in greater detail in Chapter 5, at the conclusion of this report.

1. Retain and continuously improve understanding of this complex system

We are not satisfied that the historical sand extraction approved under the Moreton Bay Sand Extraction Strategy adequately assessed the potential effects on littoral processes, with evidence indicating there was no consideration of the project vicinity. Future decisions regarding extraction, including dredging for the Channel Enhancement Project, should as fully as possible consider these dynamics, including in the case of the North West Channel, provide data and analysis of morphological changes subsequent to previous approved capital dredging, including accounting for maintenance dredging, and how the observed changes relate to changes predicted by studies that supported those approvals.

The State Government should also investigate whether there is a need to resume the proactive investigations regarding coastal matters that were part of the reason for creating the BPA pursuant to the Delft report recommendations.

2. Proactively manage, not just passively protect, the Passage and the Island

This drastic shift is recommended as the recent breakthroughs have dramatically altered the physical environment and certainty regarding the extent to which those alterations are beneficial or otherwise won't be determined in the near term. As a pilot initiative, this project has the potential to contribute learnings well beyond the obvious boundaries. This area deserves a single, coordinated, consultative and comprehensive management plan; other areas may as well.

3. Establish appropriate management arrangements

Current arrangements could be coordinated to support a shift towards proactive management. A partnered approach is recommended as it is consistent with an agile and iterative strategy that prioritises near-term action. Chapter 5 provides high-level detail regarding establishment of a Steering Committee and the initial business that body should consider progressing to move towards the future we suggest, including progressing a strategy, management plan, and works program, through community consultation, as well as investigation, design, and, if desired, options assessment.

4. A forward Works Program should consider Part 3 and Part 4 recommendations

The reports from this Review provide a conceptual framework for moving forward. The approach has reasonable community support, but continuous advice and opportunities for feedback is recommended, and planning should be sufficiently agile to allow for changes in response to views put forward.

Whilst planning is required, our approach and the community sentiment, calls for early action – this can (and should) be progressive, integrate learnings from monitoring the urgent works, including storm season response, and continuously repeat the cycle of Plan → Do → Review in a transparent and consultative manner. Overall, the priority should be to "do something"; start...

Notionally, based on historical entrance configurations, Part 4 supports and expands Part 3, adding –

- An overall north/south dimension of ~1,250 metres is suggested for the entrance, including stabilised sand spits to the north (Deepwater Point) and south (Bribie Island) each ~250m wide.
- Based on the 1967 survey (discussed in this report) an area of ~750m should be available for the entrance to naturally migrate.
- This is a suggested starting place, which can be refined based on further design investigations, observation of natural response, iterative management, and improved understanding, with tolerance and accommodation for natural variations such as weather.
- Dredging/levelling should initially be 'conservative', with 0m AHD, as a rough equivalent of Mean Sea Level, a nominal suggested target – allowing opportunity for tidal flows, etc., to influence the initial configuration.
- If a dredged channel is included, suggest a similar conservative approach – say -1m LAT maximum depth, or potentially shallower, but perhaps wider.
- In general, take a pilot approach, start conservative, and iteratively refine.

5. The Channel Enhancement Project should be, cautiously, viewed as an opportunity

Tidal flows – in and out of Moreton Bay – rather than waves, or disturbances from ships, are probably the dominant influence on sand transport – erosion and accretion – along on the northern Bribie Island foreshore. The North West Channel is both a natural and enhanced (dredged) pathway for tidal flows. An enhanced channel (deeper/wider), such as has been created through historical dredging and is proposed as part of the Channel Enhancement Project, promotes improved conveyance, at least volumetrically, if not in terms of velocities.

The coastal dynamics in this area are complex and understanding is incomplete. An enhanced channel may be the most logical and 'safest' alternative if there is a demonstrated desire to competitively align the port to meet projected international demand. We suggest it is an opportunity, as one of the best ways to improve the potential long-term sustainability of the proposed enhancement of Bribie Island would be to provide a substantial volume of sand for nearshore nourishment.

The Initial Advice Statement for the Channel Enhancement Project indicates that the expected dredging volumes will exceed anticipated demand and requests the ability to sell excess sand overseas. We recommend that priority consideration be given to using that sand for nearshore nourishment of Bribie Island. This will help to mitigate potential impacts, at least in the short term (which may be decades, or even centuries).

Nearshore sand nourishment may result in increased maintenance dredging requirements. We suggest that this would be an acceptable cost, that should be borne as part of the project, and that sand should be returned, perpetually, to the foreshore/nearshore zone. This approach will also allow for monitoring, improved understanding the dynamics of this system, and continual refinement of proactive management.

1 INTRODUCTION

1.1 Process & Purpose

As the final report, a key objective is that it fulfill the remaining parts of the ToR, as detailed in the Preface. Part 1 was primarily a historical review, focused on scientific investigations that led to the establishment of regulatory protections, which are the basis for current management arrangements. As a 'review', our focus has been on identifying existing evidence and extracting and synthesising a relevant body of knowledge.

Parts 2 and 3 also apply an engineering approach to identifying suitable solutions – treatments that are appropriate to address the management of erosion and the impacts resulting from the breakthroughs. ICM was the primary author for those two reports, which were informed by work undertaken in Part 1, as well as contributions from our technical reviewers.

This final report returns to the scientific approach that characterised Part 1, including relevant historical context. It also provides evidence to address (at least partially) matters that we consider important that appear to have been peripheral to the management of this area. That evidence is presented both categorically (e.g. Chapter 2 – Sand Movement) and in a more integrated manner in the context of policy and administrative arrangements. Overall, the intent is to complete the foundation – body of knowledge – that should inform any decisions and forward actions that arise from this Review.

2 SAND MOVEMENT

2.1 Introduction

What are the causes of the progressive erosion of Bribie Island and the subsequent wash overs and breakthroughs? This question is included in the ToR and Part 1 discussed several contributing factors. A simple answer is that 'sand moved'. A more complete answer is that 'sand moved, and the decision was made to do nothing'.

One of the sources discussed in some detail in Part 1 was the 1992 *Integrated Management Strategy* [083, 085]. The Part 1 source list includes a component study on aquaculture [090]. At that time, we were unable to locate other referenced component studies but have subsequently obtained a copy of the component study *Recent coastal changes near the northern end of Bribie Island and possible sedimentation in Pumicestone Passage* [201]. This report clearly substantiates the conscious policy to take no actions in response this known issue, as documented by these excerpts:

- The northern end of Bribie Island consists of a narrow spit which is currently subject to both westerly shoreline erosion and easterly channel erosion.
- The vulnerability of this area has been recognised for many years and several options regarding stabilisation have been proposed.
- The movement of the shoreline on Bribie Island has been monitored by the Beach Protection Authority since 1970 by hydrographic surveys. Analysis of these surveys has shown an average annual westerly recession of the shoreline in this area of about 2 metres, however individual annual erosion and aeration rates have been as high as 50 metres.
- The northern spit of Bribie Island is also vulnerable to erosion by tidal channel changes within Pumicestone Passage. A recent study by consulting engineers Cardno ·& Davies in 1987 found that the easterly erosion at the narrowest point of the spit was almost 2 metres annually, although the average rate was almost zero.
- The entrance at Caloundra Bar and the associated area of northern Pumicestone Passage are also dynamic. In the past sediment has entered the passage to form inter-tidal banks near the entrance which have reduced the tidal efficiency of the entrance and affected the tidal regime in Pumicestone Passage.
- As indicated previously the· northern spit of Bribie Island is extremely vulnerable and under present conditions a breakthrough is expected within 20 years.
- If a breakthrough were to occur then changes could be expected within Pumicestone Passage because of the resulting temporary increase in hydraulic efficiency of the new entrance.
- Secondly, the area to the north of the breakthrough would have no major mechanism for mixing or flushing because of the reduced tidal and wave activity and the water quality in this area would probably decrease. This could potentially be a major problem because of the proximity of a substantial area of residential development.
- Thirdly, the creation of a new entrance would expose the area behind this entrance to increased wave activity and therefore similar erosion problems to those now experienced at Golden Beach could be transferred to this area.
- The problems associated with beach erosion only occur once the shoreline recession or entrance change threatens property and improvements. The problem is not that the beach is eroding but that development has occurred within the zone of natural beach fluctuations.
- At the northern end of Bribie Island, the erosion prone area as designated on plan no. SC3368A (Appendix 1) is the entire width of the spit. The only permanent structure located in this area is a navigation light which has been designed to withstand erosion. Therefore in accordance with the above policy, it is recommended that the area be kept free of further development and be managed in accordance with the Buffer Zone Policy Statement guidelines.

The plan referenced above shows that the erosion prone area is the "width of the spit". Three references are included, one of which was discussed in Part 1 and is further discussed below [084]. The other two references were not located earlier, but copies have now been obtained these reports are also discussed below [212, 234].

2.1.1 Review

The following select extracts from the Part 1 report are relevant to the discussion that follows in Chapter 2:

- David T. Neil in *Moreton Bay and Catchment*, the proceedings of the Moreton Bay and Catchment conference" [104] (Part 1, p.7):
  - Pumicestone Passage geology (large scale bedforms in the deeper parts of the channel) is indicative of an ebb tide delta system, with net sand transport from the ocean/bar, into the passage (in contrast to the net northerly transport of suspended sediment loads within the passage)
- Dredging for navigational access, including most likely parts of the North West channel based on its early identification as the "only permanent approach" to Moreton Bay, commenced prior to the earliest detailed chart we were able to source (1865 with updates to 1897). (p.10 – Suggested messages)
- *Record of Caloundra Passage* compiled by the Caloundra Passage & Boating Development Association c.1964 [025]:
  - Starting from the assumption that the whole area remained in a reasonable state of equilibrium from 1845 until the early 1930's; with a good tidal prism balanced by a self-scouring entrance, which in tum controlled the erosion of King's Beach; then the following might be postulated as the sequence of deterioration.
  - The sand blow-hole, tidal wave and heavy rains of 1931 permitted a temporary break through to occur from the ocean which initiated a silting trend of the Passage Basin.
  - This continued into the early 1940's by which time the tidal prism had been so reduced that Kings Beach then began then began to control the entrance instead of vice versa as heretofore.
  - During dry spells, erosion of sand from Kings Beach would tend to choke the entrance which was then unable to cope with run offs, thus resulting in new break throughs; each time further south.
  - This cycle was repeated many times throughout the 1940's and into the 1950's. Indeed, if sufficiently accurate and detailed information could be obtained it would probably be found that these cycles were in phase with the flood runoffs of the period.
  - The cyclones and very high rainfall of 1954 breached a completely new entrance well to the south through part of Bribie and although it took nearly two years to become established, it set a new pattern to events.
  - By 1958 the remaining sandbanks had become breached from Bribie and the main channel from then on followed the island shoreline, inducing strong erosion all around its tip.
  - By 1961 this erosion was proceeding faster than the growth of the sandspit from the north; with the result that the Entrance successively widened and shoaled, thus further destabilising the balance and reducing its self-scouring characteristics.
  - Additional silting from both the ocean and creeks continued at the same time to reduce the tidal prism, so that the basin approached stagnation point.
  - It is only a matter of time before all flow stops along the north shoreline; then erosion of the neck of Bribie will increase until a cyclone combined with a flood run off will breach it, forming a new entrance ½ mile down the Island.
- Figure 13 (p.20) presented an extract from the 1965 Delft report that was included in correspondence files [025]. That full report has since been obtained and the content from the relevant section is provided below in s.2.1.3. Relevant excerpts are also included below:
  - The longshore sediment transport varies with the seasons; at the inlet the residual transport may be northerly between May and October, and southerly between November and April.
  - This is in concert with the yearly shifting of the entrance;
    - early in the year the entrance is situated just north of the tip of Bribie Island.
    - In April/May a northern channel opens, nearer to Caloundra, after the rough season with more easterly swell.
  - The southern channel shoals and closes between May and October, due to the northerly drift, and between November and April the channel shifts to the south, completing the cycle.

  - Naturally this cycle is not rigid and some years there may be deviations.
  - Due to scour from the western side the tip of Bribie Island may break through about half a mile south of the present entrance.
  - This might not be a bad place, as the tidal currents and the wave attack on Golden Beach would certainly be reduced, but the shore at Hill's Boats, south of Jellicoe Street, would suffer from increased erosion.

- Also from the same correspondence file [025]:
  - Further correspondence includes the Lands Department, with a response from the Department of the Coordinator General (**DCG**) on 03/09/1968 advising that reservation of "Deepwater Point – The Spit" for Park and Recreation purposes is consistent with the purposes of the Beach Protection Authority (**BPA**). (p.21)

- From Volume 3, *Land use investigation* [042] of the 1974 report *Coastal Management Investigation, Queensland - New South Wales border to northern boundary of Noosa Shire* (p.27):
  - Sediment transport north of Cape Moreton is a relatively slow process - in towards Bribie and Caloundra, and partly into Moreton Bay. Ebb or flood channels into the Bay may be picked from the shape of submarine shoals and the origin of the channel could be of significance in locating permanent shipping lanes. A channel eroded by both the ebb and the flood is liable to require less dredging than one which undergoes erosion on one tide and accretion on the other. (p.17)
  - Movement of sands also occurs down Pumicestone Channel from the Caloundra spit, as James, a member of the project team, has noted from aerial photographs taken in the mid-1940's. This feature, combined with discharge of sediments from streams feeding into the Channel, indicates an eventual filling of the channel - or, at least, in terms of human lifetimes - a possible limited life for the channel as a navigation way. No time estimates have been attempted. (p.17)
  - The northern entrance to Pumicestone Channel at Caloundra is very unstable. The vegetated tip of Bribie has eroded 660 m. since 1940. Before 1940 this channel was close to Caloundra but moved southward, and in 1971 breached close to the Bribie shore. Since then a sand spit has extended northward and in February 1974, the Bulcock Beach channel was flushed again close to the Caloundra side. (p.101)

- From *The report Quaternary Geology of the Sunshine Coast* [050] by the Geological Survey of Queensland, 1976 (**GSQ**) (p.28):
  - The Sunshine Coast beaches seem to represent a closed sand system. Losses into the foredune system and tidal deltas, and by longshore transport, have to be met by erosion into Pleistocene sand deposits. Replenishment of beach sand by net northerly longshore transport, a factor important on the Gold Coast, appears to be minimal on the Sunshine Coast. (p.1)
  - The South Passage tidal delta between North Stradbroke and Moreton Islands and the North Entrance tidal delta between Moreton and Bribie Islands… act as sand traps. Thus little sand bypasses the northern entrance of Moreton Bay. Underwater bedrock outcrops around Caloundra reach into fairly deep water, and these no doubt restrict the northward littoral drift of sand. Bribie Island acted as an effective sand trap during the Pleistocene. Net sand movement seems to have been southwards from Caloundra. Reserves of' sand suitable for beach replenishment occur onshore, in tidal deltas, and on inner parts of' the continental shelf. (p.2)
  - Present sand movement was studied on the Brisbane CAB 365 and Gympie CAB 7043 aerial photographs at 1~84 000 scale, The lee fronts of the underwater dune systems ("hydro-barchans") are directed northwards in the Hamilton Patches area, and in a limited area of the northwest channel between channel markers NW2 and NW4. Most other dune front show a southward direction, that is towards Moreton Bay. The order of magnitude of sand movement above -12 m (-15 m M.S L.) may be estimated from maintenance dredging in Northwest and Spitfire Channels. Redredging was necessary 8 years after establishment dredging. In 1972-73, 550 000 m3 were dredged. Considering an overdredging factor of 30 per cent, sand movement into the channel of 50 000 m3 per year is indicated (Frowd, pers. comm.). (p.8)
  - The Delft Report (1970) and similar studies indicate that the sediment interchange between the beach and the offshore area is active down to a zone of 20 to 30m depth. The sand reserves within this zone should not be dredged. The area between 30 and 60m depth could become feasible for suction dredging. This zone begins between 1 and 2 km offshore and extends for 2 to 4 km." (p.19)

- Regarding the 1978 *Northern Entrance to the Moreton Bay* [054] by A.W. Stephens (pp.28-30):
  - Stephens attributes the bypass phenomenon discussed above as responsible for the formation of the complex banks, or submarine sand platform, which he describes as extending from Comboyuro Point (Moreton Island) to Caloundra Head and labels as the 'outer or seaward tidal delta'. The included figure shows the North West Channel as the westward boundary of this imaginary line.
  - Moreton Island acts like typical south-facing rocky headland in an area with net northerly littoral drift, however, the expected pattern is disrupted at the outer end of the North Channel. He attributes offshore reef systems as contributing to the disruption and discusses three possible causes for the atypical sand curvature. He also discusses the Hamiton Patches and suggests that transport is to the north, but the actual mode of transport is not yet known.
  - Stephens discusses various components of the banks, generally noting complexities and uncertainties. He includes advice that the Spitfire Channel was dredged in 1965, with increased sand transport indicated following the dredging, but uncertainty regarding whether it was causal. In summary, he notes that preliminary measurements at this site contradict the overall hypothesis for ebb and flood channel transport (for 1966-1971). His overall summary at the end of the paper is that "Serial hydrographic surveys have shown that the accepted, generalised hypotheses (Robinson 1960) of ebb and flood channel dynamics are too simple (Langhorne 1973), especially with regard to predictions for short term movements."
- From the 1974 *Pumicestone Passage Water Quality and Land Use Study* [060-063] (pp.30-31):
  - The Caloundra bar, as well as the Skids, were identified as having a throttling effect that significantly influenced water quality.
  - The Passage is subject to a significant nett northerly tidal flow which, although small in comparison to daily tidal flow, is substantial when compared with fresh water inflows.
  - That nett flow was reported as being important to maintaining water quality, distinguishing the Passage from river estuaries. Overall, the Passage was reported as being well flushed, with "little variation during dry weather with marked short-term perturbations during and after storm-water inflows".
  - The report includes a note about some dredging having occurred in the Passage at Caloundra, the southern end, and through the central reaches. It cautions about excessive dredging, as well as destruction of mangroves, with respect to habitat/resource quality impacts, rather than water quality per se.
  - It notes that the northern shoals of the estuary are a major spawning area and that destruction of these shoals could have profound impacts both locally and more widely within the Moreton Bay and cautions against construction of a dredged entrance, bar stabilisation, or disturbance of the mobile shoals of the inner bar zone. It identifies that "The greatest concern to fisheries' interests is any development which might result in a significant increase in tidal volume causing changes to the tidal regime and estuarine conformation."
  - Construction of a dredged entrance and bar stabilization by sea walls when combined with disturbance of the mobile shoals of the inner bar zone, would constitute a major threat to the bream fisheries. (Volume 3, p.12)
  - In considering changes in nett tidal flow and velocity resulting from a dredged channel in the vicinity of Roy's, a design width of 30 m and channel depth of 2 m was incorporated in the hydrodynamic model. The channel designated on the basis of habitat disturbance was defined as a maximum width of 20 m and a depth not exceeding 1.5 m. The channel incorporated in the modelling was thus approximately twice the cross-sectional area of that deemed the maximum for habitat disturbance. The position was reviewed in terms of fisheries constraints and the conclusion is reiterated that a channel should be of not greater dimensions than 20 m x 1.5 m. It is considered that provision of a larger channel would be of danger to habitat maintenance and unduly interfere with the use-pattern of this section of the proposed marine reserve complex in the Passage. (p.18)
- From *Dredgeability of the North East Channel, Moreton Bay* [064]
  - The study notes that the ebb-delta includes two sectors.
  - The northwestern sector is of simple form, with shoals of 3-7m depth that are exposed to ocean swells and partially protects the tidally dominated North West Channel.

  - The northeastern sector, which includes the North East Channel, has a more complex morphology of ebb and flood channels, with significant wave energy present despite partially sheltering by Moreton Island and nearby reefs. The North East channel area is described as showing signs of both wave and tidal influence, suggesting that the area is highly dynamic.

- Regarding the *Integrated Management Strategy* (**IMS**) *for Pumicestone Passage, its catchment and Bribie Island* (1992-1993) a number of documents were discussed, with a note that the component studies on coastal processes were referenced, but could not be located. We have since located one of those two studies, as noted in the preface. This excerpt indicates the nature of the second study (p.37):
  - …the review of coastal processes was conducted in two parts. The first part involved an assessment of existing data to gain a qualitative impression of the coastal processes and possible future movements of northern Bribie Island and the extent, if any, of sedimentation in the central part of the Passage. The second part was a quantitative assessment of a number of factors highlighted during the first part of the study.
- Regarding the *Quaternary Evolution of the Woorim – Point Cartwright Coastline* by M.R. Jones, we noted that it provided the earliest insights we found in the record about a conceptual model for sand transport specific to the bar and open coastline, and included nearly three pages of notes, pending more thorough discussion in subsequent reports, including the following (pp.37-40):
  - Caloundra Head is a critical location in the study area. It lies at a littoral drift divide, with alongshore transport directed away from the headland to both the south and the north. Caloundra Head also separates the coast to the south dominated by tides with some wave influence, from that to the north dominated by waves with little tidal influence. Off the headland, only a shallow cover of sand remains; extensive areas of bedrock occur at or near the seabed. (p.2)
  - The erosion problems being experienced along the coast stem largely from a lack of external sediment supplies. This is despite the existence of large volumes of sand in close proximity to the coastline off Bribie Island. These deposits are isolated from the processes directly influencing shoreline stability. (p.3)
  - South of Caloundra, much of the wave energy is dissipated on the offshore banks before reaching the Bribie shore (Figure 2). Even on the eastern side of the banks (North East Channel data), shoaling has a major effect in reducing significant wave heights (Table 1). (p.5)
  - South of Caloundra Head, the coast comprises the eastern shore of Bribie Island. The shoreline is gently embayed, and oriented roughly NNW-SSE. Offshore are the North Banks (Figure 2), a triangular sand mass, with apex in the north, and extending southeastwards for more than 20km. A well defined channel along the western side of the banks separates them from Bribie Island. Further south towards Skirmish Point on Bribie Island, the alternating channels and banks of a large tidal delta occupy the entire entrance between Bribie and Moreton Islands. Here, tidal currents produce a dynamic environment for the evolution of ebb and flood dominated channels (Stephens, 1978; Harris and Jones, 1988). Along the Bribie shoreline, both wave and tidal currents are active, with tides becoming more dominant to the south (Stephens, Searle, and Holmes, 1983). (p.5)
  - …the northern part of Hamilton Patches is undergoing tidal and wave transport, resulting in a northwestward displacement of about 13m per year; despite the transport activity on Hamilton Patches, the deposits appear to be independent of the sediment budget of the beaches on the mainland and Bribie Island; a large sand bank is present in the 'nearshore zone south of Caloundra Head (Figure 26a,b); however its transport rate appears to be low, and the direction of transport northeastwards rather than onshore to supply Kings Beach. (p.12)
  - Caloundra marks a transition in coastline types in the study area. In the south, the Bribie shore receives substantial sheltering from waves due to the North Banks and Hamilton Patches. At Caloundra Head and to the north, no such sheltering occurs. Tidal transport is important in the Caloundra tidal delta at the entrance to Pumicestone Passage. Tides are also important along the channel separating Bribie Island and Hamilton Patches. (p.12)
  - Erosion in the 1960's led to the construction of a groyne at the southern end of Kings Beach. Prior to this, the stability of the beach was closely connected to the evolution of the Caloundra tidal delta immediately to the south. In the tidal delta, the main outflow channel migrated northwards and southwards over a distance of about 750m between Caloundra Head and Bribie Island. Historical data (Stephens, personal communication) shows that the outflow channel was hard against the

Caloundra shore in 1865 and 1940; in the intervening periods the entrance moved southwards, at times eroding the tip of Bribie Island before returning northwards. (p.12)

- When the outflow channel was in the north, there was an increased demand for sand from Kings Beach for the tidal delta. There was another factor also influencing Kings Beach, namely the effect of the waves. Even when the entrance moved southwards, variations in the angle of the wave crests arriving at the coastline created southward littoral drift. This also removed sand from Kings Beach, adding to its instability. (p.13)
- The Kings Beach groyne restricts the losses from Kings Beach itself, but transfers the demand for sand to the coast immediately to the south. This is seen as erosion and instability of the beach between the groyne and the Caloundra inlet. (p.13)
- The northern tip of Bribie Island developed later in the Holocene, and overlies a humic sandrock layer. The sandrock is exposed in the side of the channel on the mainland side of Bribie Island at the northern limit of vegetation. (p.19)
- On the offshore sand banks, a circulatory pattern of sand movement is observed, with one side being flood tide dominated, and the other ebb tide dominated (Kenyon & others, 1981; Harris & Jones, 1988). This allows a degree of conservation of sediment budget by recycling the bank sand. In contrast, when the migrating tidal channel impinges upon a large emergent bar, namely Bribie Island, only one side of the circulatory pattern can be established; no recycling can occur, and so a net loss of sand takes place along the channel margin. This produces an erosional scarp along the shoreline whereas an offshore bank merely shifts sideways while maintaining it overall shape. (p.24)
- There is little evidence for present day onshore supply from the tidal delta at the southern end of Bribie Island; neither is there evidence for onshore transport in the northern area near Caloundra. However, air photo data show that northward directed bedforms with wavelengths of 100-200m and 500-700m occur in the shipping channel 12km south of Caloundra Head. Sequential sounding data suggests that Hamilton Patches is moving northwards. This information confirms that sediment transport can, and is taking place. However, since the areas where transport is occurring are outside the nearshore zone, there is probably little influence on the sediment budget of the beaches. (p.24)
- Littoral drift along Kings Beach is to the south (Figure 37), and sediments moving in the beach and nearshore zones are transported towards the Caloundra Inlet. Although some of these sediments are lost to the littoral transport system by being trapped in the Caloundra Inlet tidal delta, the remainder contributes to the southward movement along Bribie Island. The source of these deposits can only be the nearshore zone south of Caloundra Head. Yet the data indicate very limited sand resources in the nearshore zone, with the only significant bedform moving to the northeast rather than onshore to the northwest. Under these conditions, the prospects for coastal accretion at Kings Beach and along the northern part of Bribie Island are poor. (pp.24-5)
- It is uncertain how much sand is transported southwards across the Caloundra Bar. Although tidal currents are substantial in the inlet channel, the ebb tidal delta seawards of the shoreline is comparatively small. The size of the ebb delta is usually determined by a combination of factors such as sediment transport rate, wave energy, and strength of tidal currents. Caloundra Bar has an added factor in that the estuary in which the flood delta lies - Pumicestone Passage - is a continuous waterway connecting through to Moreton Bay in the south. This may increase the asymmetry of the flood and ebb flows, and contribute to a large flood delta in the passage and a small ebb tidal delta in the nearshore zone. Nevertheless, alongshore transport rates to the south are likely to be small. This is supported by the bedrock and humic sandrock outcrops in the nearshore zone at Kings Beach and along the northern part of Bribie Island. With high transport rates, the outcrops would probably be buried. (p.25)
- Comparison of air photo data from 1958 and 1972 shows significant modification and expansion of the tidal delta deposits inside the Caloundra Bar during this period. The main outflow channel in 1958 was directed towards the southeast, and was located against the northern vegetated tip of Bribie Island. The channel was approximately 100m wide. By 1972, the channel was positioned further north and had an eastward orientation; erosion had truncated the sand spit attached to the mainland on the northern side, and the channel had enlarged to a width of 400-500m. During this period, the vegetated tip of Bribie Island was also eroded. The erosion was principally on the landward side due to lateral movement of the main tidal channel. Within the tidal delta proper, the main changes were an increase in the size and extent of the shallow sand banks. The growth of

the banks restricted the tidal flow, and the channels in 1972 were more numerous and complex than in 1958. (p.25)

  - Between 1958 and 1972, it is estimated that 3-400 000m3 of sand was released by erosion of the northern tip of Bribie Island. During the same period, a net gain of 125-130 000m3 was identified. This accretion occurred mainly as intertidal banks in the estuary. Approximately 220 000m3 was not accounted for. If this sand was supplied to the ebb tidal delta and subsequently removed by littoral drift, the volume may provide a minimum estimate of the littoral drift rate. Over the 14 year period, this provides an average of about 15 000m3 per year. The littoral drift direction indicated by the Kings Beach groyne is to the south, so the littoral drift in the vicinity of the Caloundra Bar may be of the order of 15 000m3 per year to the south. (p.26)
  - South of Caloundra Head, sand may be transferred shorewards from Hamilton Patches towards Kings Beach. This sand could supply the Caloundra Bar and tidal delta, as well as the Bribie shore. However there is no firm evidence to support this. Rather the differences in sediment type between the nearshore zone and Hamilton Patches suggests that the two zones are totally independent. (p.33)

- From *An assessment of the stability of the Bribie Island Spit based on studies of geomorphology, sedimentology and shoreline processes* [106] presented in 2000 (pp.42-43):
  - Between 1978 and 1993 the eastern shore of the spit experienced erosion at a rate of approximately 144 000 m3/yr with approximately 80% of the eroded sand being deposited in the flood tidal delta of Caloundra inlet. The system experienced a loss of sand of approximately 30 000 m3/yr by littoral and offshore drift, which highlights the negative imbalance in the sediment system.
  - Severe storms constitute the main erosional events impacting on the spit. However, as the rate of erosion has increased since 1972 without a commensurate increase in storm activity, it is suggested a number of other factors are involved in the present erosional regime. They include a reduction in the rate of sediment supply from offshore, an increase in the rate of longshore drift, a rise in sea level, and anthropogenic impacts such as dredging in the inlet and North West Channel.
  - Some additional points he makes are that tidal action is potentially more significant than wave energy to sediment transport in this system, so morphological changes can occur even during times of low storm activity, particularly on the inside of the passage, and that a well developed ebb tide delta (ocean bar) at this location has a substantial impact on the northern spit, refracting waves and promoting southwards transport of sand from the delta to potentially nourish the spit foreshores.
  - He also notes other influences, including extension of the northern end westwards into the estuary and stabilisation by vegetation, as well as the build up of sand banks within the interior of the passage. He notes that this could result in a breakthrough to the south across narrow parts of the spit and possibly closure of the northern bar (p.71).
  - His field work included calculating sand budgets, which he compares to those provided by Jones [084] to conclude that erosion rates have increased. He reports an estimated system loss of 30,000 m3/yr during 1978-93 – that sand being transported into the North West Channel and Moreton Bay – a doubling of the loss reported by Jones for the period 1958-72.
  - He estimated that the majority of the eroded material, 144,000 m3/yr, roughly 80%, was imported into the Passage, whereas Jones provided an estimate of 32% for the earlier interval. He notes that storm activity for the two intervals was similar, so not likely to be a contributing factor.
  - He also advised that dredging of the flood tide delta, the sand banks inside the passage, occurred in 1991 (40k m3) and 1999 (25k m3) to provide foreshore nourishment. He acknowledges that these volumes are less than the theoretical deposition, but observes that the dredging potentially creates accommodation space – a ‘void’ that may encourage transport from the flood delta into the passage, thereby affecting nourishment of foreshores to the south of the bar.
  - He also noted the potential influence of the oyster banks on circulation in the Passage and erosion of the interior foreshores (p.83).

- The Brisbane Airport expansion EIS [113-116] advised that
  - 15M m3 of sand from the Middle Banks was considered as a scenario with an expert panel endorsing supporting studies

  - That the Queensland Government completed the Moreton Bay Sand Extraction Study in 2005, as well as a strategy to coordinate extraction to meet regional demand.
  - That on the basis of the study the government decided that of the estimated 3,770M m3 of sand available, it would support extraction of 60M m3 over the next 20-years, including:
    - 40M m3 for Australia TradeCoast projects (including expansion of the Brisbane Airport and the Port of Brisbane) and an additional
    - 20M m3 to support the construction industry.
- Sources [142-144] advised of additional dredging of 1.1M m3 to support extension of the Sunshine Coast Airport.
- Advice from the 2009 Coastal Processes report [129] procured by SCC included:
  - In addition to the low littoral drift rates, onshore sediment supply from the inner shelf may also reduce the magnitude of the shoreline erosion driven by the littoral drift gradients. Recent studies completed by Patterson (2009) for the Gold Coast, approximately 150km south of the Sunshine Coast, indicate that the supply of sediment to the nearshore active profile from the inner shelf may occur in locations where the offshore profile is milder than the equivalent deepwater equilibrium slope. (p.1-10)
  - As mentioned in Section 1.3.1, it is possible that a sediment source from the inner continental shelf may be acting to supply small volumes of sediment to Sunshine Coast beaches. This process has been hypothesised by Roy (2001), Cowell et al. (2001) and Goodwin et al. (2005) and is assumed to occur in areas where the offshore profile slope is flatter than the deepwater "equilibrium" slope, commonly observed to be approximately 1 in 55m (e.g. Patterson, 2009). Figure 2-4 shows relatively flat offshore profiles throughout the study area compared to the deep water equilibrium slope. It is expected that a small supply of sediment from the inner shelf to the active beach system (shallower than approximately -15mAHD) will occur at these locations. (s.2.5)
- The technical paper *Shelf sand supply determined by glacial-age sea-level modes, submerged coastlines and wave climate* [157] included the suggestion that: "The paleoshoreline and shelf evolution is key to understanding the distribution of present-day shelf sand deposits and the contemporary sand budget response to future wave climate changes." Perhaps controversially, they conclude that: "Our results indicate that wave climate variability in the subtropical to mid-latitudes is far more variable than previously thought... The assumption that the modal wave climate for the past half century is the best baseline for predicting future coastal change is flawed."
- The *Review of Causes of Northern Bribie Island Erosion* [172] reported that:
  - Natural processes were the most significant contributor, both within the Passage (channel migration due to sand shoal growth) and on the open coast (wave action with inadequate replenishment supply).
  - Dredging of the nearshore and offshore areas was dismissed as a contributing factor due to a lack of supporting evidence.
  - Vessel wash and propeller turbulence were found to contribute, but at an insignificant level, with waves from vessels breaking on the foreshore having relatively low energy compared to total wave energy received on that shore.
  - Finally, Lamerough Canal was investigated through modelling with no contribution detected.

2.1.2 Models

Models are frequently used to refine and document understanding of coastal and estuarine systems, notably with respect to the movement of water and sand (coastal processes). Part 1 discussed various historical modelling that has been undertaken relevant to the matters of this review. As noted in Part 3, the long-term solutions are provided at a conceptual level, with acknowledgement that detailed design, including potentially modelling, will be required. What follows is an introduction to the fundamental types of models that are commonly applied, to ensure that our broad audience appreciates the distinctions.

Conceptual

Conceptual models, as the name implies, describe relevant processes at a conceptual level, typically through a diagram, accompanied by a narrative description. Part 1 reviews reports discussing conceptual models for coastal processes in the broader project area. They can be regarded as the simplest of the three types of models discussed here, but they remain a fundamentally useful tool, despite advances in other modelling techniques. An apt analogy of their functional role is that they focus on the forest, rather than the trees. That breadth makes them useful for interpreting the outputs of more complex/detailed types of models.

Physical

Physical models involve the construction of a 'replica' system, typically at a reduced scale. They are dimensioned to reflect a natural system that is of interest/being studied, and may include other characteristics, such as the use of different materials to simulate roughness that may contribute to turbulence or frictional losses, and incorporate features such as headlands that are non-erodible, or include mobile materials that simulate the movement of sand, and/or larger materials (rocks, built concrete structures such as for breakwaters, etc.). They have mechanisms to regulate the flow of water, including potentially generating waves of various magnitudes. They are often adaptable, so they can be reconfigured to test various scenarios. Evolutionarily, they are the are the successor to conceptual models, which, as noted above, is not to suggest they supplanted the need for conceptual models, but they can be used to test conceptual theories.

The photo below is believed to be a model constructed to simulate the effects of a proposal put forward by a community group in to stabilise the Caloundra Bar. A newspaper clipping that was separately included in the records we received, included the hand-written note "Nambour Chronicle 13/2/69". The short article, headlined "Model Test" advises that the Caloundra Passage Development Association's first meeting for 1969 was a success and that "Mr M. Ahern M.L.A. reported that he had made inquiries regarding the model test and announced that construction work would begin next week", refer to Figure 1.

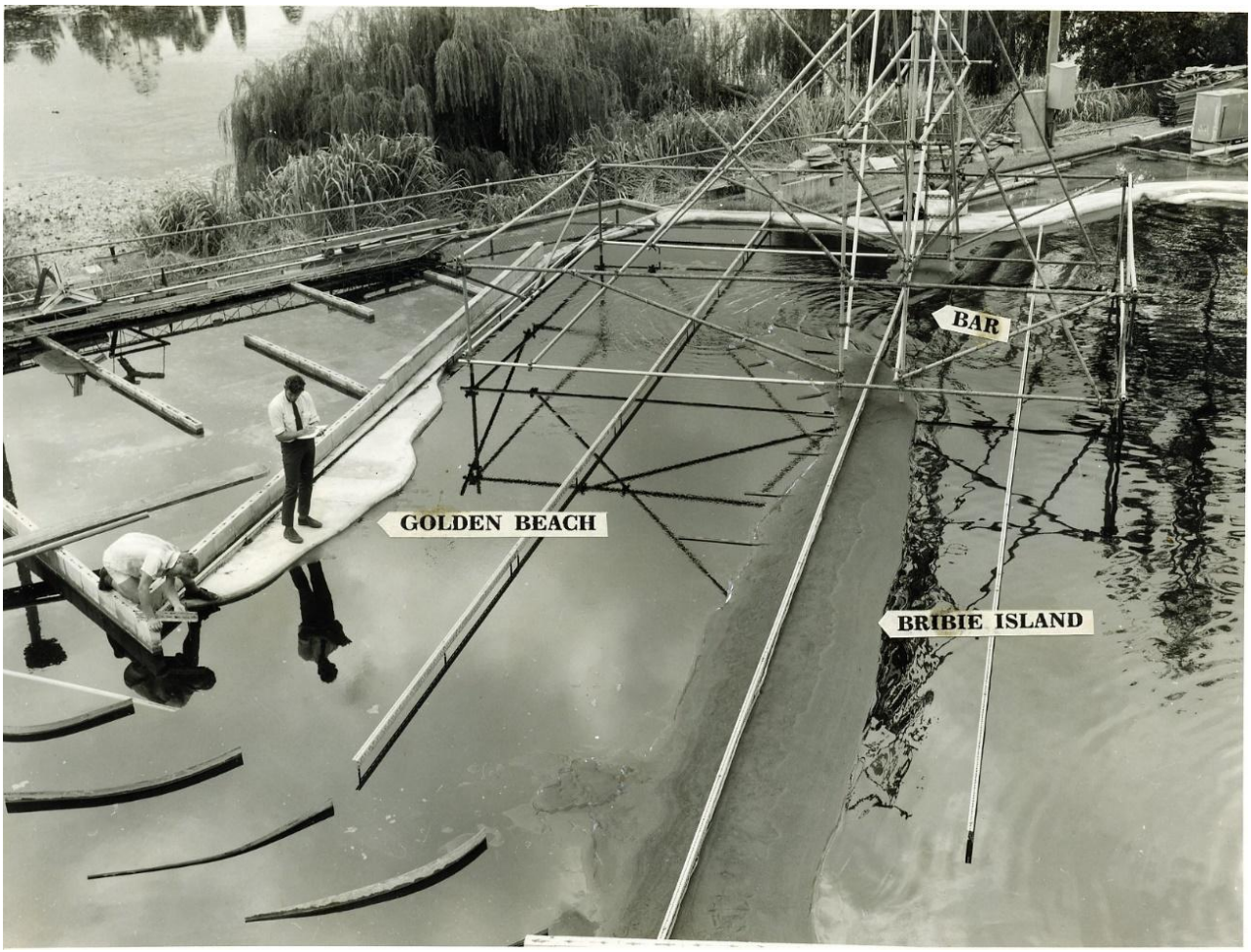


Figure 1: Physical model, c.1969, as discussed in Part 1 (photo courtesy of PPCMB)

Numerical

Numerical models are the most recent tool, possibly due to advances in computing technology. They have been steadily growing in ability, sophistication and adoption. Hydrodynamic models, typically for flood modelling were an early entrant. Dispersion modelling is another application, for example, predicting how the plume from a contaminant spill, or an outfall pipe, will spread, including dilution. The IMS modelling discussed in Part 1 was used to predict water quality changes in Pumicestone Passage given various catchment inputs and tidal dynamics. Sediment transport modelling, predicting morphological changes to bedforms (such as beaches, or river beds and banks) is also widely used, although arguably a less common specialty. There are many other numerical modelling applications, for example, much of the predictive science related to climate change relies on models, as does meteorology.

Numerical models are typically either two or three dimensional (2D or 3D). Waves or surface currents can be suitably modelled in 2D, but sediment transport typically requires a 3D model. Returning to the 'forest and trees' analogy introduced earlier, potential model errors can arise from boundary determination – creating a model environment that excludes relevant external influences. This issue is not limited to numerical models – it may apply to physical or even conceptual models.

At the simplest level, nature is integrally interconnected, and any model attempts to artificially consider one segment of a whole. With numerical modelling, this is often addressed through using 'nested' models, for example a 2D model of a large area (outer boundary) possibly at a relatively crude scale, nested inside another 2D model – smaller area and possibly finer scale, nested within a 3D model to simulate sediment transport. Sophisticated models can consume significant computer resources and model run times can be extended (multiple days or longer), particularly if the output requires them to forecast change over long periods of time. Nesting models is a way to use more inclusive boundaries and control run times.

Uncertainty - Gold Coast waterways

To round out this brief introduction to models, a case study regarding modelling undertaken to construct the Gold Coast Seaway is relevant in several respects. In Part 1, we advised that whilst this review was focused on the northern Bribie Island coastal and adjacent Pumicestone Passage environs, and that it was appropriate to extend the 'outer boundary' of consideration south to the Seaway, as the Caloundra Bar and Seaway are respectively the northern and southern outlets for the Moreton Bay, hydrodynamically connected. Knowledgeable readers would be correct to point out that reasonable evidence supports a tidal null point somewhere in The Skids (around Coochin Creek possibly, see 2.1.3 below).

Regardless, a null point does not exclude a north/south hydraulic connection, it is simply the location where the two forces meet and effectively cancel each other out. Changes in morphology, such as shoaling or scour, or catchment inputs, or an event such as the recent breakthroughs, would be expected to have an influence, potentially shifting the location of the null point. In a similar manner, changes such as the development of the Gold Coast Seaway, as discussed further below, could potentially affect the tidal dynamics in Pumicestone Passage. In addition, these two extents of the Moreton Bay system share a common coastal environment, notwithstanding the considerably different dynamics of sand transport, which will be discussed further in s.0 of this report.

The Seaway, the stabilised/trained entrance for the Broadwater, Nerang and Coomera rivers, was conceived in the 1970 Delft report, but construction didn't commence until 1984. Considerable data collection, studies and design occurred during that 14-year window, including construction of the current Queensland Hydraulics Laboratory at Deagon, to house a physical scale model that informed the eventual design.

By design, the Seaway and coastal bar should provide about 6.0m of water (5.3m AHD, 6.0m LAT). Within about 18-months of opening, parts of the Seaway were over 12m deep, with a peak of nearly 20m in 2007. Yet the ocean bar frequently had shoals above 4.0m. Another contested aspect of the design was the extent to which it would affect tide levels in the Broadwater, with the then Department of Harbours and Marine (**DHM**) predicting an 0.5m increase for the Broadwater and the former/original Gold Coast Waterways Authority (**GCWA**) anticipating minimal to nil change.

DHM was proven correct, with high tide increasing from ~1.2m (similar to Pumicestone Passage prior to the breakthroughs) to ~1.7m, near full open ocean conditions. However, GCWA was arguably also correct, as this change in tides reflects the unanticipated scour mentioned above.

As an aside, If you assume a 12m average depth for the Seaway, the scour had the effect of doubling the conveyance capacity, so an increase in tide heights would be expected. As discussed in previous reports, the breakthroughs increased high tide levels by about 0.3m (higher with storm surge). The Seaway is 300m

wide, so at an assumed average 12m depth, ~3600 m2 in cross section. Breakthroughs #1 and #2 are ~1,500m wide presently, but the average depth is likely to be <1m at low tide, and significant sand shoals have formed inside the Passage behind the breakthroughs, so the cross sectional area is less than the Seaway and the configuration is much less efficient than the Seaway with its relatively small surface area and reduced frictional losses and turbulence accordingly, so this lower tidal attenuation is not surprising, but it is worth noting that a constructed trained entrance could actually result in increases in tidal attenuation above the present conditions.

Returning to the point of sharing this case study, the unexpected scour of the Seaway post-commissioning was not due to a lack of proper planning; there was ample time for studies and contributions from world-class international expertise, and construction of a physical scale model. The effort was most likely state-of-the-art, given what was possible at that time. Yet, it arguably failed monumentally in terms of predicting outcomes. The scour was sufficient to expose the sand bypass transfer line (installed at -10m, so with ~4m of sand cover by design) resulting in retrofitting support piles within less than 2-years of commissioning. Furthermore, the training walls, which accounted for ~$43M of the $50M build cost – the balance being the Sand Bypass System – had depths significantly deeper than the 6m design specification, threatening their stability (the scour is asymmetrical, so closer/deeper along the southern wall).

Aside from the retrofit of support piles, the response was largely monitoring and studies, with the results indicating that the scour approached an asymptote (further annual change approaching zero). Progressive shoaling at the entrance (ocean/ebb delta) was attributed to 'leakage' past the Sand Bypass, with various studies suggesting possible modifications to improve efficiency, such as extending the southern training wall and/or extending the Sand Bypass Jetty and installing additional jet pumps.

The author of this report, as the manager for the Sand Bypass System at GCWA, created a Scientific Advisory Committee (**SAC**), and one of the projects progressed under the Scientific Research and Management Program produced the first new insight into the nature of the unexpected behaviour, ~25-years post-commissioning. The research question was simple – *do we have a boundary effect?* The monitoring consisted of twice-yearly surveys of the Seaway, from Wave Break Island to the outer edge of the delta. Whilst that data suggested an asymptote, that only meant the *net* change had minimised, that there was a balance between scour and deposition, which could mean there was still substantial sand movement occurring, as well as possible scour outside our monitoring boundary.

To explore this, we digitised a pre-Seaway (c.1984) bank-to-bank survey of the Broadwater. Most hydrographic surveys have a relatively limited footprint, for example a navigational channel (or a small part of one where shoaling is known to present hazards) or an entrance delta. So, bank-to-bank surveys are less common and often require collection of near shoreline data by surveyors manually collecting points along a line, as the water depths are insufficient for vessel-based sonar (today, additional alternatives such as LiDAR and swath bathymetry are possible). We had a second surface (~2005) from data the City of Gold Coast had collected to support hydrodynamic modelling related to sewage effluent releases (GEMS – Gold Coast Estuarine Model Study). We adjusted for known dredging volumes, did some 'clever stuff' to account for various sources of error, and ended up with a result that demonstrated substantial scour throughout the Broadwater across the ~25-year period. An additional check, following the acquisition of a third surface via aerial topo-bathy LiDAR, confirmed the results, as well as more moderate changes between 2nd and 3rd surface, suggesting that the scour in the Broadwater was associated with the Seaway commissioning and the system was approaching a new equilibrium.

Additional insight was contributed by a 1946 paper by T.H. Connah, published in the Queensland Government Mining Journal, titled "Stradbroke Island Erosion and Broadwater Silting, Southport" [202]. As an aside, T.H. Connah is amongst the experts that are thanked for their contributions in the 1965 Delft Report. Connah was 'sent' to investigate the issue of the migrating Nerang River entrance (in the 1860's, it reportedly met the ocean in Broadbeach, although Connah's discussion places it about 0.5 mile north of the Main Beach Surf Club in 1887, "Porpoise Head" on old maps) and the northwards erosion of the southern tip of South Stradbroke Island, including the loss of the town of Moondarewa.

His discussion supports advice by locals that the erosion of the Island and movement of the entrance are associated with the breach that formed Jumpinpin (1896); prior to the breach, North and South Stradbroke were joined to form a single island. Jumpinpin created a second outlet, weakening the flows through the Nerang River mouth. Prior to the breach, the Nerang likely had an ocean/ebb delta and the Nerang River, as well as the Broadwater were reported to have had depths suitable for navigation, including yacht races and barges used to transport timber harvested from the Gold Coast hinterland. After the breach of Jumpinpin, under reduced ebb tide flows, the ocean/ebb delta potentially became a flood delta, shoaling the Broadwater (he notes that some of the shoaling is likely due to the erosion of South Stradbroke Island).

The SAC agreed that the evidence supports a view that the Seaway appears to have reversed that trend, with the increased hydraulic efficiency exporting sand from the Broadwater flood delta onto an ocean/ebb delta. As a result, we produced a revised conceptual model. One component of the revised model was that the growth of the delta post-commissioning could be largely accounted for by the export of sand from the Broadwater, rather than "leakage" past the Sand Bypass System. Another revision to the conceptual model came from work by Dean Patterson, who was a member of the committee, as was Rodger Tomlinson, as chair, who has contributed to the Review as part of ICM. Dean's work (his PhD thesis) is mentioned in Part 1, as well as the review above. His contribution resulted in adjustment to the net littoral drift rate, from 500k m3, as provided in the 1970 Delft report, to 630k m3, based on the influence of an offshore sand body, the historical delta for the Nerang River, located off Main Beach. As an offshore sand source, the prevailing thought was that the sand was not available to support the movement of sand along the foreshore (littoral drift). His thesis demonstrated that this could occur under certain conditions. So, an increased rate of transport provided an additional possible contribution to the growth of the Seaway delta post-commissioning.

For the purposes of this review, the case study is intended to offer several lessons. Firstly, models can be wrong, with the choice of boundaries being a potentially critical element. Secondly, coastal entrance dynamics are often a subtle balance, with small environmental changes potentially sufficient to catalyse larger changes, such as transition from an ebb to flood dominated system, or vice-versa. Third, these systems are complex, and our understanding is constantly evolving. Science inherently includes an ongoing process of challenging what is known, evidenced by the use of 'theory' typically, and 'law' rarely. Finally, similar to Pumicestone Passage, the Broadwater is a double-ended barrier estuary (or arguably triple-ended with Jumpinpin, or two connected double-ended systems). For those that are interested, a fact sheet regarding the "Seaway Evolution" project is attached, refer to Appendix D.

2.1.3 1965 Delft Report

Part 1 discusses the Delft reports, including a 1-page excerpt that we found from a 1965 report, which concerned the northern Bribie Island/Caloundra Bar area. The better known series of reports in 1970 are restricted to the Gold Coast area (North Stradbroke Island as the northern extent). Due to that limitation, we did receive some queries from reviewers regarding the relevance of that report. Subsequent to finalising Part 1, we were able to locate a copy of the 1965 report and it confirms that the initial preliminary investigation by the team from the "Hydraulics Laboratory Delft The Netherlands", elsewhere shortened to the Delft Hydraulics Laboratory, did include various site visits further north in South East Queensland, and is titled: *Queensland Coastal Erosion: Recommendations for a comprehensive coastal investigation* [233]. The first two of the seven recommendations in the report are provided below:

1. It is essential that a comprehensive investigation covering all aspects of the coastal hydraulics and morphology be carried out on the south-east coast of Queensland. Without adequate basic data no technically sound and economically justified coastal engineering works can be designed and those carried out may constitute a danger to adjoining parts of the coast.
2. The executive authority responsible for the investigation should be a technical body on state level to ensure co-ordinated works. The Government should not only rely on specialist advisors but create a central body for applied hydraulic research and planning. Its field of work should not necessarily be restricted to the Gold Coast or Moreton area but cover the entire coast of Queensland.

As discussed in Part 1, the Gold Coast area was determined by the Queensland Government to be the urgent priority, with other areas to progressed later. Whilst the Beach Protection Authority (**BPA**) was formed with a broad geographic mandate, we did not locate a report that would be equivalent to the 1970 Delft report that is focussed on either the Caloundra Bar, or other areas of Queensland. The extract from the 1965 report in Part 1 was complete in that it reflected the material that we found in the correspondence file, however, the full report that we now have provides some additional text, so the complete text of that section of the report is provided below:

2.5 Caloundra-Noosa area. Bribie Island.

The general character of the coast in the Caloundra-Noosa area is virtually the same as that of the Gold Coast. Headlands of bedrock at Caloundra, Mooloolaba, Boolum and Noosa, enclosing low sandy and swampy grounds, and connected by a narrow strip of dunes. There are tidal inlets at Caloundra, Mooloolaba and Noosa. The one at Caloundra is connected at its southern end to Moreton Bay by Pumicestone Channel, thus cutting off Bribie Island from the mainland. Eight miles from Caloundra, near the confluence of Coochin Creek, is the likely tidal division of the Pumicestone Channel. The northern part is filled and emptied through the Caloundra inlet, the southern part via the Toorbul inlet. Observations of tide and currents will reveal whether a residual flow exists through Pumicestone Channel. A lot of information about the history of

the north Pumicestone Channel is available according to a memorandum by Mr. Peter Nelson Gracie dated July, 1964. The aerial photo's from 1942 up to present are a valuable source of information. The inlet is not stable, and it is not to be expected that it ever will be, unless it will have been fixed by permanent training. The longshore sediment transport varies with the seasons; at the inlet the residual transport may be northerly between May and October, and southerly between November and April. This is in concert with the yearly shifting of the entrance; early in the year the entrance is situated just north of the tip of Bribie Island. In April/May a northern channel opens, nearer to Caloundra, after the rough season with more easterly swell. The southern channel shoals and closes between May and October, due to the northerly drift, and between November and April the channel shifts to the south, completing the cycle. Naturally this cycle is not rigid and some years there may be deviations. Due to scour from the western side the tip of Bribie Island may break through about half a mile south of the present entrance. This might not be a bad place, as the tidal currents and the wave attack on Golden Beach would certainly be reduced, but the shore at Hill's Boats, south of Jellicoe Street, would suffer from increased erosion. It is clear that in a permanently shifting and changing system no static equilibrium can exist. There is little doubt that a favourable permanent solution can be found just as in the case of Southport. But at Caloundra it is equally impossible to have a front-row seat for a sixpence. The area between Bell's Creek and Caloundra should be considered as one unit and works be directed toward an overall hydraulic and morphological sanitation. The groyne under construction in 1964 down Dingle Avenue may have had some local effect, but its planned length was too small to have considerable influence. With sufficient length this groyne might stop south going sand, nourish Bulcock Beach and keep the inlet near Deep Water Point. It is doubtfull whether this is a favourable condition as the waterfront between Tripconny and Deep Water Point will be permanently exposed to wave action and currents. An other solution is a fixed opening about a mile south of the Esplanade, with a defended shore opposite the opening, a trained course of Pumicestone Channel and a wide and protected boat basin with beaches in the one mile "cul de sac" north of the opening. Pollution of this water by sewage discharge in the Pumicestone Creek should in that case be prevented. Of course such works will have to be based on facts rather than on possibilities, and some basic hydraulic and hydrographic observations will first have to made. In the meantime the administrative aspects can be discussed.

The southern part of Bribie Island near Woorim and Skirmish Point has to be watched closely. The dune protection is narrow, a seven fathom channel (~13.2m) runs parallel to the coast at a distance of less than half a mile, and minor changes of the obtaining wind, current and wave pattern may affect this part of the island greatly. The least to be done here is a periodic hydrographic survey and the consideration of suitable laws for the conservation and protection of beaches and dunes.

A planned boat harbour for the pilot boats might be combined with the above sketched possibilities for Caloundra. If this is not feasible the site at Mooloolaba, between Pt. Cartwright and Alexandra Head may be seriously considered. Due to these two rock headlands the situation seems to be rather stable but here, too, a detailed sounding chart is the least requirement.

The influence of Mudjimba Island on the alignment of the coast is outspoken. Repeated hydrographic surveys are expected to give much insight into the seasonal and the residual wave influence and sediment transport along this stretch of coast.

The beautiful and very attractive area of Noosa offers few alarming problems at present. But here, too, basic information has to be collected and recorded to provide accurate data for possible future works. However, if the need may be, artificial beach nourishment at Noosa Heads may be applied as emergency measure, as it is expected to have only local effect and not to be detrimental to the environment. It should be emphasized that early collecting of basic data need not be expensive. It is the lack of sound big-scale planning combined with a competent organization to make the observations and to elaborate them which is being felt from Coolangatta to Noosa.

As detailed in Part 1, community-driven proposals for a Caloundra boat harbour, pilot station, and trained entrance lost out to a competing proposal at Mooloolaba, and instead protected areas were declared and coastal policies adopted to not intervene in the erosion of the northern tip of Bribie Island. These protections also effectively constrained dredging of the Caloundra Bar as well as Pumicestone Passage, as well as potentially stifling any further suggestions to construct a stabilised entrance or otherwise seek to manage navigational access, other than at minimal levels of intervention with little evidence of comprehensive planning regarding alternative options.

2.2 Open coast

2.2.1 Introduction

This section considers the available evidence regarding coastal processes, notably sand transport, in the project vicinity, allowing for a relatively broad boundary envelope for the reasons stated above. This is not intended to suggest that the boundary could not, or should not, be extended further (and some readers would, no doubt, suggest we have drawn too wide an ambit).

This is a review, so we have not undertaken numerical modelling (and certainly not constructed physical models). However, we do conclude with a conceptual model that attempts to integrate salient points and highlight uncertainties to inform future planning. That conceptual model concludes this section on 'sand movement', so it includes consideration of both 'open coast' and the connected Passage, which is discussed in the following section, 2.3.

Similar to Part 1, this report, particularly this chapter, provides a substantial amount of information, including cataloguing available imagery and other data sources. Whilst the available information is substantial, it does not fully answer important questions, for example regarding sand transport dynamics in the project area. Early studies defined the general complexity of those dynamics, but they also suggest the need for further investigations to refine that understanding. The records we identified, as discussed below, suggest reasons why those further investigations may not have occurred. As with Part 1, some of the information we present has not been widely available, and it is certainly possible, perhaps likely, that other relevant information has yet to be (re)discovered.

Sea level rise merits mention, however, for the purposes of this review, we limit our coverage to a note that whilst there is significant uncertainty regarding the exact progression, the trend is widely accepted and the Queensland Government has adopted a projected sea-level rise of 0.8 metres by the year 2100. The SCC Shoreline Erosion Management Plan (**SEMP**) provides local planning in alignment with that adopted projection [129]. Planning and decisions that my eventuate from this Review will, as noted earlier, require detailed design, which should include appropriate consideration of projections as they may evolve over time, as well as actual conditions should they vary from those predictions. A decision to manage Bribie Island as a dune barrier that protects the mainland foreshore will provide some benefits, as evident by the changed conditions following the breakthroughs, however, sea level is still likely to rise, so implementing shoreline protection under the SEMP will remain a prudent forward strategy.

2.2.2 Sunshine Coast

South of the Moreton Bay delta (south of North Stradbroke Island) there is a prevailing southeasterly swell, which results in a net northward littoral drift of ~500k m3/yr (recent revisions suggest ~550k m3/yr). Around the Sand Bypass Jetty (prior to the revision to 630k m3/yr) the gross northward transport is ~1M m3/yr, but about half of that sand is transported back south when the prevailing swell changes orientation and for other reasons, such as beach morphology.

The Moreton Bay delta is believed to act as 'sand trap', locally altering the littoral drift pattern that occurs to the south. The net northwards sand transport is believed to continue up the coast to Fraser Island, which is the terminus of the process that extends southwards into New South Wales. Point Cartwright is identified as the location where northwards sand transport begins to resemble processes that are more similar to the open coast to the south of North Stradbroke Island. Estimated annual net littoral drift rates for the coast between the project area and Noosa Head are shown below, refer to Figure 2.

As documented in Part 1 and the review above, the Moreton Bay delta in the vicinity of the project area includes complex dynamics of waves that are modified by Moreton Island, as well as both ebb and flood tide transport, with the North West Channel adding a further element that influences littoral dynamics of the Bribie Island shoreline. The prevailing theories are largely aligned to a view that there is little supply of sand from the offshore banks to the nearshore environment.

Part 1 provides comprehensive (if not exhaustive) coverage of studies and investigations regarding sand transport processes in the project vicinity. That coverage includes the 2013 *Coastal Processes Study* [129] that underpins historical SCC coastal hazard planning. This study provides a detailed technical discussion of processes and is accessible on the SCC website with other SEMP related materials. For the purposes of this report, additional detailed description is not seen as necessary, however, the following excerpts are provided from s.2.5 of that report as they relate to subsequent discussion in this report:

- The Sunshine Coast is largely disconnected from the prevailing northerly transport of sand along the Australian east coast that supplies Holecene sands to the Gold Coast, Stradbroke Island, Moreton Island and further north to Fraser Island. As discussed in Section 1.3, Jones (1992) suggests Caloundra Headland represents a divide in the current littoral drift, with slow northwards transport on its northern side and slow southward transport on its southern side.
- As mentioned in Section 1.3.1, it is possible that a sediment source from the inner continental shelf may be acting to supply small volumes of sediment to Sunshine Coast beaches. This process has been hypothesised by Roy (2001), Cowell et al. (2001) and Goodwin et al. (2005) and is assumed to occur in areas where the offshore profile slope is flatter than the deepwater "equilibrium" slope, commonly observed to be approximately 1 in 55m (e.g. Patterson, 2009). Figure 2-4 shows relatively flat offshore profiles throughout the study area compared to the deepwater equilibrium slope. It is expected that a small supply of sediment from the inner shelf to the active beach system (shallower than approximately -15mAHD) will occur at these locations.

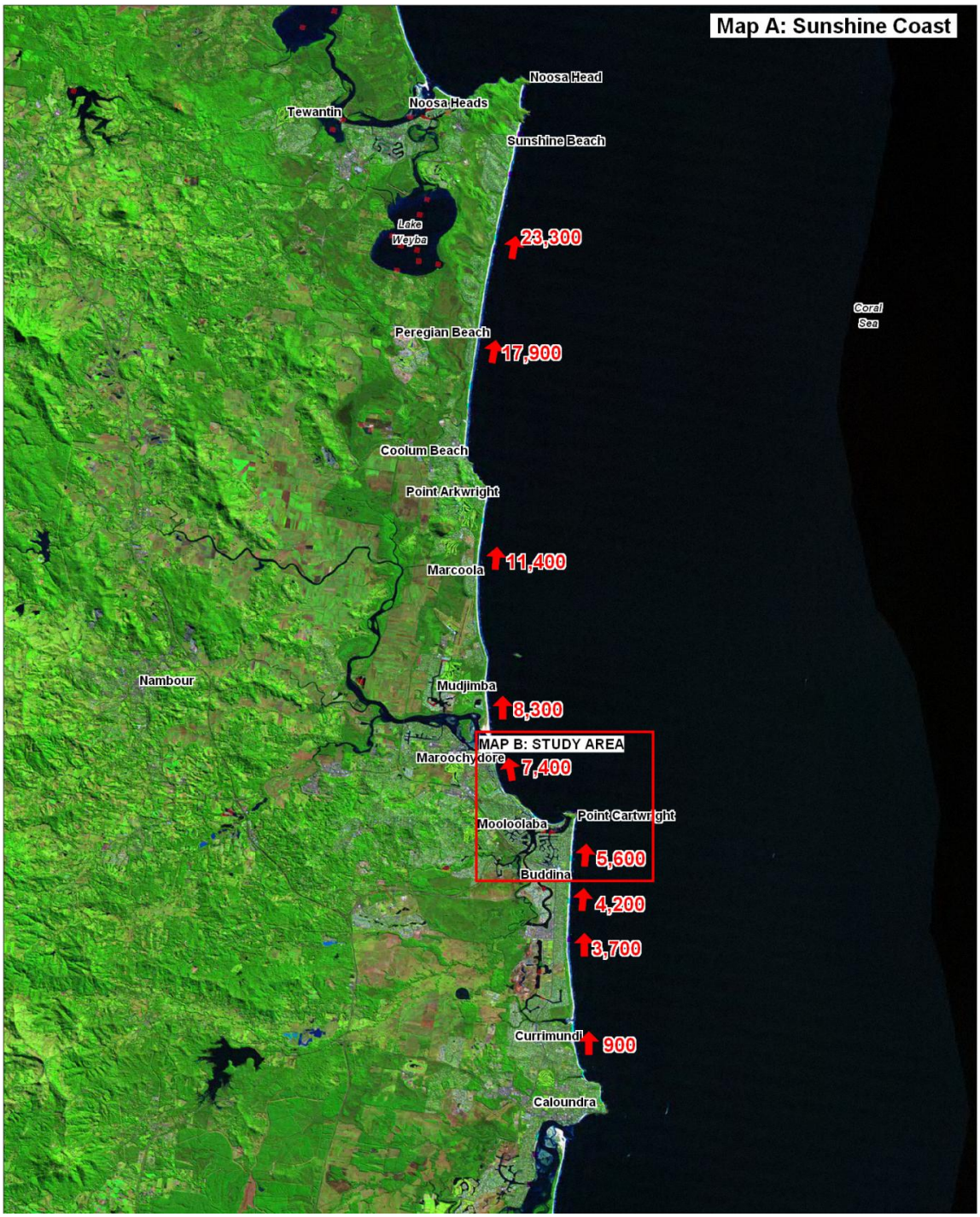


Figure 2: Potential wave driven longshore sediment transport [129] (Fig.3-24 - partial)

2.2.3 Dredging

As noted above, the ToR include consideration of dredging and shipping channel operations in Moreton Bay. As discussed in Part 1, early nautical charts (1865, revisions to 1897) show the North West Channel, and the Caloundra lighthouse, with depths generally >7 fathoms, about 12.8m, providing a 'gutter' between Bribie Island and the offshore banks. We also noted that an accompanying report indicated dredging for navigation had occurred prior to 1900, although records and locations were uncertain.

Figure 3: Detail from 1897 nautical chart, North West channel entrance [004] (full image provided in Part 1)

2.2.3.1 Port of Brisbane

Harbours & Marine – Port & Harbour Development in Queensland from 1824 to 1985 (**DHM History**), published in 1986 by the Department of Harbours and Marine (**DHM**) provides a detailed account (850+ pages, large format) of the formation and operation of the DHM [203]. It is organised chronologically, with chapters for seven sequential time periods. Whilst separate sub-sections for dredging are provided in some chapters (not all) those sections are often about the various dredge plant, and occasionally where along the coast they were working. There are also sub-sections for Moreton Bay, which were the ones that most frequently contained information relevant to the project area, including regarding the North West Channel.

The book also provides information on fisheries, including oysters, often with accounts reflecting productivity (earnings/value and/or quantity harvested). The formation of the Boating and Fisheries Patrol as well as the

Beach Protection Authority are discussed, both of which were part of the DHM.[1] The excerpts provided below are the result of manually scanning the book for relevant references (the index was of some assistance, however, oddly there are no entries for the North West Channel, even though the dredging entry lists a large number of locations, e.g. “Dredging, Brisbane River”). These excerpts are presented in the order they appear in the book, generally chronological, but with some variance as excerpts may have been drawn from different sub-sections of a chapter.

- In 1846 Brisbane was declared a Port of Entry and in 1849 a Warehousing Port. A Customs House was erected in 1850. (p.28)
- On 6 June 1859 letters patent were issued creating a new colony to be called Queensland. Separation from New South Wales was finally granted on 10 December 1859. (p.31)
- 1847 - SAILING DIRECTIONS FOR THE NORTH CHANNEL INTO MORETON BAY (p.35) are provided as published in the *Moreton Bay Courier* (24/04/1847), which, as reflected by the title, reflect entry off Moreton Island, not via the North West Channel. (p.35)
- The wreck of the steamer *Sovereign* on 11/03/1847 whilst attempting to use the south passage, with only 10 of the 54 passengers and crew aboard rescued, resulted in the following editorial comment (in part) in the Moreton Bay Courier (17/03/1847):
  - With regard to the southern entrance into Moreton Bay, it may be observed that this place remamed undiscovered until about the year 1826. Notwithstanding the previous examination by Flinders, Oxley, and others, some persons unfortunately found what was asserted to be a shorter route to Sydney by forcing a vessel out to sea through the surf and shoals of the Amity Point Passage. Although the safety and superiority of the northern entrance had been established by Lieut. Flinders in 1797, and subsequently by the Hon. Capt. Rous in the *Rainbow,* by Sir James Stirling in the Success, and by Captain Freeman of the merchant-schooner *William,* who came in, at night, about three years ago, and frequently since that time without difficulty, it was abandoned on the recommendation of less competent persons, and the pilot was stationed permanently at Amity Point, where, in bad weather, it is impossible to get out to board vessels in the offing, when his service are required.

    The recent survey of the north entrance by Captain Wickham, who kindly volunteered his services for the purposes when the subject was mooted by the Moreton Bay District Association, has recently re-established its superiority; and it is to be hoped when Lieut. Moriarty, the Harbour Master, sends the buoys which have been ordered by the Government to mark the channel, the result of Capt. Wickham's labours will be made public. The Harbour of Moreton Bay will then rank as one of the best in New Holland, and the security to life and property in vessels will be amply provided for. (p.39)
- The condition of the South Passage continued to deteriorate and more vessels used the North Passage. Eventually the pilot station at Amity was closed and was officially moved to Moreton Island on 1 August 1848 where it was located first at Cowan Cowan, and finally at Bulwer. (p.40)
- With ships again using the northern entrance around Cape Moreton there was need for a conspicuous light to mark the entrance to the Bay. Cape Moreton lighthouse was built during 1856. (p.41)
- The Ship Channel in Moreton Bay, though tortuous and awkward for the navigation of sailing vessels, had been the most used deep water entrance to the bay until 1879 when it became crossed by a series of narrow sand ridges and was closed to navigation. The Portmaster, Commander Heath, thoroughly sounded the banks and channels and stated that there was no danger of the port being left without a deep channel for, by the channel from Caloundra Head along the eastern shore of Bribie Island to Cowan Cowan, the largest vessel at any time could be brought to the anchorage at the Bar. This channel was convenient for vessels to or from the northwards but was extremely inconvenient for vessels from the south, giving an additional distance of some 23 to 29 miles from Cowan Cowan to Cape Moreton, and in heavy south-easterly gales or easterly weather was unsuitable for sailing vessels

[1] As reported, the Boating and Fisheries Patrol was formed from within DHM, however, the BPA was transferred, from the Department of the Coordinator General to the DHM in 1970, in conjunction with the ‘*Beach Protection Act Amendment Act of 1970*', which also transferred the administration of the Act from the Premier to the Minister for Conservation, Marine and Aboriginal Affairs, and provided that the Director, Department of Harbours and Marine, became the Chairman of the Authority in place of the Co-ordinator-General of Public Works.

entering the Port. However, when the ship channel closed, the North or Howes Channel remained good and became the channel most used by vessels entering or leaving the port. It had a depth of from 19 to 20 ft. at low water springs. The middle channel could also be used by vessels of moderate draught in fine weather. Freeman's Channel was subject to many changes, but was useful for small vessels as a passage of not less than 8 ft. at low water springs could usually be found. (pp.130-133).

- By 1892, with the size of vessels ever increasing, the need to light the northwest channel, which was beaconed for day use, was becoming evident as it had a depth nothing less than 6 fathoms at low water. (p.133)
- The banks at the northern end of Moreton Bay continually changed, banks grew out and closed channels, while other channels opened and deepened. In 1882 the growth of the Venus Banks to the northward necessitated the shifting of the yellow Patch Lighthouse, 300 ft. to the north-east, and by 1891 this light was being moved for the fourth time. The move in 1882 was carried out by the Harbour Master without interrupting the use of the Middle Channel for more than one night... Comboyuro Point light and the keeper's cottage were moved some 200 ft. further inland in 1890 a move necessitated not by the movement of the channels, but by the encroachment of the sea. (p.133)
- A survey of the northern portion of Moreton Bay was commenced by E.A. Cullen, nautical Surveyor, in the middle of November 1890, and continued until April 1891, when owing to the continuance of bad weather the work was stopped and the crew were paid off. The surveyed portion lay between a line from Cape Moreton to Caloundra Head, and a line joining Reef Point with Shark Spit. The coastline included had been traversed with theodolite and tape, and the triangulation computed from a base line 26,227 ft. in length, on Moreton Island. The topography was partly sketched in and all the larger summits fixed. The chart was plotted from a base 50,214 ft. in length, and drawn to a scale of 2 in. to a sea mile. The survey showed that, except for the north channel, changes had not been either extensive or sudden. (p.133)
- In the case of the North Channel, changes had been very great, such as could occur only under the conditions of banks of fine sand opposed to very heavy seas and strong tides, and gave every indication that the North Channel would close as the Ship Channel had done in 1870. (p.133)
- While realising the importance of providing navigation aids for the main shipping channels, the Department acknowledged its responsibilities to the smaller vessels, and instituted a policy of providing, wherever practicable, navigation aids and charts for the more frequently used bay and river channels... At the northern end of the bay the passage between Bribie Island and the mainland was beaconed in 1882, as far as it was navigable. (p.138)[2]
- Excluding the Brisbane River, other works carried on in Moreton Bay and near north Coast creeks included: –
  - A survey of Pumicestone Channel inside Bribie Island, between Toorbul Point and Caloundra Head. The more difficult parts were beaconed in 1885. (p.204)
- The North West Channel, which had remained a stable, safe and easy deep water channel, was not lit until 1896 when three lights were placed on shore and three gas buoys were moored to mark the extremes of the Spitfire, Western and Yule Banks. Two of the shore lights were leading lights on towers on Bribie Island, and the other was a lighthouse at Caloundra to direct vessels approaching the entrance to the channel. (p.272)
- Eventually the North West Channel was declared the safest entrance into Moreton Bay and, indeed, the only entrance to be used in bad weather or by deep draught ships. H.M.S. *Royal Arthur,* drawing 26 ft., was safely navigated into Moreton Bay at night time through this channel in 1897, although the navigating officer had never visited the port before. (p.272)
- The North West Channel again proved its worth in the heavy south-east gales during April and May 1904, when wind, accompanied with rain and the heaviest sea that had been experienced for many years in Moreton Bay, caused the sea to break along the 8 fathom contour off Cape Moreton to the Fairway Buoy on several occasions, and rendered the navigation of the North Channel too dangerous to attempt. On several occasions vessels arriving were signalled to stand to sea, pilots being unable to

[2] Unclear from the text whether the beacons were installed from the Bay to The Skids, or from Caloundra to the Skids, but presumably the former, based on the likelihood that population and small boat ownership would have been predominantly in Brisbane.

attend, yet, on the whole there was little delay, as during daylight the pilots were able to board ships at the entrance of the North West Channel. (p.272)

- The banks in the North West Channel slowly extended in a northerly direction, and by 1914 necessitated opening the leads to enter with safety. A channel carrying 6 fathoms at low water was obtained by the removal of the front Bribie lead 190 ft. to the northward, and a gas buoy was placed on the extremity of the North Bank to replace an unlighted buoy which marked an important turning point. About the same time, the lights shown from gas buoys in this channel were increased from 70 to 120 candle-power, by conversion from the flat flame to the incandescent system by means of incandescent mantles. (p.272)
- By 1920 the North Channel, which for some years previously had been used by small vessels day or night in good weather, had become intricate and dangerous to navigate, especially at night, and was virtually closed. The Freeman Channel, however, had maintained its permanency but was still not lit for night navigation. All vessels entering and leaving the port at night time were using the North West Channel, thus adding 25 miles to the distance if bound south and 27 miles if bound north. (p.272)
- The North-East Channel was shorter and easier to navigate but did not carry as much water as the Freeman Channel, having, by 1935, only 16 ft. L.W.S.T. The seaward entrance of this channel was exposed and, although protected by the banks, the channel itself was sufficiently exposed for damage to the buys to occur at nearly every cyclonic blow. In 1935 the Fairway Buoy, North-East Channel, was lost during a severe cyclone. It travelled north and was salvaged from the beach north of Caloundra, but the whole of the top work, with the lantern, had disappeared. During the cyclonic disturbance of March 1946, which not only dislocated traffic but brought to a standstill for several days all vessels seeking to enter and leave Moreton Bay, all the buoys of the North-West Channel[3] were swept out of position. None, however, were lost out of the bay and they were replaced immediately the weather moderated. (p.444)
- To more clearly mark the entrance to the North-West Channel in 1939 a new gas buoy was placed at the intersection of the red sector of the Caloundra light and near to the line of the Bribie lead about 2 1/2 miles from the Fairway Buoy. This new buoy proved a valuable aid to vessels making the North-West Channel in thick weather. (p.444)
- When the Navy took charge of the pilot vessel in 1940 the vessel's station was changed to the entrance to the North-West Channel instead of off Yellow Patch, but by I941 the vessel was again on station off Yellow Patch. (p.444)
- By 1943 the North-West Channel was the only channel entrance to Brisbane in use; and acting under naval directions the back light, Bribie Island was discontinued and an entrance to the channel further north, under the guns of Caloundra, was used. (p.444)
- The North-West Channel remained the main entrance to the Port of Brisbane and in 1950 it had a depth of 32 ft. at L.W.S.T. (p.447)
- On 5 June 1950, the cruising ground of the pilot vessel was again changed from off Cape Moreton to off Caloundra. The ground then lay within an imaginary line drawn from Caloundra Head 059 degrees 6 miles thence 180 degrees to the edge of the North Banks to the entrance to the North-West Channel. The change in location facilitated the picking up of pilots required by any vessels entering or leaving the port. (p.447)
- The re-opening of the Bribie leads, closed during the war, was deferred in view of the contemplated use of the port by vessels drawing up to 32 ft. when there would be no advantage to be gained by re-opening this entrance to the North-West Channel. (p.447)
- During the year ended June 1948, 60 beacons were pile driven in Pumicestone Passage, clearly marking the channels from Bribie to Caloundra and a white flashing light was established on a new beacon structure at the entrance to the channel at the southern encl of Bribie Island. (p.447)
- In the last years of the 1940s Brisbane assumed the role of a major port; a first port of call, and, possibly, a last port of call, with the usual concomitant feature of greater depths in channels and wharves. By 1951 it was apparent that, with the deeper draught vessels wishing to use Brisbane, it

[3] Spellings for the North West Channel provided in this section are as provided in the original text, which uses several different variations; similarly, some references to other channels are capitalized and others are not.

would be necessary to procure the services of a sea going dredge; a dredge that could work in a seaway and also one that could, during the bad weather or summer months be of such a size that It could work in the Brisbane River, one of about 2,000 cubic yards hopper capacity, able to dredge to 50 ft. and with a speed of 10 knots. This type of ship would maintain the North-West Channel, open up the Freeman Channel, and should the Brisbane River become heavily silted, such a ship could materially assist in restoring the cuttings to their former depths. (p.526)

- In 1960 the pilotage for the Port of Brisbane was still carried out from the pilot vessel QGMV *Matthew Flinders* anchored at the pilot boarding grounds near the N.W. Fairway Buoy off Caloundra, in Moreton Bay, or in her absence by the relief pilot vessel QGS *John Oxley*. (p.615)
- During 1961/62 assessments were made of hydrographic, engineering, navigational and economic factors associated with a small boat harbour and shore based pilot station at Moffat Beach, Caloundra. Although many aspects of this scheme showed favourable results it was decided to further examine the scheme before commencing construction, especially to examine wave heights and surge effects under adverse conditions. A model test, undertaken by the Queensland University, drew attention to factors which otherwise could not have been forecast including a critical wave height which was not the maximum wave and the advantages of strategically placed wave traps at the entrance. The model also made it clear t**ha**t the cost would be much higher than originally expected. Investigations were then made of other possible sites, viz. South-West Bribie, North-West Moreton Island, Northern Pumicestone Passage, and Mooloolah River. So definite was it by this ti8me that funds were allocated in the 1964/65 budget although the site had not been finalised.
- The site finally chosen was the Mooloolah River. The scheme comprised breakwaters, river training works, mooring basins, an entrance channel, a pilot jetty, a public jetty, two pilot launches, a pilots' hostel, twelve residences for launch crews, signal station and lighthouse at Caloundra and signal station at Lytton, four residences for signal men at Caloundra, as well as navigational aids and public facilities. Further model test carried out by the University of Queensland provided data needed for the design of the breakwaters, channels, and mooring basins. (pp.615-618)
- In 1960 the main entrance to the Port of Brisbane was still the North-West Channel which maintained a navigable depth of 32 ft. The North-East Channel, with a navigable depth of 15 ft. L.W.S.T. was available for small vessels. The least depth in the Brisbane River channel up to New Farm was 26 ft. L.W.S.T. with depth increasing towards the river mouth. (p.619)
- By 1965 the Port of Brisbane was being prepared to cater for the larger, more modern ships, especially tankers. The new North-West Channel area had been dredged to 42 ft. 6 in. and the East Channel to 40 ft.; from the Pile Light to Luggage Point the depth was 38 ft.; from Luggage Point to Pinkenba 28 ft.; Pinkenba to Norris Point 27 ft.; Norris Point to Circular Quay 22 ft.; and Circular Quay to Victoria Bridge 17 ft. The deepened North-West navigation channel was dearly marked with buoys and leading lights for large ships but the North-East Channel remained unlit. (p.619)
- In 1971 all old beacons in Pumicestone Passage were removed and replaced by buoys which could more easily be shifted as the channels altered. (p.621)
- In 1963, probings and samplings were conducted with Departmental nautical survey parties and plant providing the necessary controls to assist in the calling of tenders by the Co-Ordinator General's Department for the deepening of the Moreton Bay channels leading to the mouth of the River to provide access for large oil tankers. Contracts were eventually let totalling £1,950,000 for deepening of the North West and Spitfire channels to 42 ft. 6 in., the East Channel to 40 ft., the channel from the Pile Light to the River entrance to 38 ft. and a Swinging Basin to 40 ft. L.W.S.T. (p.713)
- The decision to deepen the entrance to the River mouth to depths varying from 38 ft. to 42 ft. 6 in. strengthened the need for a large suction dredge as the plant then retained by the Department could not maintain the required depths. The north-west channel maintained a natural depth of 32 ft., the North-East Channel in 1963 was 20 ft. L.W.S.T. and the least navigable depth of water in the Brisbane River channel up to New Farm was 26 ft. L.W.S.T. with depths increasing towards the River mouth where 28 ft. was available up to Pinkenba Wharf. (p.713)
- Two contracts were let during the 12 months ending July 1964 to dredge bay channels and a swing basin to handle super-tankers of about 80,000 tons capacity, namely: –
  - (a) Christiani and Nielsen for £421,266.13s.4d.: North-west channel - 1,000 ft. wide to 42 ft. 6 in. at L.W.S.T.; and East channel - 1,000 ft. wide to 40 ft. at L.W.S.T.…

  - (b) Standard Dredging Co. of New York for £1,529,61 2.10s: Bar Cutting - 400 ft. and 500 ft. wide to 38 ft. at L.W.S.T. and Luggage Pomt Swing Basin - 1,800 ft. wide to 40 ft. at L.W.S.T. (p.713)

- The whole work required the removal of an estimated 13,257,000 cubic yards of material and was to be completed in 16 months from 29 August 1963, i.e. on 31 December 1964. By the end of June 1964, Christiani and Nielsen had completed its contract and, in addition, had cut off the corner of the Hamilton Patches near N.W. No. 1 Buoy; all dredged spoil had been dumped at sea or at selected areas in Moreton Bay. (p.713)
- Surveys of the North West and East channels in 1970 showed **that** maintenance dredging was essential to provide the depths of water required **for th**e large tankers but the existing dredge fleet could not dredge to the depths required in these channels. (p.714)
- The maintenance dredging of the Moreton Bay Channels, East Channel, Spitflfe Banks Channel, and North-West Channel was completed in early 1973. (p.715)
- Although the Beach Protection Authority devoted a considerable amount of its resources to persuading local authorities and other relevant government agencies to adopt its buffer zone policy in relation to new developments, the buffer zone concept was also extended to dealing with existing erosion problems. Where such problems existed, the creation of a new buffer zone to improve beach conditions and remove any erosion threat to development could be achieved by the placement of sand directly onto the beach in question. Beach nourishment was carried out at Surfers Paradise in 1974 by the Gold Coast City Council involving almost 1.4 million cubic metres of sand pumped from the Southport Broadwater. In spite of numerous periods of severe erosion along the Gold Coast beaches up to 1984, the nourished beach at Surfers Paradise retained its ability to provide both protection to the beachfront road and enjoyment to hundreds of beach users. The results of the Authority's investigation programme along the Queensland coastline confirmed the Authority's recommendation that beach nourishment was the best solution to many of the erosion problems existing in Queensland. (p.793)
- Regular close monitoring of beach behaviour along Queensland's long coastline of over 5,000 kilometres was not practicable with the limited resources available to the Beach Protection Authority. However, vertical aerial photography provided an effective means of identifying significant coastal changes and sedimentation patterns. (p.798)
- In 1974, the Authority commenced a programme of regular aerial photography from the Queensland-New South Wales border to Cooktown. Each of four sections of coast and major offshore islands were photographed to provide quality colour prints at a scale of 1: 12,000 every 4 years. (p.798)
- By 1984 the Authority had an extensive library of such photographs which proved invaluable in the assessment of coastal change and beach processes, particularly in remote areas. They were also widely used in the mapping of soil and vegetation types as part of the Authority’s investigations. (p.798)
- The Authority introduced its Coastal Observation Programme Engineering (COPE) in 1971, Through this programme, field data on waves, currents and beach conditions were measured each day by volunteer observers. In this way useful information was obtained from beaches not included in the Authority’s major investigation areas. (p.800)

The above excerpts range beyond the issue of dredging, but provide additional information relevant to this Review, and potentially to members of the local community with interests that extend beyond the ‘boundaries’ that we have set as independent reviewers, so we have included them as a concession to the more full coverage that they may have wished for, and as we consider them an important supplement to the history that was provided in Part 1.

With respect to dredging, the book provides tabular accounts of dredging by year and by plant as appendices, but the tables do not provide details on the basis of channels. The text includes extensive accounts of ongoing cycles of both capital dredging to establish desirable navigation depths within the Brisbane River, as well maintenance dredging to remedy siltation of dredged areas (channels as well as wharves, etc.), and also investigations for flood control, as well as reclamation to create port facilities, and creation of dredge spoil disposal areas (offshore as well as within Moreton Bay). A very quick summary of

the table for the Port of Brisbane indicates that during the period covered (~90 years) more than 260M m3 was dredged.[4]

Returning to the earlier discussion of models and the potential errors arising from boundaries, we note that in a conceptual model context, it would potentially be an error to limit consideration of dredging activity to the North West Channel or the portion of it that lies within the project vicinity. It is likely that the progressive dredging has resulted in a net increase in the Moreton Bay tidal prism, both due to an increase in volumetric space as well as conveyance efficiency (channelisation). Arguably, given the size of the tidal prism, the volumetric change is small on a percentage basis, however, the improved conveyance efficiency is potentially significant enough to consider the overall works as an anthropogenic contribution to natural coastal processes operating in the broader Moreton Bay area, as well as potentially in the project vicinity.

With respect to sand movement, we offer the following narrative summary of the detailed account provided above. Brisbane was declared a port of entry in 1846. Published sailing directions for the northern entry used channels off Moreton Island, not the North-West Channel. The pilot station at Amity was closed and was officially moved to Moreton Island in 1848. By 1879, The Ship Channel, the main northern entry, was crossed by a series of narrow sand ridges and was closed to navigation. Survey in 1890 indicated that the North Channel was likely to close as the Ship Channel had done.

In 1892, the North West Channel had a reported depth of nothing less than ~11m at low water. By 1896 the North West Channel was lit, including with leading lights on Bribie Island, reflecting its importance as a northern entry. Northerly extension of the banks in the North West Channel necessitated opening the leads, with a channel of ~11m reestablished by moving the Bribie lead northward. By 1920 the North Channel virtually closed, with all vessels entering and leaving the port at night time using the North West Channel. By 1943 the North-West Channel was the only channel entrance to Brisbane in use.

In 1950 the North West Channel had a reported depth of 9.6m at L.W.S.T., which it is reported as maintaining in 1960. In 1964-1965 the North-West Channel was dredged to ~13m deep by ~305m wide. Those works removed ~13.3M cubic yards, although this includes works outside the North West Channel. The works included cutting off the corner of the Hamilton Patches near N.W. No. 1 Buoy[5]. Surveys in 1970 of the North West and East channels showed that maintenance dredging was essential, with maintenance dredging of the Moreton Bay Channels, East Channel, Spitfire Banks Channel, and North-West Channel completed in 1973.

It is worth noting that the BPA operations included a number of dimensions and that their investigation program confirmed that beach nourishment was the best solution to many of the erosion problems existing in Queensland. However, that solution was typically limited to areas where built assets were threatened. In other areas, including the known coastal erosion of the northern Bribie Spit, there were no assets to protect (other than the light, which as noted above was considered built to withstand erosion). For Bribie, the adopted approach was to declare the entire width of the Island in this location to be an erosion prone area.

Finally, the above account adds further insight into the discussion in Part 1 about proposals, by community groups and other parties, to establish a small boat harbour and stabilise the entrance. Pumicestone Passage was included, including both northern and southern Bribie, along with several other areas, with Mooloolaba chosen, although associated pilot facilities and navigational infrastructure was also included at Caloundra. Also, model testing was carried out in relation to this ‘competition’ and is likely the source of the photo provided above.

2.2.3.2 Moreton Bay Sand Extraction Strategy

The DHM History [203] concludes in 1984. The Moreton Bay Sand Extraction Study (**MBSES**), discussed peripherally in Part 1 (in relation to Brisbane and Sunshine Coast Airport projects discussed therein), commences in 2001 with the Phase 1 report, so that leaves a gap of ~15-years. The MBSES includes some historical information and provides strategic insight regarding the extraction of sand from the delta/banks.

Information regarding historical sand extraction is also included in the 1998 *Moreton Bay Marine Park Extractive Industry Strategy Sand Resource Study* [204]. This report notes that Harris et al. (1990) reported that ~14M m3 of sand was dredged in 1983 to support the Brisbane Airport construction. The extraction area

[4] The table includes quantities in four different units, sequentially for various time periods, initially Cubic Yards, followed by Barge Yards, then Tons, and finally m3, so the above estimate includes both high-level summation and conversion.

[5] The text seems to suggest (“in addition”) that these works were not necessarily part of the originally contracted works.

was on the east side of Middle Banks, to a depth of 17m, with seismic and echo sounding showing that the bank was rebuilt by July 1989. They further advise that Harris et al., (1992) interpreted the infill was from the immediately adjacent East Channel to the north, so a southward transport.

The MBSES includes several fact sheets, as well as supporting reports regarding economics, cultural heritage, sand geochemistry and other matters, but the key components considered for this review are:

- 2001, Phase 1 Report [205]
- 2003, Phase 1 – Hydrodynamic Impacts Review [206]
- 2004, Phase 2 – Wave Penetration Study [207]
- 2005, Summary of Findings [208]
- 2021, Final Report [209]

The Executive Summary for the 2001 report establishes the context and purpose for *the MBSES as follows:*

"An economic and reliable source of sand either for the production of concrete or as high quality fill is instrumental in the economic growth of the South East Queensland region. Northern Moreton Bay contains a huge resource of this material that has been accessed previously. It also has a high degree of environmental significance, commercial, recreational, and traditional fishing activity and tourist activity.

This report comprises the first stage (Phase 1) of a study to compare issues associated with land-based extraction of sand and issues associated with extracting sand from Northern Moreton Bay. The report describes the environmental, social, economic and cultural issues associated with sand extraction. Analysis of information gaps and recommendations for further study in Phase 2 is presented."

Regarding historical access, this information is provided:

"Extraction of sand from Northern Moreton Bay currently occurs through the operation of licences by five extraction companies. Permit areas for sand extraction include Spitfire Bank, Yule Bank, Central Banks, Middle Banks and South West Spit. The total permitted extraction volume is 465,000 cubic metres per year but the actual volume extracted is substantially less than this (depending on demand) and has recently been approximately 340,000 cubic metres per year. In 1998, a detailed resource assessment of sand in northern and central Moreton Bay was undertaken which identified a total available sand resource of approximately 3.8 billion cubic metres."

Hydrodynamics is summarised as follows:

"This study has examined the potential effects of several indicative options for extraction of sand from Northern Moreton Bay. These options each provide 30 million cubic metres of sand, which represents the combined demand for extractive industry and major development projects (eg. Brisbane Airport Runway Construction) over the next 10 years. The preliminary stage modelling that has been undertaken indicated that all of the four options would cause only a localised redistribution of water flow with no overall change in tidal regime or levels in Moreton Bay. The options examined were dredging from:

- *North Bank/Spitfire Channel*
- *Middle Banks*
- *Northern Delta (Western and Central Banks, South West Spit)*
- *North East Channel*

While impacts varied somewhat between options, the overall impacts were generally low with any adverse affects able to be managed by the design of the dredging works."

This report also advises that commercial sand extraction in Moreton Bay has been occurring for at least 25-years, primarily for commercial uses, capital projects, and navigational access. The study process included a Steering Committee and Scientific Panel, as well as two stakeholder groups, the Indigenous Reference Group (later, Traditional Owner's Advisory Group) and the Extractive Industries Implementation Program Group, both being established within the Moreton Bay Waterways and Catchments Partnership (MBWCP).

Regarding historical sand extraction, the report includes redevelopment of the Brisbane airport, with ~19M m3 of sand extracted for reclamation purposes from the Middle Banks area, as well as maintenance dredging in navigation channels (approximately 600,000m3 /year). Details are provided regarding the companies and locations holding current extraction permits but are not included here. However, it is worth noting that the report advises a current declared depth for the North West Channel of 13.5m, corresponding

to the 1965 dredging discussed above, and a 'future planned declared depth' of 15.0m, corresponding to the current approved depth, as well as a depth range of 13.5 to 22m. This maximum depth (22m) corresponds to about 12 fathoms, with the 1897 chart showing depths of 10 and 11 fathoms to the west of Spitfire Banks. Our searches did not result in documentation related to approvals for the apparent capital dredging to increase the dept from 13.5 to 15.0m.

Regarding morphological processes, an extract from Stephens 1992 is included (similar to that provided above and in Part 1). The report also includes advice from Jones 1992 that there is no evidence of sand from the North Banks being supplied to the shoreline of either Bribie Island or Caloundra (also similar to that provided above and in Part 1).

The report advises that the majority of the tidal prism of the Bay (~3,000x106 m3) flows through the channels and across the sand shoals of the Northern Delta, with lesser contributions from the south entrance and the Broadwater-Nerang system. The peak tidal current speeds (0.5-1.0m/s) are characterised as sufficient to cause extensive mobility of the shoal sands, particularly in conjunction with wave action. The Northern Delta shoals are noted as have a major controlling influence on the tidal regime and flushing/exchange processes within the Bay due to the substantial frictional resistance they present to tidal flows.

Hydrodynamic modelling found that the effects on tidal regimes from the extraction of 30M m3 of sand were imperceptible. Only in the case of extraction in the North East Channel area would current speeds be potentially increased along any shoreline areas (notably Comboyuro Point). It advises that associated dredging at Yule Road could be used to offset such an effect. Removal of sand at a slow rate over a long period from some areas where re-siltation would occur over time would minimise impacts on currents.

The *2003, Phase 1 – Hydrodynamic Impacts Review* provides refined modelling, progressing preliminary advice presented in the 2001 report, including incorporating modifications to the sizes and locations of the areas, to reflect scenario developments, as well as introducing updated bathymetry. Regarding that bathymetry, the report notes that it necessitated some increases in the footprint of the Central and Middle Banks scenarios to obtain the nominated extraction volumes at the specified limits for dredging depths. That may be simply due to accuracy of the original bathymetry, but given the documented mobility of the banks, it is reasonable to speculate that this change may also be due to rearrangements in shoals during the interval between surveys. See further discussion below regarding the model boundary.

This report reiterates the advice above about the importance of the Northern Delta, notably shoal and channel bathymetry, to the Moreton Bay tidal regime. It adds advice that the North East Channel area is potentially more critical than other parts of the banks, but that even substantial quantities of sand extraction are generally of relatively minor significance as the vast size of the Delta means that extraction from relatively small footprints has minimal overall effect on the bathymetric and frictional controls to tidal flows. The report repeats advice regarding potential progressive infilling of dredged areas.

The modelling results reported confirm those provided in the earlier report, notably that there are no significant impacts to shorelines. The modelling included ten different scenarios (4 areas, differing depths), which we will not detail here, but we do include the following advice:

- "For the Middle Banks case the velocity along Moreton Island is decreased slightly as more flow can occur through the dredged area than before dredging;
- For the Central Banks and Spitfire Channel and Bank cases the velocity impacts are more extensive but because of the location away from the shore there are no impacts at adjacent shorelines." (p.4-4)

The *2004, Phase 2 – Wave Penetration Study* notes that the Phase I report showed active sediment transport processes throughout the northern banks, but on the basis of peak tidal flows, with no consideration of potential sand transport by wave action. The 2004 report provides advice about modelling undertaken to fill that gap, including that the model outputs are based on immediate, rather than gradual removal of sand, and that a more practical (slower) rate, would likely be accompanied by natural smoothing and redistribution of adjacent material, so the reported results are accordingly conservative.

The general results reported include:

- Swell waves refracting around Cape Moreton lose a large proportion of their energy to the delta;
- At the dredge sites, wind waves are as high or higher than the swell, but with a shorter period;
- Increased depth from dredging:
  - Alters shoaling patterns locally (at the dredge site) and downstream;
  - Reduces waves locally, and increases wave propagation past the area with slightly less loss;

- Slightly increase the height of wind generated waves locally (reduced resistance);
- Impacts from increased depth are less significant than increased dredge footprint;
- Affects swell wave heights and directions more than wind waves (longer period 'feels the bottom');
- The SE and E swell in particular show this effect, however wind waves are more significant locally;
- Due to the dredge site locations, Moreton Island impacts are greater than Bribie Island or Redcliffe;
- Generally, isolated local changes in wave heights are <5%;
- The Middle Banks option has no significant impacts on wave conditions at adjacent shorelines;
- The Spitfire Channel and shoal options generally allow up to 15% higher swell waves (<0.3m);
- The Yule Banks options generally allow up to 10% higher swell waves (<0.3m);
- The Central Banks options generally allow up to 10% higher waves (<0.2m).

The report does include cautions regarding accuracy, particularly where wave heights are low, e.g. <0.1m. It advises that information regarding whether the shoreline along Moreton Island is controlled by wave or tidal transport is unavailable, but the location of spits south of prominent points suggest net southward transport, and as absolute wave heights are low (0.3m in 5m water depth) sand transport is most likely dominated by tidal currents, with smaller contributions from wave induced resuspension. Accordingly, the relatively small changes in wave heights due to sand extraction are unlikely to significantly impact sand transport. The boundary for both models appears identical and excludes the project area, refer to Figure 5.

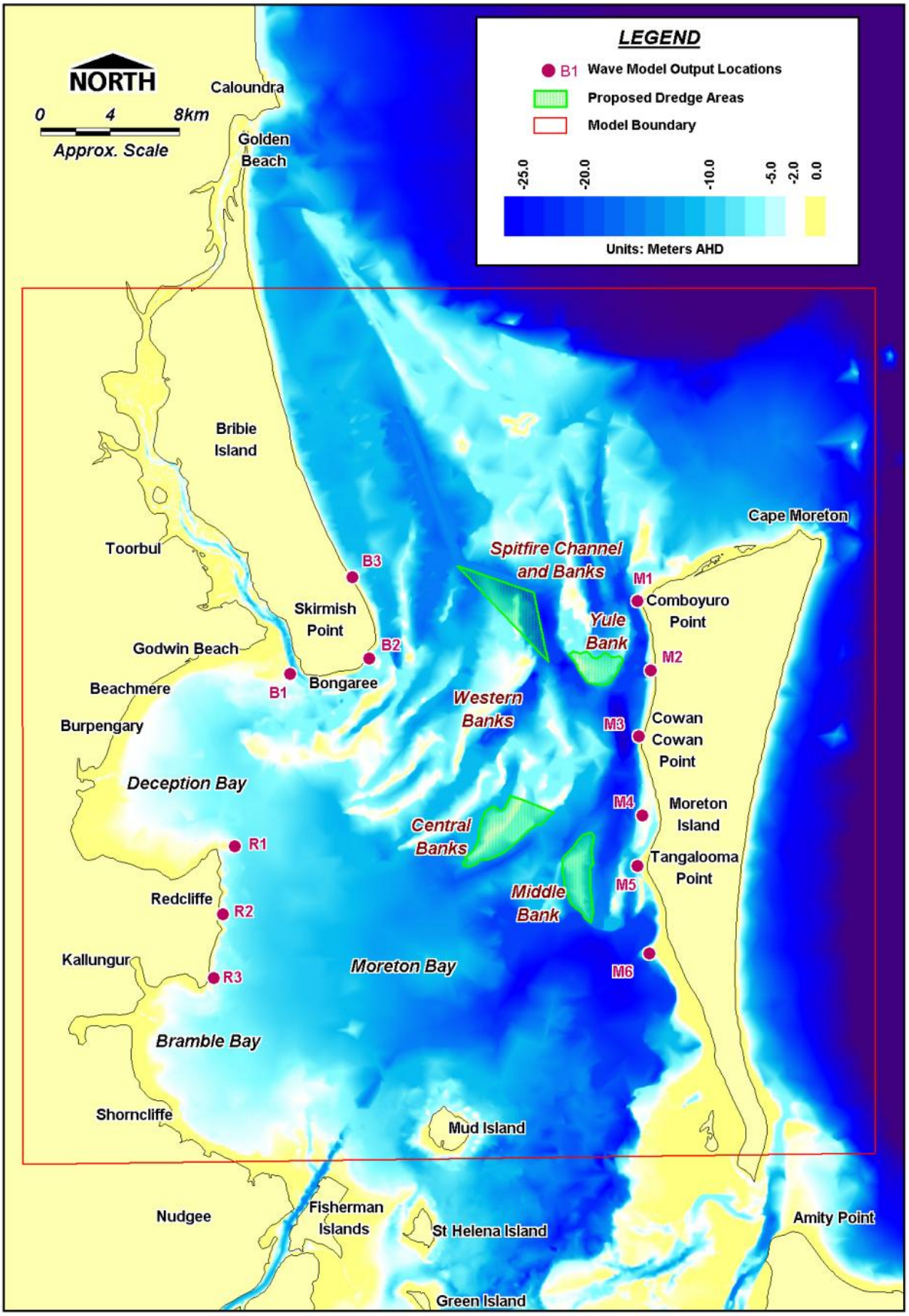
The report notes that swell waves in the north to northeast sector have direct access to the Northern Delta and may propagate directly into the Bay, particularly at higher tide levels. Accordingly, wave influence on the Bay, adjacent shorelines and delta shoals depends intimately on seasonal wind and weather conditions. The historical and ongoing general process reported is that the northern delta shoals are progressing slowly southwards. As well, it notes that major storm events (e.g. May 1996) are capable of inducing significant short term effects on the arrangement of the northern delta shoals, although with no net gain/loss of sand (following work by Stephens and others, tidal currents act to conserve, or 'trap' sand in the broader system).

The 2005, Summary of Findings (report is actually undated, but the DETSI library catalogue entry suggests 2005) reports on the overall process, including investigations summarised above, other studies, and details regarding steering committee and advisory panel membership. The findings demonstrate impacts are acceptable – generally minimal or temporary – and that extraction is an economically viable and generally appropriate complement to land based extraction to supply anticipated regional demand. It notes that the extraction scenarios would alter tidal delta morphology, but that prevailing sediment transport processes would in most cases result in a gradual infill of the extraction sites. The study area and overview of environmental constraints from this report is included below, refer to Figure 6.

That 2005 report does not provide advice regarding decisions arising from the MBSES, but a 2005 Queensland Government information sheet [210] reports the decision to allocate 60M m3 for the next 20-years (to ~2025). It further advises that sand extraction for the construction industry will be largely directed to areas that supplement straightening of the Moreton Bay shipping channel and that extraction from the Middle Banks area would occur only on completion of the EIS for the proposed Brisbane Airport expansion project. A four-stage process is outlined allowing for a transition, through expressions of interest, from existing arrangements to new allocations that are limited to shipping channels and adjusted for demonstrated future needs (2006-2008), followed by a further 6-year allocation (~2008-14) based on projected demand following completion of the Brisbane Airport Expansion EIS. Details regarding both historical and approved future extraction is summarised tabularly, refer to Figure 4.

	Past 20 years	**Next 20 years**
Construction industry	2 million m^3	20 million m^3
Australia TradeCoast projects, including Brisbane Airport	19 million m^3	25 million m^3
Port of Brisbane channel maintenance and capital works	18 million m^3	15 million m^3
Total	**39 million m^3**	**60 million m^3**

Figure 4: Historical, and approved future sand extraction arising from the MBSES [210]



Locality Map Figure 3.1

Figure 5: Locality map, showing model boundary for the MBSES [207]

Figure A – Study Area and Overview of Environmental Constraints

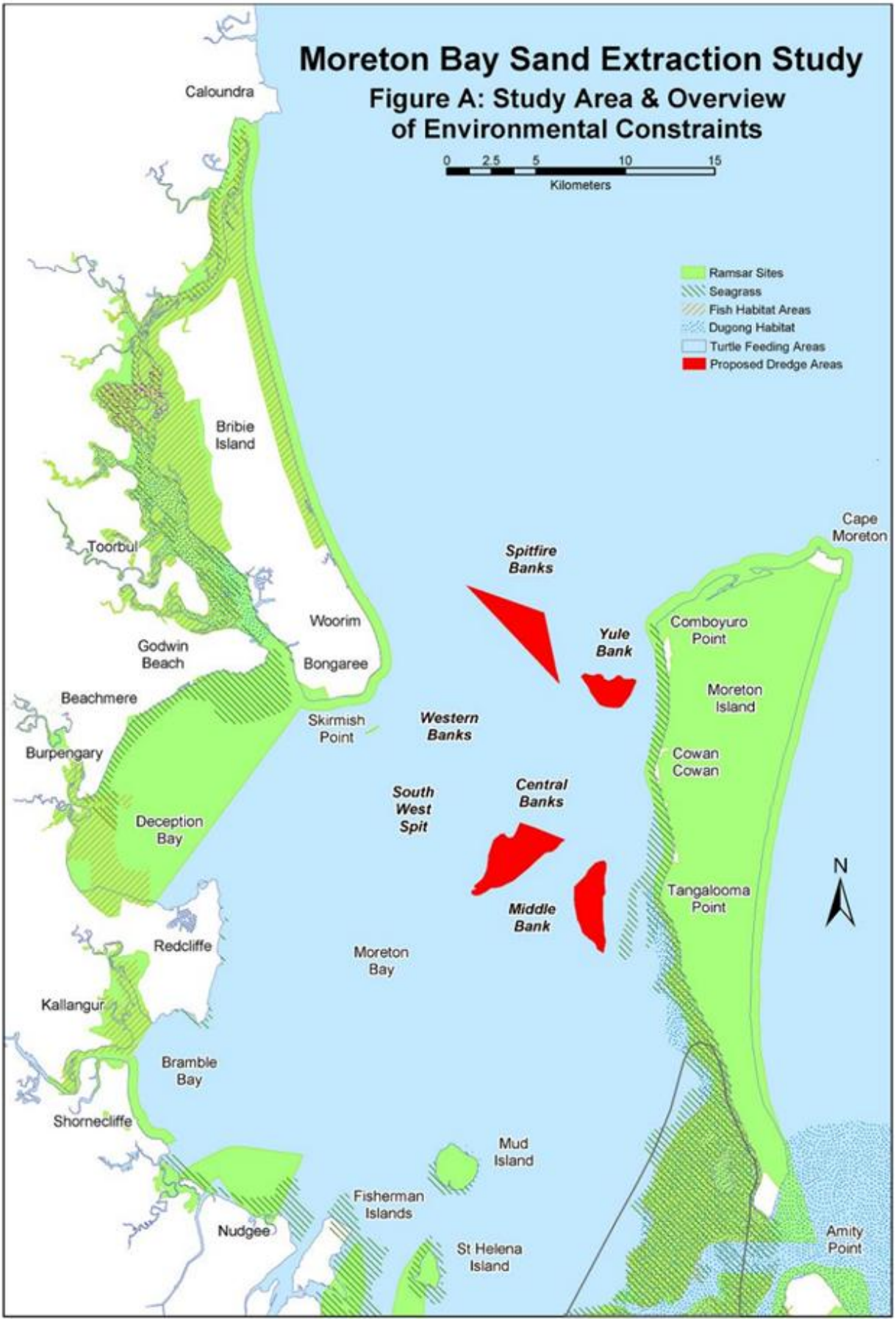


Figure 6: MBSES study area, showing considered extraction areas and environmental constraints [208]

The 2021 *Final Report* provides an overview of key issues arising from approved extraction, and details field investigations at sites preferred for further extraction (Spitfire permit area, Middle Banks and East Knoll). The report was funded by the Department of Environment and Science (DES) and Cement, Concrete & Aggregates Australia (CCAA). Regarding the Spitfire Permit Area, the report advises that:

- A large part of the permit area was below the approved depth limit of -16 m LAT when allocated (2006), particularly the northern and eastern flanks;
- Whilst the MBSES anticipated long term infilling and replenishment of the northern delta, surveys demonstrate little to no local infill or replenishment of sand from natural processes;
- The report attributes this to slow natural replenishment rates, with the northern and eastern part of the delta at Yule Banks and North Banks possibly being preferentially active;
- Additionally, it notes that the deeper shipping channels are likely intercepting some infill.
- It advises that the permissible dredge depth limit of -16 m LAT was extended to -20 m LAT by DES in 2018 due to dwindling sand supplies
- An estimated 7.6M m3 of sand remains at the Spitfire Permit Area above -20 m LAT, which is unlikely to meet projected demand beyond the current allocation period (to 2025).
- Extended dredging depth in this area is possible based on sand characterisation and other investigations (noting some further recommendations to fill gaps) with the following possible yields:
  - Extension to -25m LAT, ~30M m3
  - Extension to -30m LAT, ~41.6M m3
- Consideration could also be given to increasing the allowed depth for the adjacent Spitfire Re-alignment Channel Area to -20 m LAT as a supplementary sand source (current PoB allocation is -17.3 m LAT).

Regarding the Middle Banks area, advice provided includes:

- Brisbane Airport EIS investigations, notably detailed seismic and geotechnical investigations, support a revised footprint of 514 ha, allowing extraction of ~36M m3 based on -20m LAT depth limit, with existing depths ranging from shallow banks (-3m LAT) to deeper channels (-20m LAT).
- Access to these resources is better than the Spitfire area (more protected, closer to stockpiling areas);
- Seagrass cover reported in the EIS (5%) has diminished (<1%); attributed to natural causes;

Regarding the East Knoll area, advice provided includes:

- East Knoll is a potential sand source that would provide shipping navigational benefits;
- Deepening and widening of the current East Knoll Bypass channel area to 1 km wide down to -16 m LAT could provide ~22M m3
- The bulk of the sand volume is in the western part of the area where shallow sand banks are present.

Figures from the report identify the historical (pre-MBSES allocation) extraction areas (vs the MBSES areas shown in Figure 5) and the Investigation areas discussed in the report, which include areas that were not part of the MBSES, including one adjacent to the North West Channel, refer to Figure 7 and Figure 8.

Regarding commercial extraction, activity is reported as roughly approximating the permitted allocation of 1M m3/yr, with industry anticipating similar demand for the next 20-yrs. The report also notes interest from several local government areas for sand to support beach nourishment studies. Sediment sampling (locations indicated on Figure 8) indicates that all of the nominated investigation areas have sand that meets industry specifications, with the exception of the southern extent of the Middle Banks, which has an unacceptably high fines content.

The report advises that sediment sampling was not undertaken at the Northwest Channel Investigation Area, but 2015-16 data provided by the Port of Brisbane confirms high silt and organic content (including indurated sand/coffee rock layers) that make it unsuitable for construction/concrete manufacture purposes. Volume estimates for the investigation areas to various depths are provided in Figure 9.

The report notes that the scale of the northern delta system means sand transport from natural processes is relatively slow and imperceptible. It advises that cumulative volume of sand extracted in the past ~40 years for navigational and commercial purposes (~60M m3) is only ~1.6% of the overall delta system (~3,770M m3).

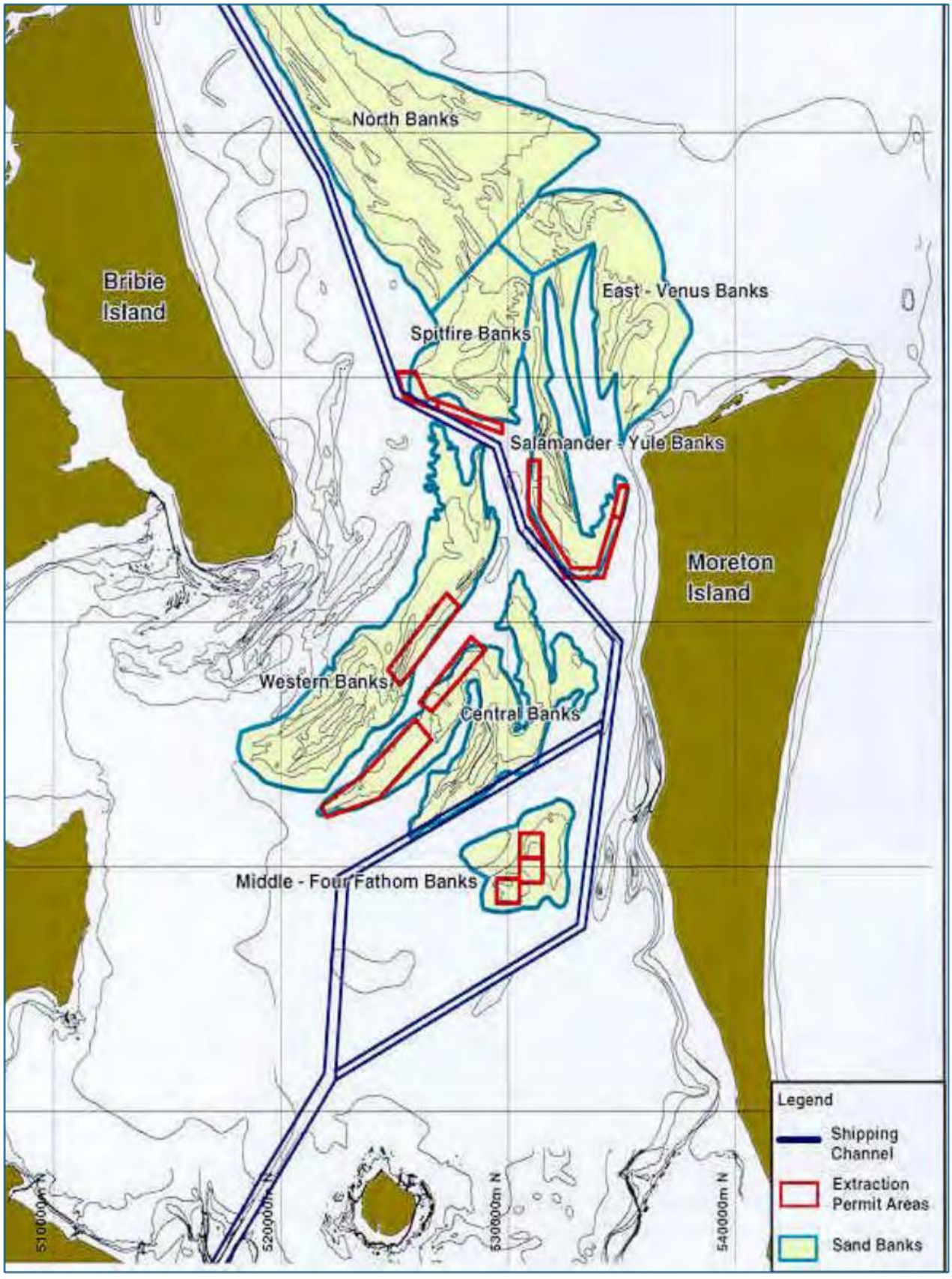


Figure 2-1 Sand Banks within the Northern Entrance Tidal Delta of Moreton Bay, the Shipping Channel Network and the Historical Sand Extraction Permit Areas (Source: PPK 1998)

Figure 7: Historical (pre-MBSES) extraction areas with original source as noted [209]

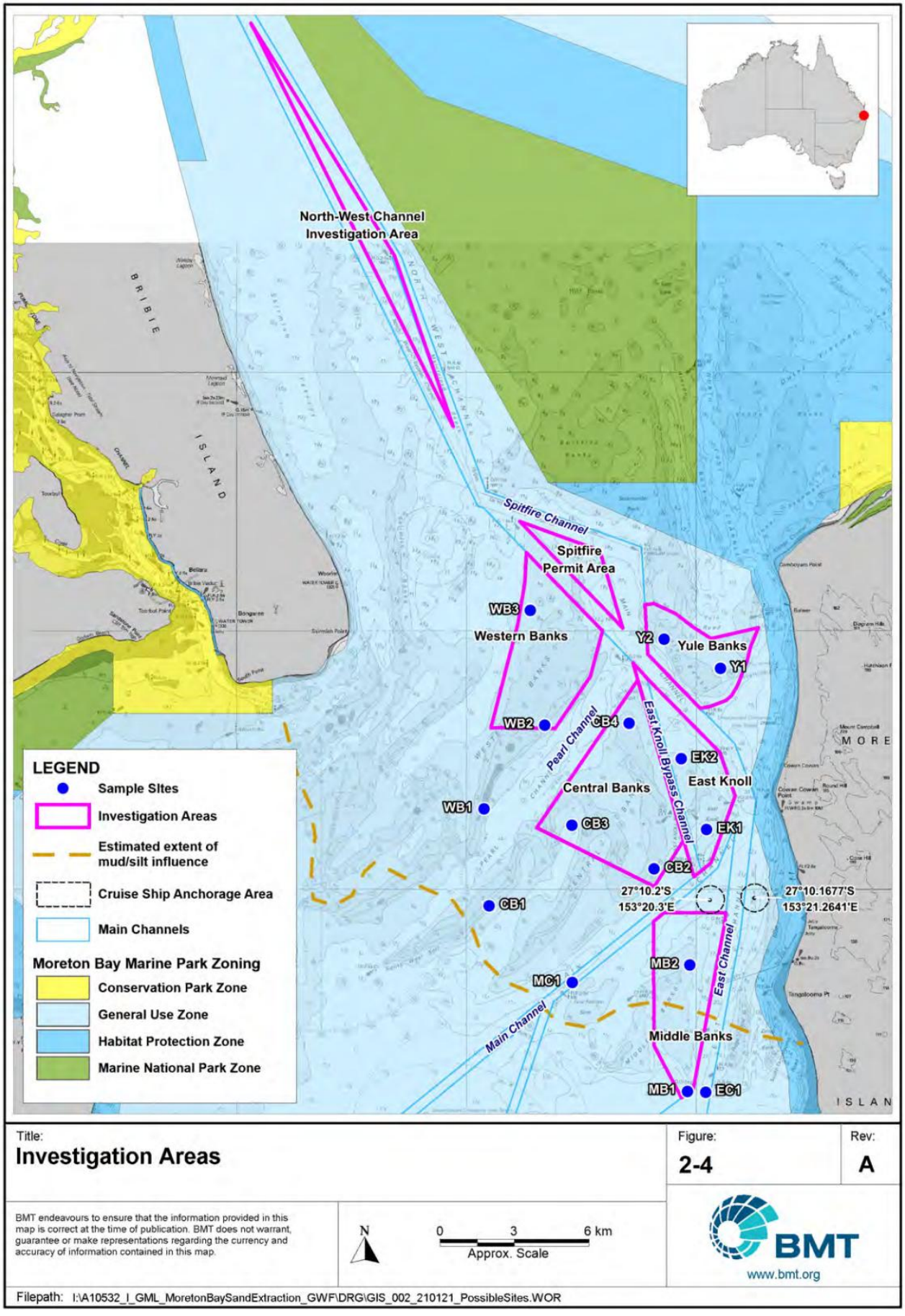


Figure 8: Investigation areas for potential future sand extraction [209]

Table 2-3 Sand Investigation Area Volume Estimates

Investigation Area	Total Area (m^2)	Volume above -16 m LAT (m^3)	Volume above -20 m LAT (m^3)
North-West Channel	6,962,000	6,658,499	27,065,580
Spitfire Permit Area*	3,650,000	841,957	7,957,172
Western Banks	14,250,000	150,478,245	207,351,706
Yule Banks	8,437,000	51,811,947	82,118,177
Central Banks	19,380,000	158,304,074	234,882,115
East Knoll	10,880,000	44,509,266	84,471,986
Middle Banks	12,160,000	32,844,365	67,415,560

**calculations completed by the Port of Brisbane on behalf of Riverside Marine (2020)*

Figure 9: Investigation area volume estimates [209]

The report notes that of the 550,000 m3/yr (current revised estimate) arriving at the Bay delta from the south, ~200,000 m3 /year deposits within the South Passage tidal delta (citing Stephens 1992), with the remaining ~350,000 m3 /year supplying the east and north coasts of Moreton Island, Northern Delta, and potentially further northwards transport beyond Caloundra to Fraser Island.

Multi-criteria analysis (MCA) undertaken and associated sensitivity assessments found:

- The East Knoll Investigation Area scored highest in both unweighted and weighted analyses;
- The Yule Banks, Central Banks and Western Banks all scored about the same but were slightly less preferred compared to East Knoll; and
- The Northwest Channel Investigation Area scored lowest.

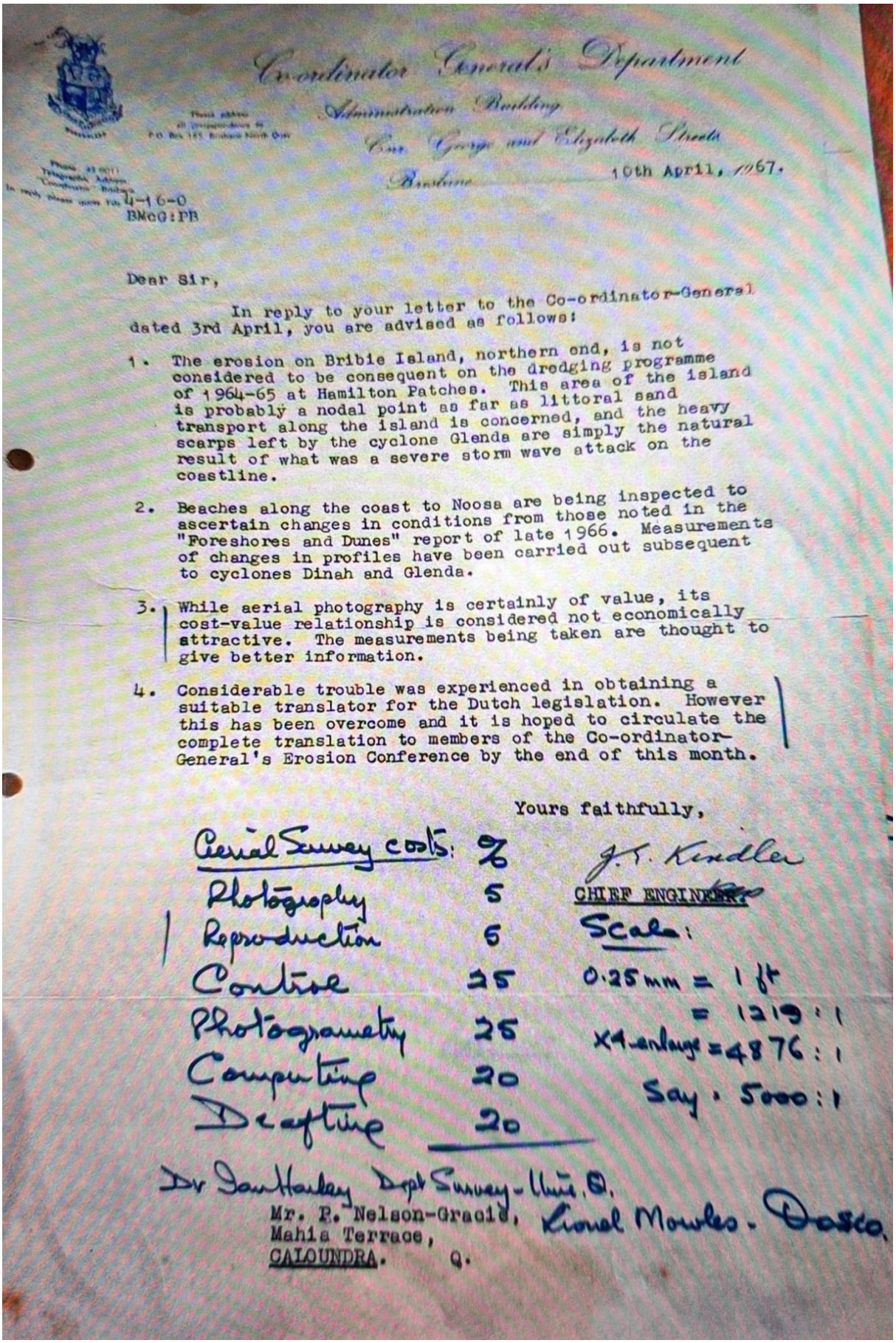
Regarding the Northwest Channel, the report notes that the low score was due to the quality of the potential resource not meeting industry standards, however, in terms of navigational benefits, it ranked highest. The report provides further details on stage 2 investigations for three preferred areas, Spitfire Permit Area, Middle Banks, and East Knoll, supporting the summaries provided above for these three areas.

2.2.3.3 Pumicestone Passage

The DHM History includes two relevant references for this section of the report:

- “To assist trawlers and other small boats based at Caloundra in 1966 the Department dredged a channel through the shifting bars at the northern entrance to Bribie Passage. A special tunnel stern launch was used as a sand-scour and it proved effective in providing temporary access for the launches.” (p.718)
- “In 1971 all old beacons in Pumicestone Passage were removed and replaced by buoys which could more easily be shifted as the channels altered.” (p.621)

Regarding the 1964-65 dredging of the North West Channel, including cutting off the corner of Hamilton Patches, that was discussed above, we did come across correspondence, from the Coordinator General’s Department to Peter Nelson-Gracie. The 1967 correspondence is a reply; we do not have copy of the letter from Mr. Nelson-Gracie, but the reply suggests that Peter, either as an individual or on behalf of the community group he had been involved with (see Part 1) had suggested that dredging may have caused or contributed to the erosion issues at the northern end of Bribie Island, refer to Figure 10.



Co-ordinator General's Department
Administration Building
Cnr. George and Elizabeth Streets
Brisbane 10th April, 1967.

4-16-0
BMcG:PB

Dear Sir,

In reply to your letter to the Co-ordinator-General dated 3rd April, you are advised as follows:

1. The erosion on Bribie Island, northern end, is not considered to be consequent on the dredging programme of 1964-65 at Hamilton Patches. This area of the island is probably a nodal point as far as littoral sand transport along the island is concerned, and the heavy scarps left by the cyclone Glenda are simply the natural result of what was a severe storm wave attack on the coastline.

2. Beaches along the coast to Noosa are being inspected to ascertain changes in conditions from those noted in the "Foreshores and Dunes" report of late 1966. Measurements of changes in profiles have been carried out subsequent to cyclones Dinah and Glenda.

3. While aerial photography is certainly of value, its cost-value relationship is considered not economically attractive. The measurements being taken are thought to give better information.

4. Considerable trouble was experienced in obtaining a suitable translator for the Dutch legislation. However this has been overcome and it is hoped to circulate the complete translation to members of the Co-ordinator-General's Erosion Conference by the end of this month.

Yours faithfully,

J. F. Kindler
CHIEF ENGINEER

Aerial Survey costs: %
Photography 5
Reproduction 5
Control 25
Photogrametry 25
Computing 20
Drafting 20

Scale:
0.25 mm = 1 ft
= 1219 : 1
x4 enlarge = 4876 : 1
Say : 5000 : 1

Dr Ian Harley Dept Survey - Univ. Q.
Mr. P. Nelson-Gracie, Lionel Mowles. Dasco.
Mahia Terrace,
CALOUNDRA. Q.

Figure 10: Coordinator General to P. Nelson Gracie, with advice of 1964-65 dredging at Hamilton Patches (courtesy of PPCMB)

The 2013 *Coastal Processes Study for the Sunshine Coast* [129] includes the following information:

- Dredging of the Bells Creek entrance has occurred since 1970 and provides deep water shelter for small boats. During the 1970s some of the material was used for land reclamation. Surplus dredge material was pumped to the north of the entrance and created a large shoal which has remained relatively stable.
- Dredging in 1973 and 1974 created the anchorage at the Caloundra Power Boat Club (north of Lamerough Canal). The dredge spoil was used as reclamation material to extend Woorim Park.
- Rapid construction of the Pelican Waters canals took place in the early 1990s however aerial photos show the initial canal construction actually commenced in the early 1980s.
- Mangrove clearing and land reclamation works occurred in the early 1980s to create the land where the TS Onslow Naval Reserve is now located.
- An area offshore from the Caloundra Power Boat Club was first dredged in the early 1980s to provide an anchorage area. The ongoing maintenance dredge requirements of this area are uncertain.

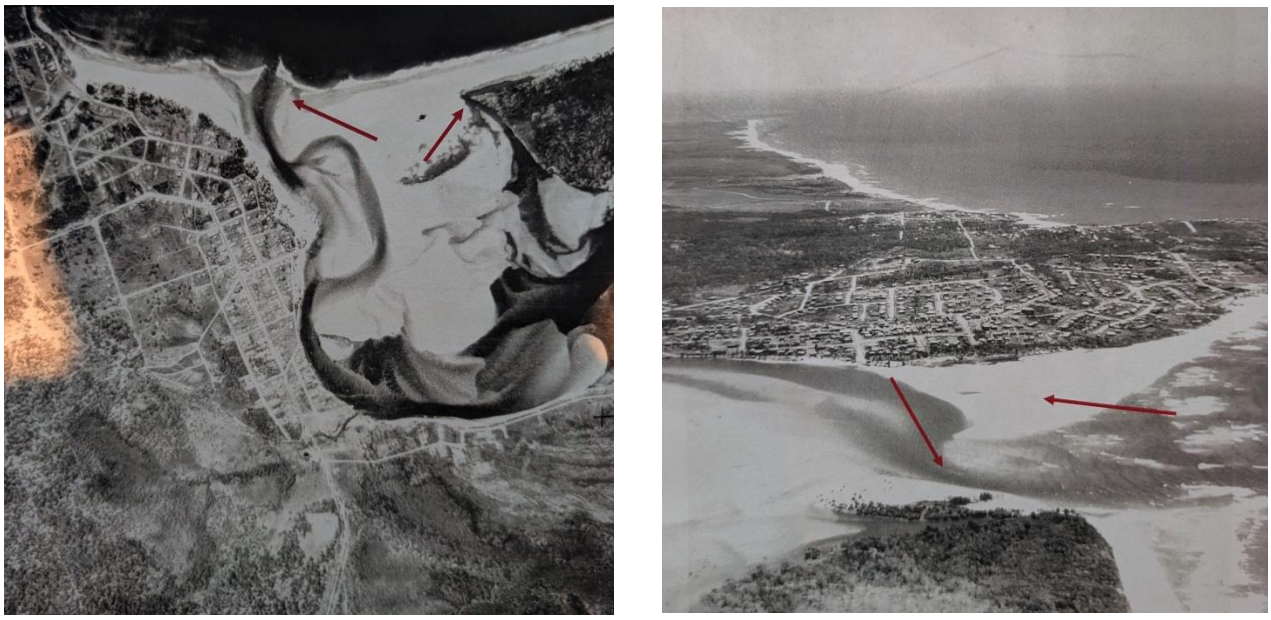
We note the differing dates for dredging of the anchorage in front of the club. These excerpts appear in two different parts of the report. From the text, it appears that there was most likely only a single dredging event, with the exact date uncertain, however, aerial photos provided in 2.3.6 indicate it was there in 1980.

SCC holds an approval to dredge 10,000 m3/yr from within the passage, for nourishment of the foreshores. They have also at times obtained approval to dredge larger quantities (~100,000 m3) on a one-off/project basis. The exact timing and total quantities dredged was not available in the records we reviewed.

Recent dredging to nourish the foreshore in front of the Power Boat Club was observed on site visits during the course of the Review. As documented in previous reports, the foreshore at that location has been severely eroded post-breakthrough. There have also been issues with sand accumulating on the boat ramp to the south of the Club, which may be in part related to these nourishment exercises, and/or the result of sand that has moved into the Passage post-breakthrough migrating into the boat ramp area.

Overall, there is relatively little evidence of dredging within the Passage, with only the one event mentioned above from the DHM History of dredging the bar for navigational purposes. There may have been other instances, but the lack of evidence suggests it has been an infrequent event.

Local historian John Groves has published several histories of the area, including one entitled *Bribie Island Washovers and Breakthroughs* [232] in which he documents a 1933-34 initiative where locals shifted the entrance by hand digging a small channel over the course of a few nights. The story, as he recounts it, is that the entrance in 1933 was hard up against Caloundra headland, with the bar traversing a natural rock shelf, on which the current groyne at King's Beach is built, the rocks adding an extra hazard to the bar crossing. The new channel was dug to the south, at the junction of the vegetated northern tip of Bribie Island and the sand. He provides two photos ('before and after') to accompany the tale, refer to Figure 11.



1933 *1934*

Figure 11: Photos, with arrows by J.Groves, to show shifting of the entrance by enterprising locals [232]

2.2.4 Digital Earth Australia

Digital Earth Australia (**DEA**) is a Commonwealth Government online mapping platform by Geosciences Australia that provides access to coastal datasets, as well as other relevant layers. The data may also be streamed to use in other applications, such as Geographic Information Systems (**GIS**).

The tidal modelling uses an "ensemble process", which assesses different tidal models at any given coastal location to identify the one that provides the best fit with local satellite-observed patterns of tidal inundation, as well as water levels measured by satellite altimetry. A single ensemble tidal output is generated by combining the top three locally optimal models and then used to derive products.

DEA Coastlines provides representative shorelines (at mean sea level) for each year, commencing in 1988, so over 35-years of trend data, for the entire Australian coastline. The products include both shorelines and estimated rate of change.

Figure 12 shows DEA shoreline rates of change for the extended project area. At this scale you can get a sense of areas where the shoreline is retreating (red dots) and where it is growing, or accreting (blue dots), with areas that are relatively stable shown in white. This figure also includes the Australian Hydrographic Office Electronic Navigation Chart (**AHOENC**), which adds an indication of the large shoal areas, including the banks to the north of Moreton Island and offshore from Bribie Island. The North West Channel is also indicated, to the west of those banks. The Brisbane River is visible entering from the lower left of the map.

Regarding Bribie Island, this map shows that significant erosion, or retreat, on the coast side is limited to the northern tip. Most of the area to the south is either stable, or accreting, although towards the southern end, retreat is indicated. Detailed views of the northern tip (to about Egg Island, where the trend shifts from retreat to accretion) as well as the more immediate project area, are shown in Figure 13.

Shoreline positions are shown in Figure 14. This figure is complex; however, it conveys a general sense of the highly variable arrangements – shifting sand – which are discussed further in s.2.3.

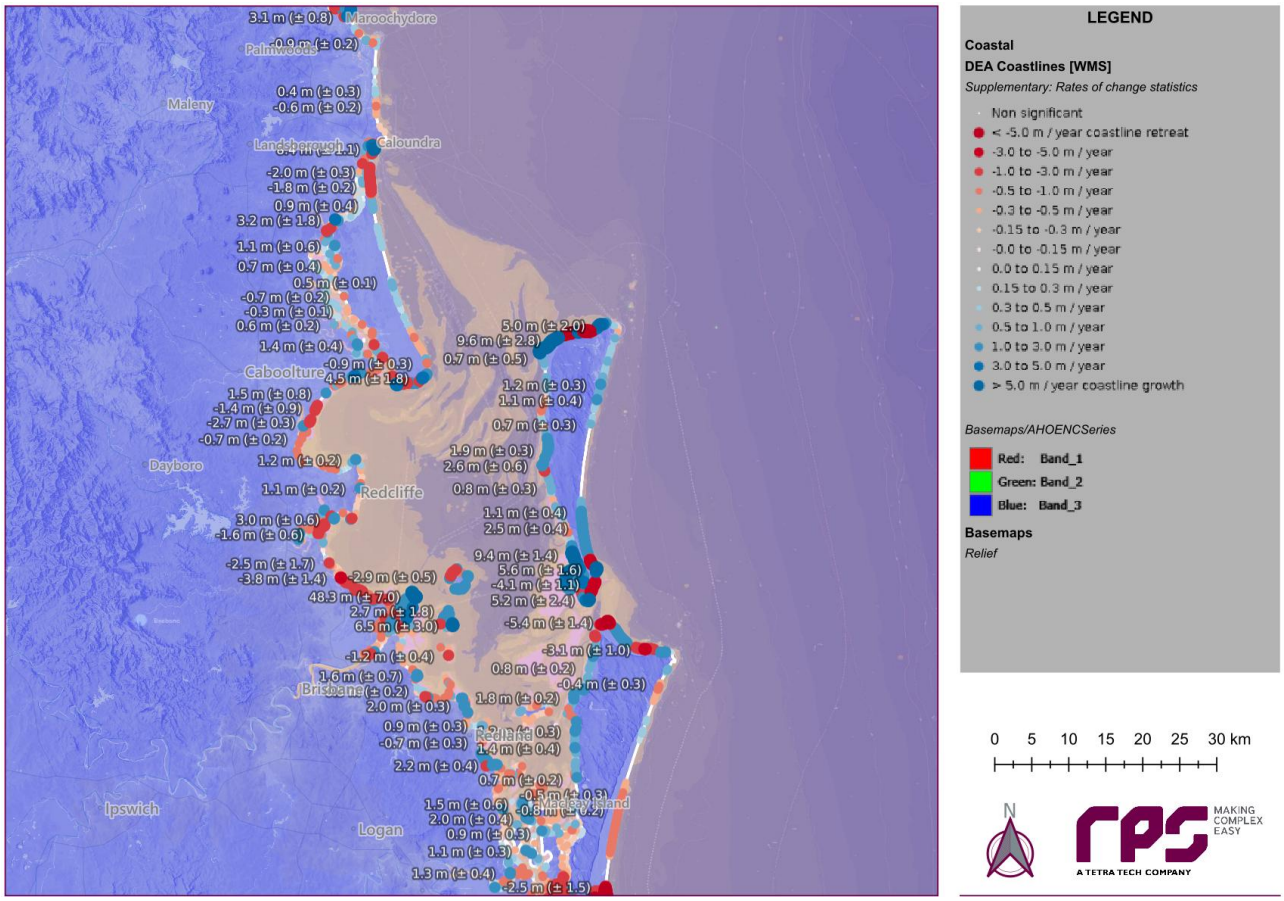


Figure 12: Shoreline rates of change and shoal areas – Overview (DEA + AHOENC – further details in text)

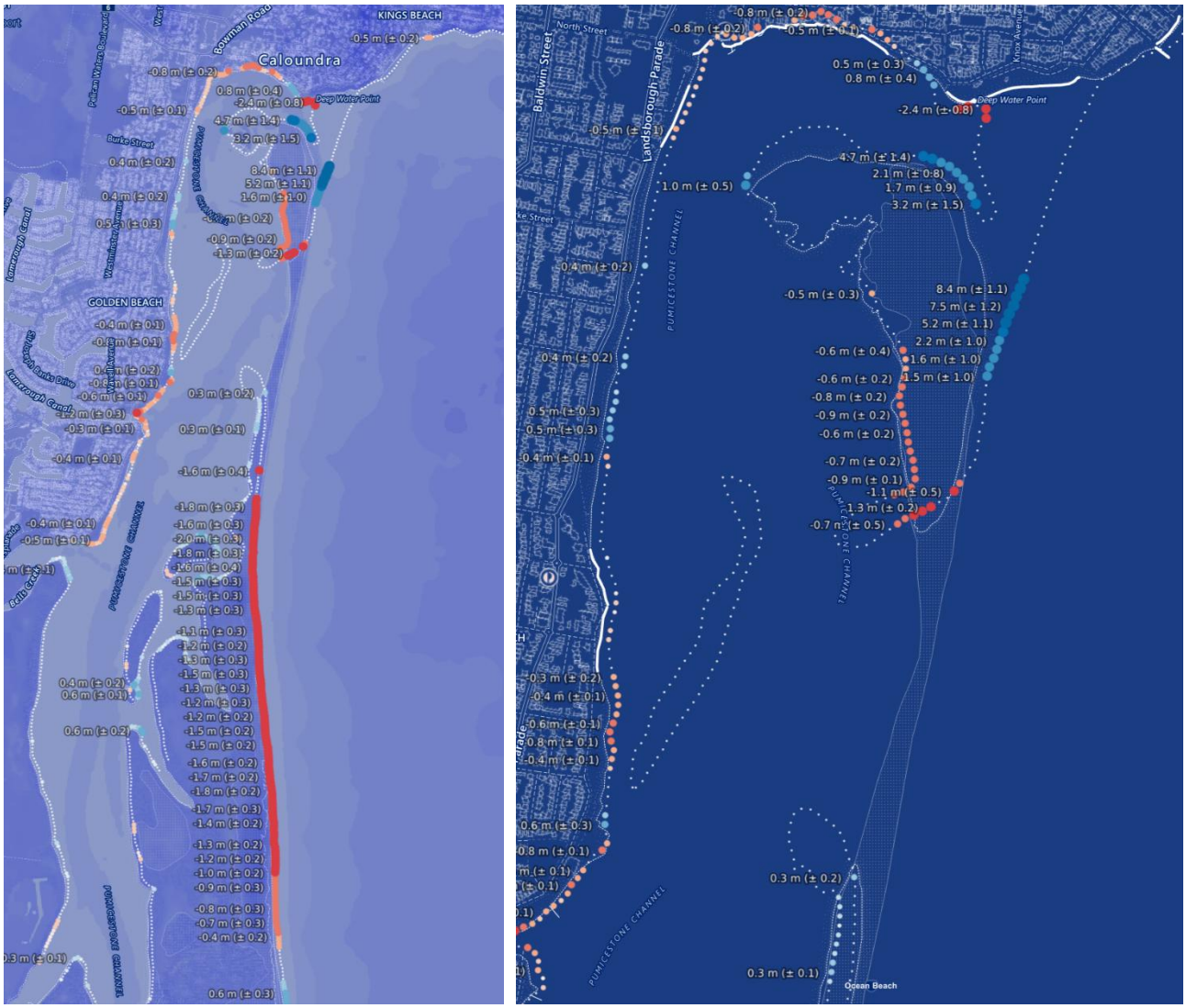


Figure 13: Shoreline rates of change – Detailed views, Northern Bribie (Left) and Project area (DEA)

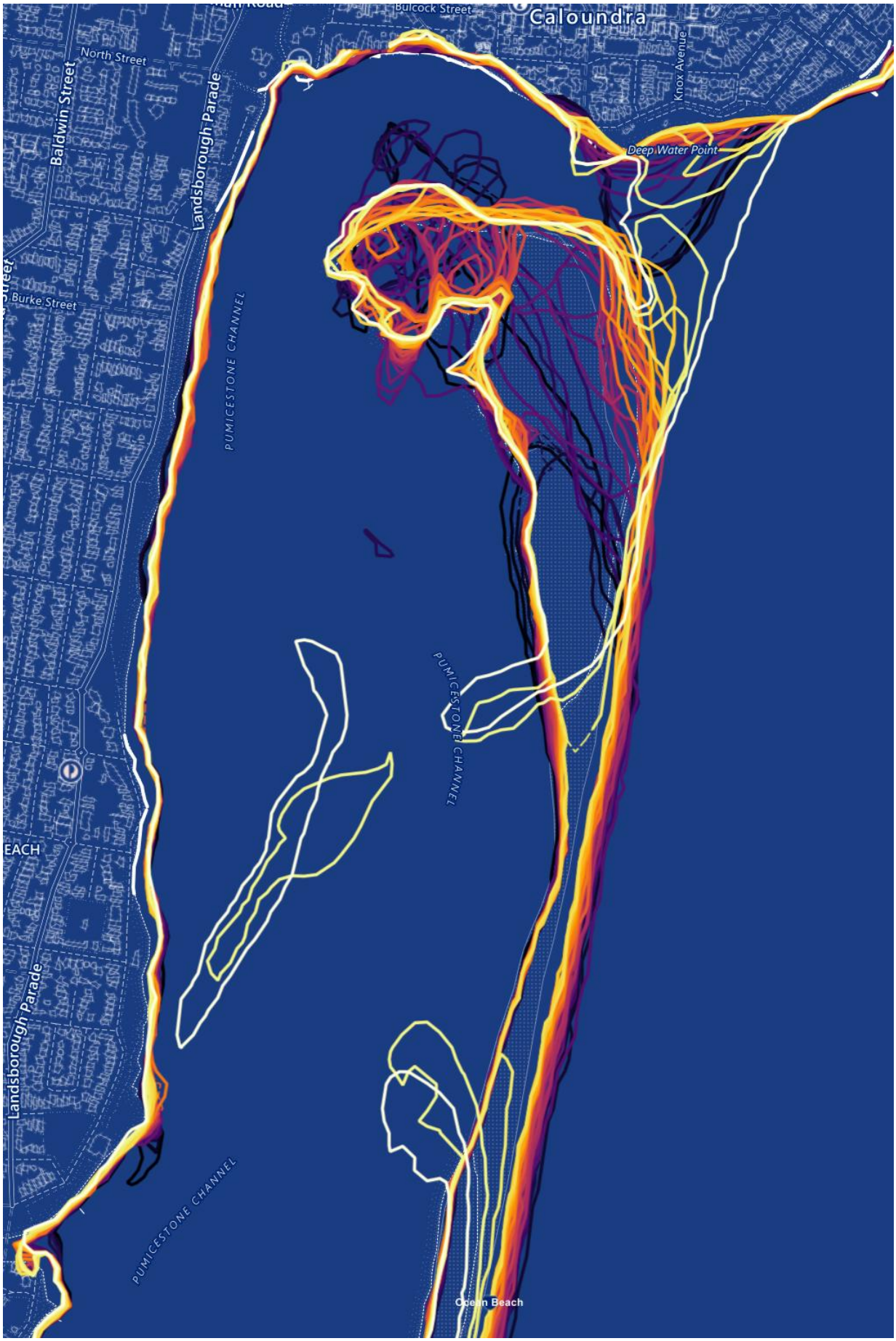


Figure 14: Shoreline positions – 1988 (black) to 2024 (white) (DEA)

2.3 Pumicestone Passage

The preceding section dealt with the 'Open coast', whilst this one is focussed on the estuary. As the two are interconnected, the estuary and entrance are partially addressed in s.0, however, this section delves into deeper consideration of the entrance. Material addressed here also concerns the open coast side of the Island. Structurally, it makes some sense to separate these topics, however, we do so with the caution and acknowledgement that the open coast and estuary are two components of a single system and management should holistically include consideration of the integrated whole, including the broader components that may be outside the boundaries that may be appropriate to apply at a project level, versus planning at the program/policy level.

2.3.1 Review

The review in s.2.1.1 is generally inclusive of material discussed in Part 1 that pertains to both the open coast and the Passage, however, the following summary from the 2013 Coastal Processes Study is repeated here as an introduction:

- Tidal currents dominate the sand transport in the northern section of Pumicestone Passage. The flood tide transports sand from north to south with flood tide sand transport observed in aerial photography as far south as Bells Creek.
- The small prevailing waves within the passage work the sand onto the shoreline. The existing geofabric sand container groynes at Golden Beach have accumulated sand on their southern side. This indicates a net northern sediment transport direction in the nearshore region, primarily driven by the small prevailing south easterly waves.
- Mangrove clearing and land reclamation works between Bells Creek and Lamerough Canal appears to have commenced in the late 1950s. This relatively low lying land is now dominated by residential development and is part of the Pelican Waters community.
- Dredging of the Bells Creek entrance has occurred since 1970 and provides deep water shelter for small boats. During the 1970s some of the material was used for land reclamation. Surplus dredge material was pumped to the north of the entrance and created a large shoal which has remained relatively stable.
- Dredging in 1973 and 1974 created the anchorage at the Caloundra Power Boat Club (north of Lamerough Canal). The dredge spoil was used as reclamation material to extend Woorim Park.
- Mangrove habitat was removed to the south of the Club and replaced with narrow sandy beaches (Riedel and Byrne, 1979).
- Rapid construction of the Pelican Waters canals took place in the early 1990s however aerial photos show the initial canal construction actually commenced in the early 1980s.
- Mangrove clearing and land reclamation works occurred in the early 1980s to create the land where the TS Onslow Naval Reserve is now located. Today this area suffers shoreline erosion problems.
- During 2007 and 2008, concrete blocks were used to defend the shoreline at the Naval Reserve. This material type is inappropriate and likely to accelerate local shoreline erosion problems.
- The area north of Oxley Street including Leach Park has been protected by a rock wall since the mid 1960s. Geofabric groynes have been unsuccessful in stabilising a beach in this area. These groynes have recently been formalised by rock however it remains unlikely that a beach will form in this area until the main channel migrates offshore (possibly driven by morphological change at the entrance).
- Bulcock Beach has remained relatively stable due to the control provided by the rocky outcrop around Deepwater Point. Bulcock Beach is observed to widen and extend to the east when the channel entrance migrates toward the south.
- Significant change along Nelson Street to Earnshaw Street shoreline has occurred, generally in response to the changes to the Pumicestone Passage northern entrance and flood/ebb channel morphology.
- Since 1999/2000 this section has been stabilised by a geofabric sand container groyne field. Prior to stabilisation, Riedel and Byrne (1979) described some of the changes along this section associated with the migration of the flood and ebb channels (*discussed further below, s.2.3.4*)

2.3.2 Estuary dynamics

Coastal wetlands, including to varying extents estuaries, can be considered as a transitional, temporary, ephemeral ecosystem, compared to something like a mature forest ecosystem, which may be considered an 'end state'. Nature is cyclical, with evolution a constant and inherent 'strategy' to respond to periodic 'catastrophic' events such as volcanic eruptions, earthquakes, severe storms and bushfires, as well as longer-term events such as geologic processes, including littoral transport on a more immediate as well as longer-term processional scale, reversals in the earth's magnetic field, plate tectonics, and climatic cooling/warming cycles that result in sea level fluctuations.

Natural succession is a term used to describe the process by which ecosystems transition. As discussed in Part 1, sea levels were higher in the relatively recent past, and the Moreton Bay estuary at that time was different, arguably 'better' or 'optimal'. Sea levels have also at times been lower and the present day offshore banks are potentially deltas from a previous era. Estuaries such as Pumicestone Passage are ephemeral in that they arose as a result of sea level fluctuations, and they are naturally subject to transitional or successional processes.

Depending on the catchment condition as well as rainfall and other factors, estuaries/coastal wetlands are likely to steadily shoal – to act as a 'sediment sink'. As discussed in Part 1, historically higher sea levels were likely associated with higher rainfall, but less sediment transport due to heavily vegetated catchments; and, more recent times have included both reduced rainfall, affecting vegetative cover, and extensive clearing, as well as transition of catchments to uses such as agriculture and grazing that promote erosion and mobilisation of sediments, which progressively move 'downstream'. Coastal estuaries are terminal points for this transport, the 'end of the line' (so to speak, nature continues to 'shift sand').

Coastal estuaries may evolve to 'braided floodplains' – relatively flat areas with numerous small channels, that shift alignment in response floods and other factors. Along the shoreline, vegetation such as mangroves may trap sediment and shorelines may steadily extend into the waterways. In response, channels may become more defined – deeper and fewer in number. Marshes may become meadows and then woodlands, with the defined channels becoming rivers, and adjoining riparian vegetation and open woodlands may evolve into forests.

Shallower parts of estuaries may resemble this situation, and even where there are deeper waters, particularly near the estuary mouth where it joins the sea, sand bars may form and exhibit a similar process of periodic rearrangement. Areas above high tide, as well as intertidal areas, are subject to vegetative colonisation, with birds, other wildlife and wind assisting with propagation. The vegetation may promote the accumulation of sand, both wind-blown and delivered by tides and wind waves.

Just like a braided floodplain, severe events may remove vegetation, but over time progressive islands may evolve, spits may extend, etc. Those features may impact the movement of tidal flows and, similar to the floodplain, more defined channels may develop, and shift over time. For the project area, The Skids represents a location where tidal flows are reduced and the waterway is relatively narrow and shallow, conditions that promote sedimentation. These conditions support successional process could result in the formation of a land bridge to the island, separating the southern and northern parts of the Passage.

The concept of succession acknowledges transitional processes that are likely to occur, observable. Such changes may not occur in some situations, and the process may include 'false starts', with severe weather or other disruptions resulting in 'one step forwards, one step (or two) backwards'. Change is generally inevitable, but when and how varies. The discussion that follows provides evidence of how these transitions may have occurred within the project area.

2.3.3 Historical maps (1842-1995)

The chronological collection of historical maps provided below illustrates how the northern tip of the island has been perceived and depicted over time. Some of the figures are 'authoritative' (e.g. based on survey), whilst others may be of questionable or uncertain accuracy (possibly relying on previous renditions).

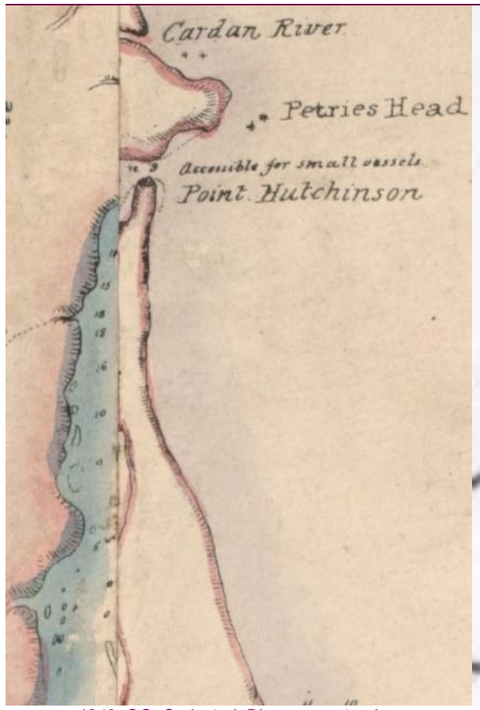
Prior to 1940, as well as at times thereafter, the northern tip of Bribie Island is typically shown as a narrow, north/south aligned, 'finger'. Thereafter, a bulbous tip emerges (and then disappears again), transitioning to a kink or dogleg, with the tip pointing inwards, to the northwest.

The entrance and channels can also be seen to transition. A prominent channel along the northern shoreline is predominantly present, but at times a prominent spit can be seen extending southwards from Deepwater Point, with the channel bending around it towards a more southerly mouth.

Similarly, sandbars are shown on many of the maps and transitions in arrangement is suggested. Further discussion regarding this, as well as additional evidence, is provided in subsequent sections. Regarding the labels that are provided below each image, as well as in similar materials presented in this part of the report, a few explanatory conventions and additional source notes regarding Table 1 are provided below.

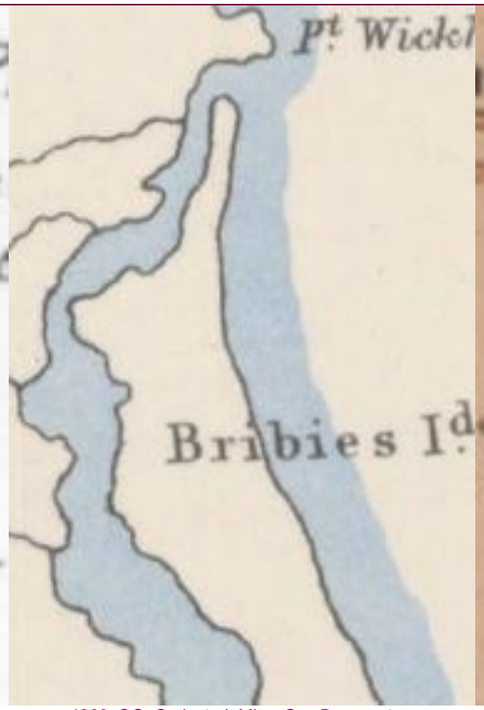
- The first part of the label is generally the date (Year and, in some cases month)
- An underscore is generally included to separate the date from the 'author' –
  - QG – Queensland Government
    - May be followed by a "-" and abbreviation for a department, e.g –
      - DHM for Department of Harbours and Marine
      - QT for Queensland Transport
      - TMR for Transport and Main Roads
  - GBHD – Great Britain Hydrographic Department
  - CTH – Commonwealth
- The remainder of the label is a title and/or descriptor; the following notes may apply –
  - "Cadastral" is an official QG plan related to land parcels
  - "Topo" refers to a topographic map, which typically includes elevation or other relief details
  - For DHM charts, the survey number as shown on the plan is provided
- The majority of these maps are available online –
  - A guide to historical maps and links is provided here: Historical topographic maps | Recreation, sport and arts | Queensland Government
  - The process is logical, once you get the hang of it; the following guidance may help –
    - Access QLD Globe as instructed, including launching the topic
    - When the topic launches, all of the layers will be loaded and turned on, but you may not see anything
    - Find your area of interest and the use the information tool to search a point or area
    - The search results will include all of the relevant maps for your area of interest
    - Explore the detail of each result and you'll get links to preview or download
    - The preview won't occur in QLD Globe, it will open a new window and show an image
    - Download and preview have similar results, but the preview may be lower resolution
    - If your bandwidth and data download quota are not an issue, just download instead
- The DHM surveys are generally not available online (although a few are in the State Archives collection)
- All of the images below and in subsequent sections have been cropped to show a common area of interest and aspect ratio (2:3). The general goal was to include the jetty south of Lamington Canal in the lower left corner, and the Kings Beach groyne in the upper right corner. However, in some cases the area may be larger, or smaller, based on the quality and/or extents of the source image.
- Images are high quality, as possible, so on many you can zoom in on the computer to see details.

Table 1: **Chronological collection (1842-1995) of excerpts (northern Bribie Island and Pumicestone Passage) from historical maps, including bathymetric charts (various sources, see text for further description of included content)**



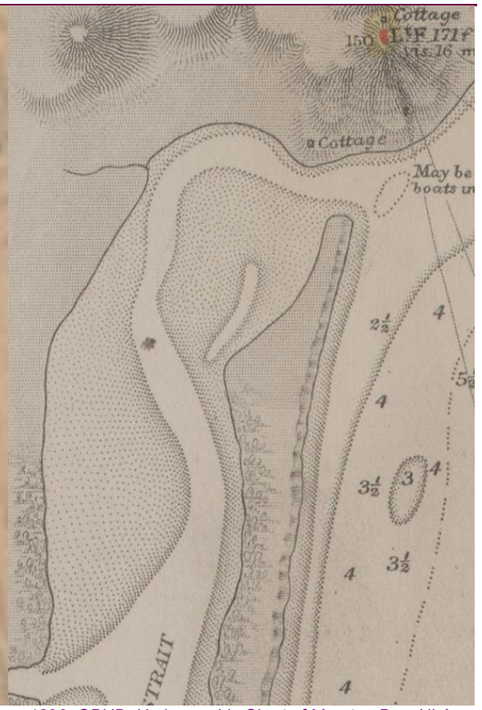
1842_QG_Cadastral_Dixons-moreton-bay

1846_QG_Cadastral_Bakers-moreton-bay-map

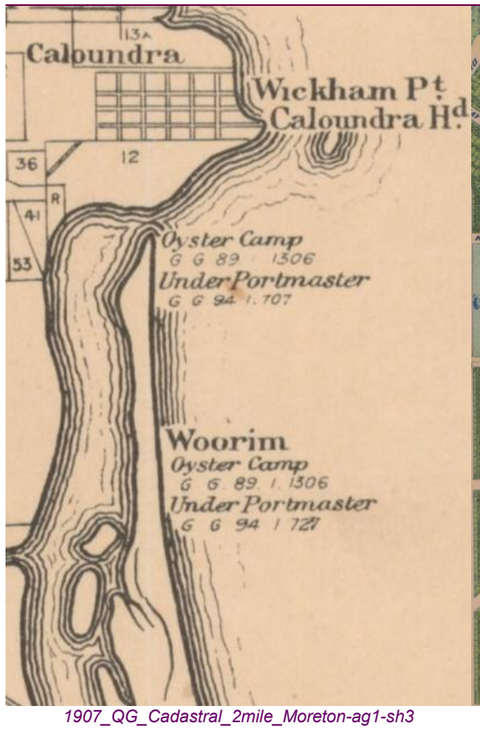


1860_QG_Cadastral_Misc_Gov Bowens-tour

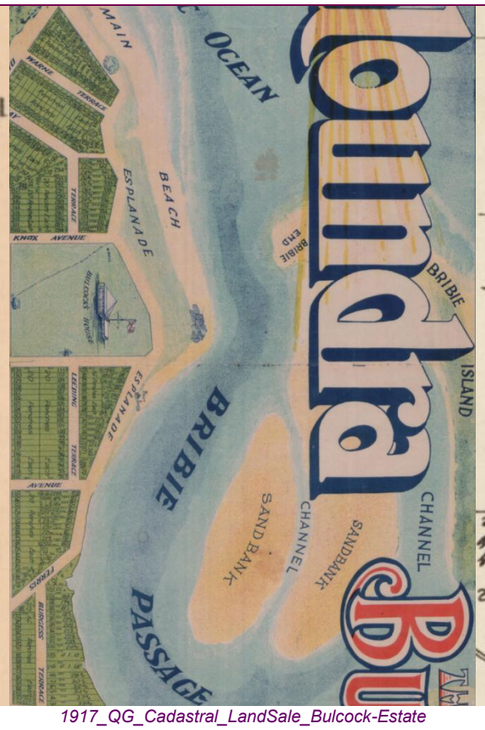
1893_QG_Cadastral_Catchments



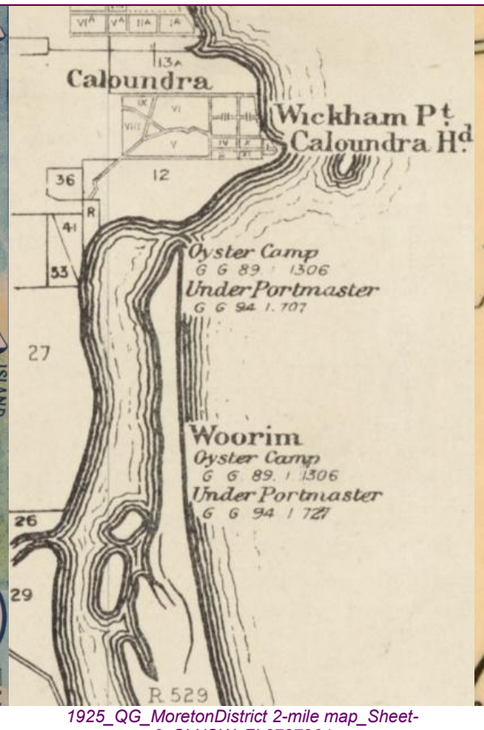
1896_GBHD_Hydrographic Chart of Moreton Bay_NLA-230057663



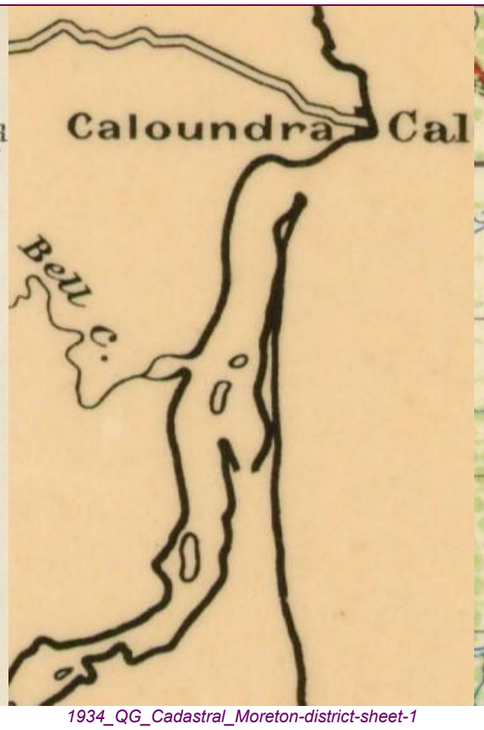
1907_QG_Cadastral_2mile_Moreton-ag1-sh3



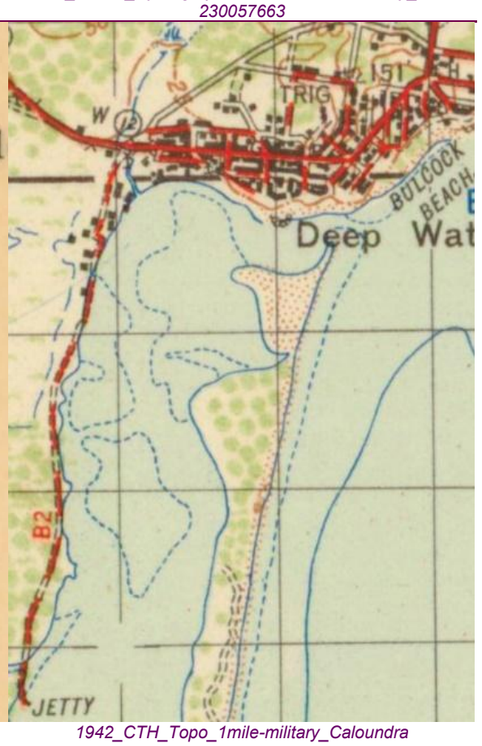
1917_QG_Cadastral_LandSale_Bulcock-Estate



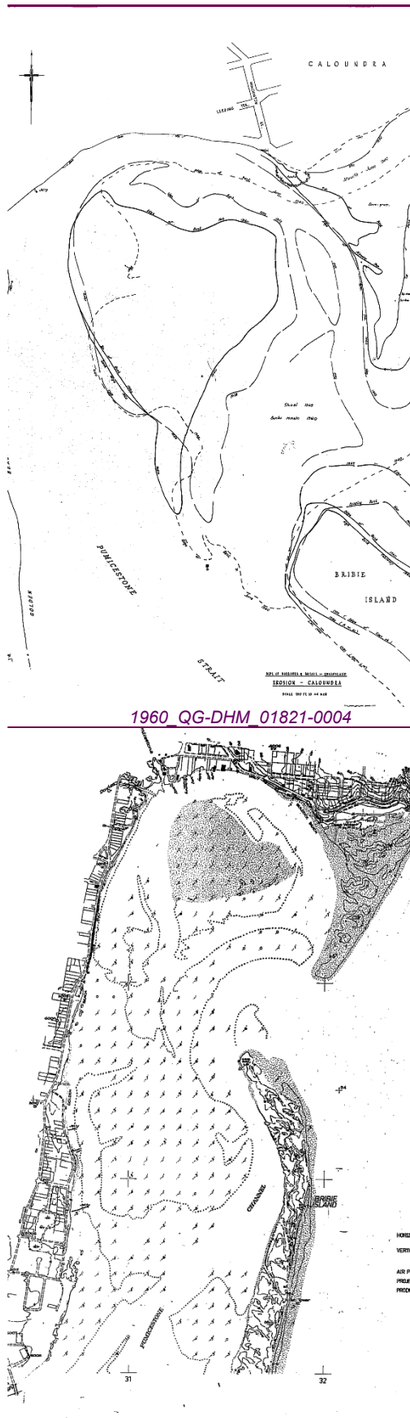
1925_QG_MoretonDistrict 2-mile map_Sheet-3_SLNSW_FL8787364



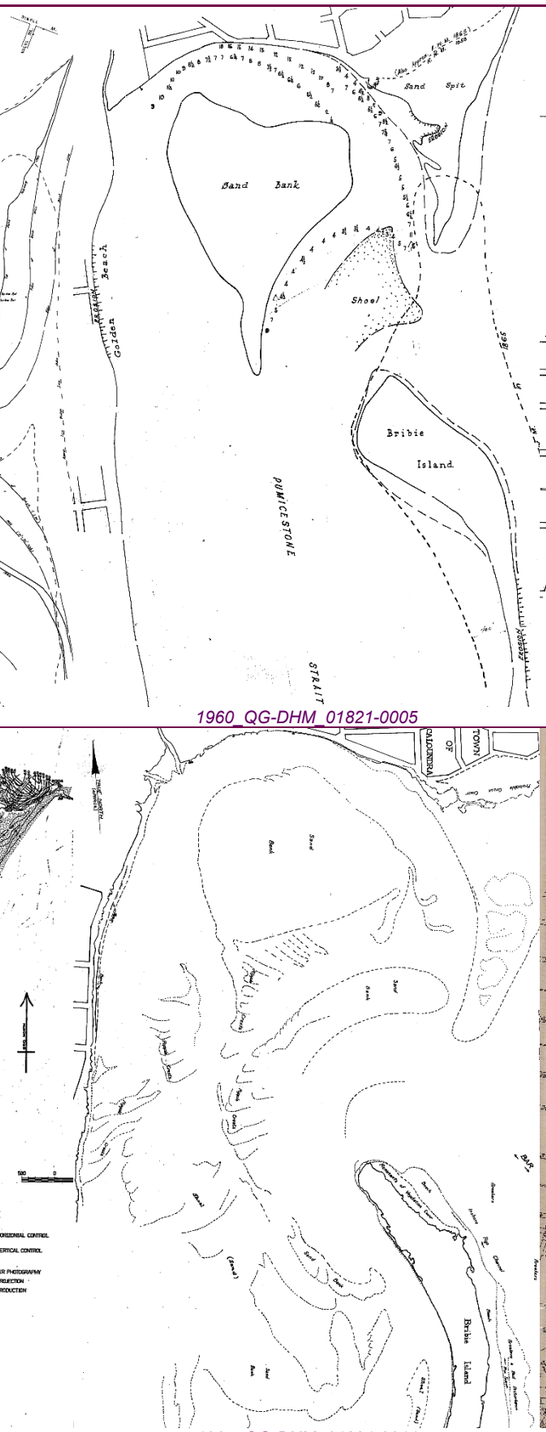
1934_QG_Cadastral_Moreton-district-sheet-1



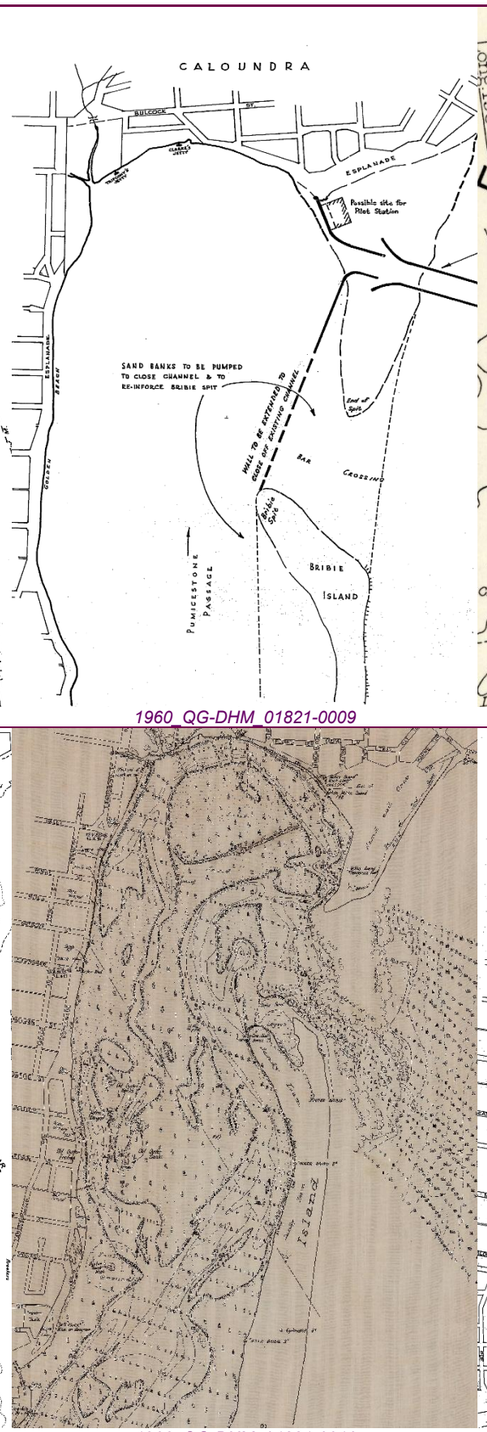
1942_CTH_Topo_1mile-military_Caloundra



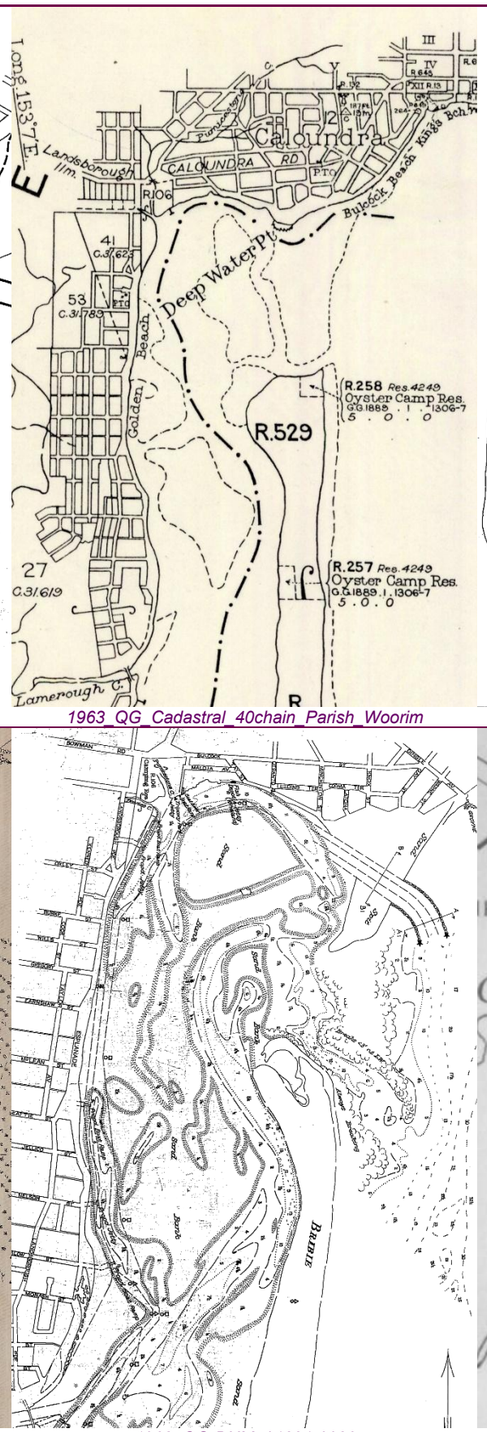
1960_QG-DHM_01821-0004



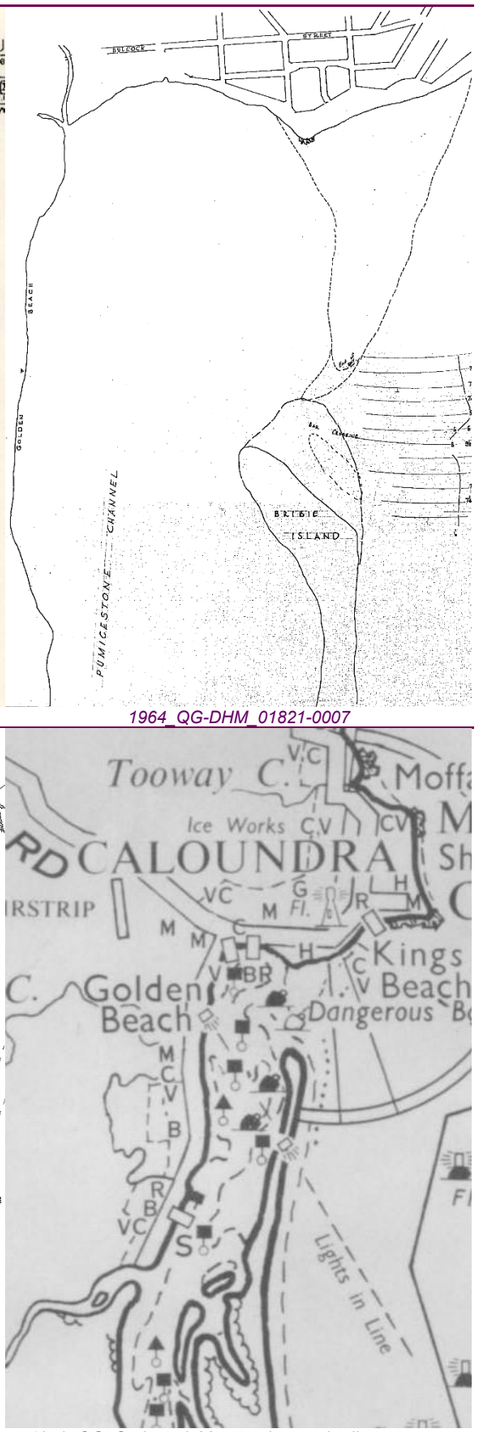
1960_QG-DHM_01821-0005



1960_QG-DHM_01821-0009



1963_QG_Cadastral_40chain_Parish_Woorim



1964_QG-DHM_01821-0007

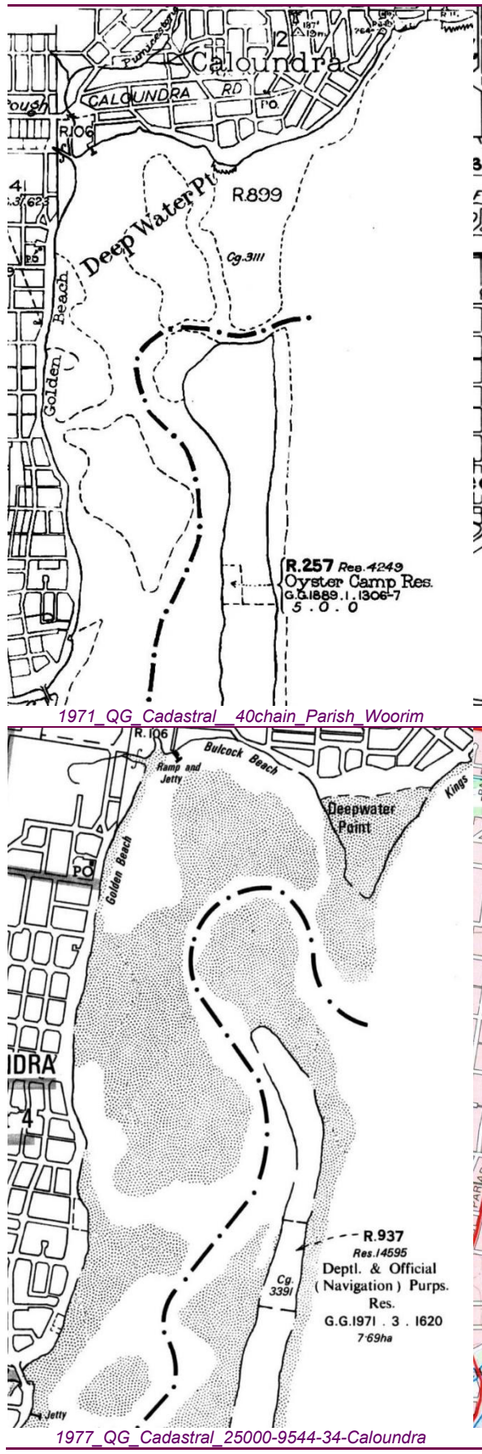
1964_QG-DHM_01821-0019

1965_QG-DHM_01821-0011

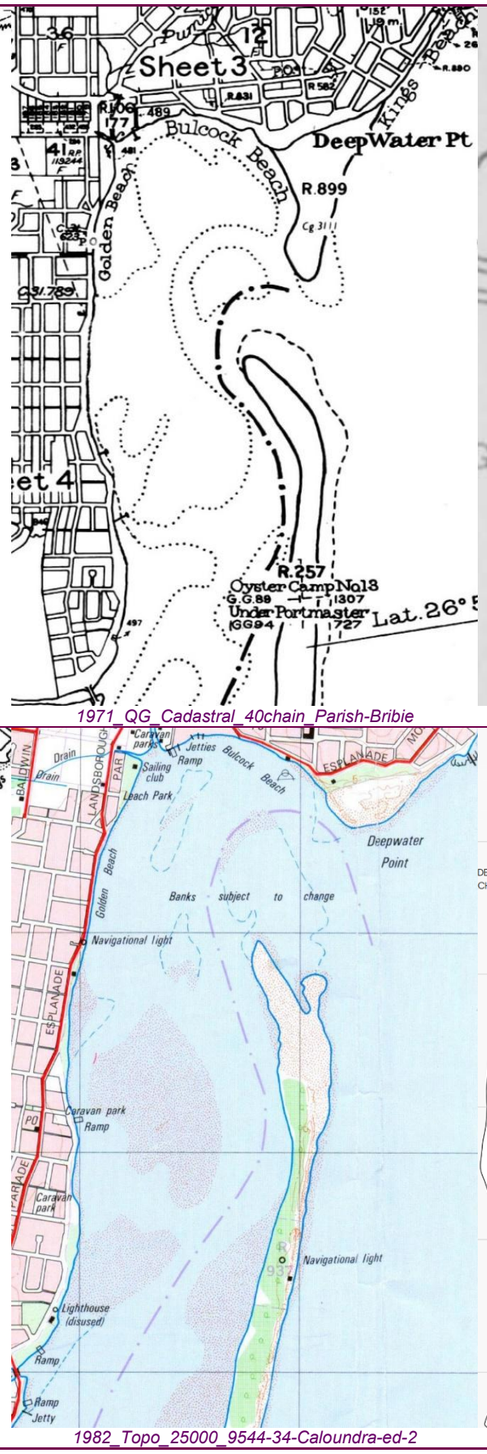
1966_QG-DHM_01821-0016

1968_QG-DHM_01821-0020

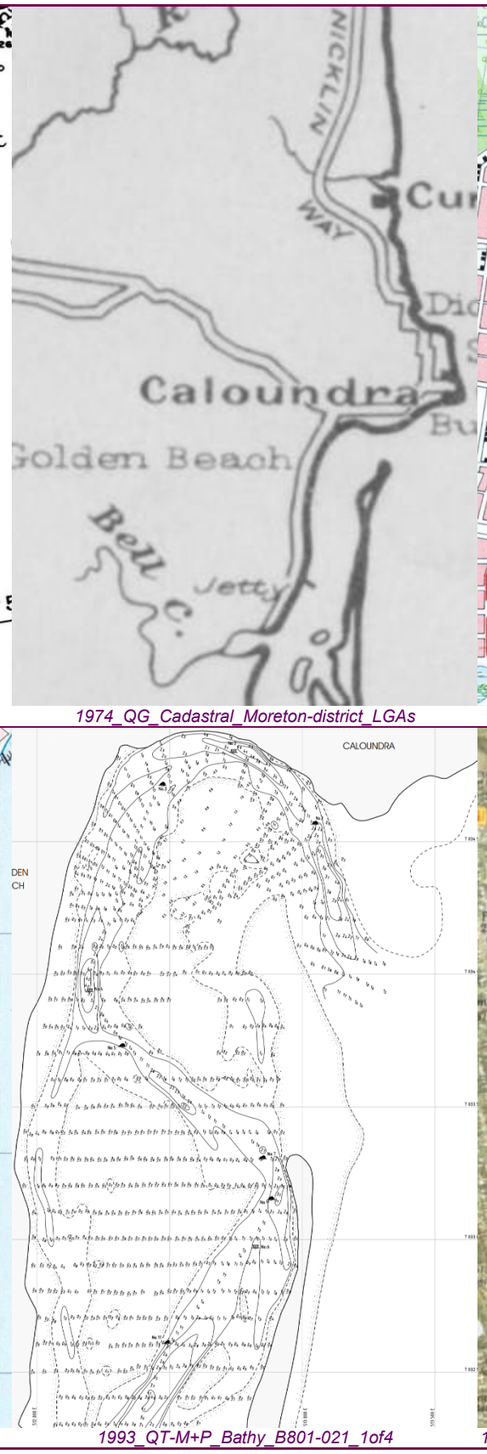
1970_QG_Cadastral_Moreton-bay-and-adjacent-areas



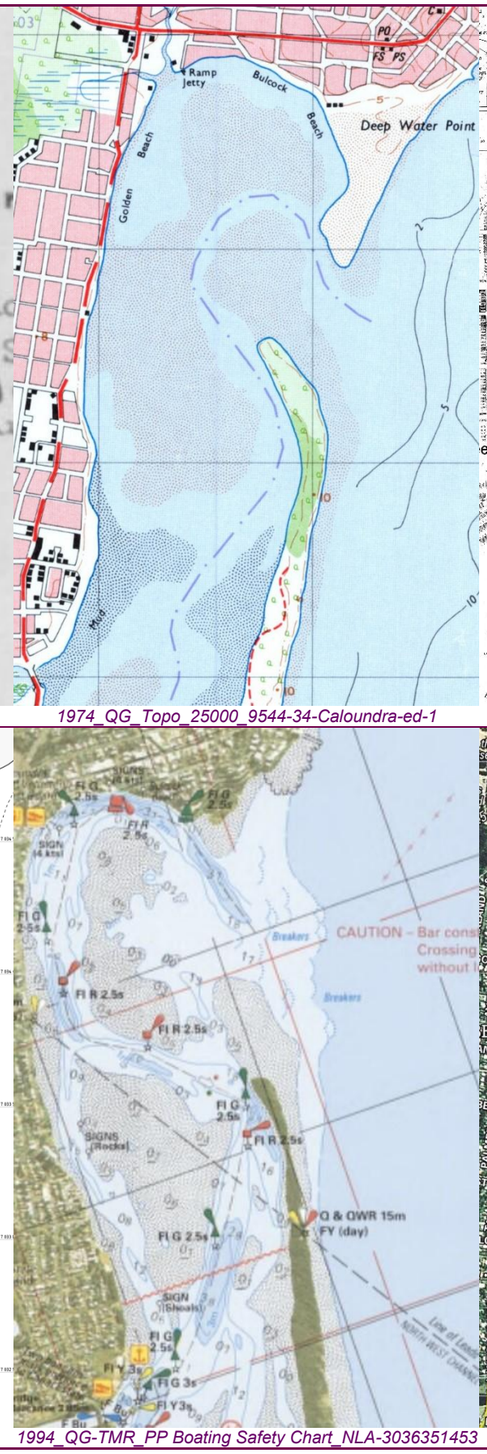
1971_QG_Cadastral__40chain_Parish_Woorim



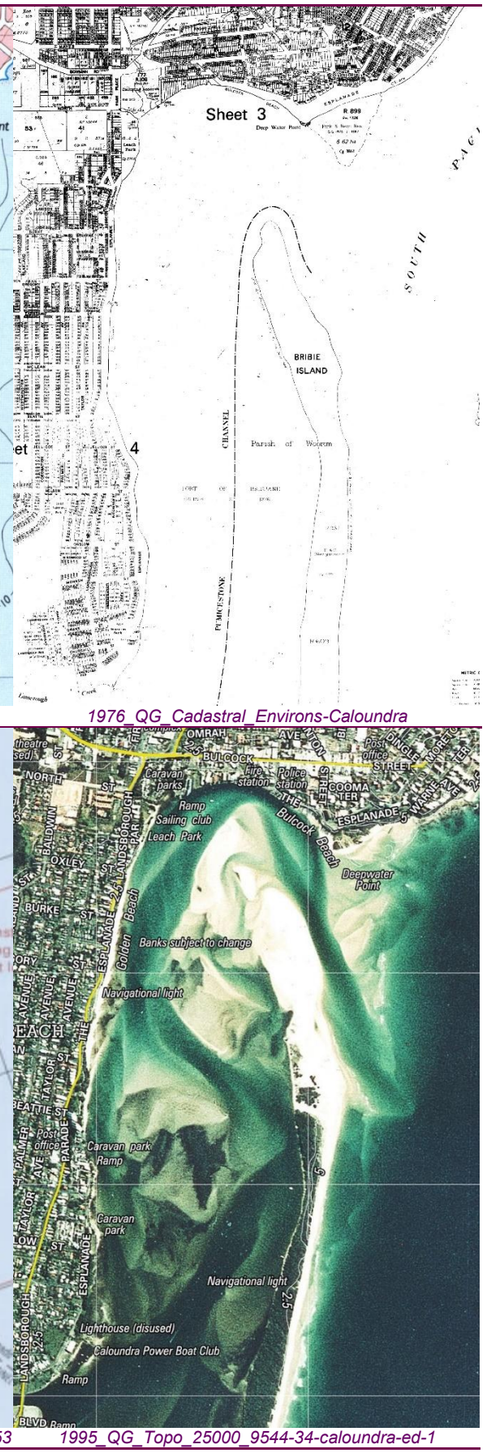
1971_QG_Cadastral_40chain_Parish-Bribie



1974_QG_Cadastral_Moreton-district_LGAs



1974_QG_Topo_25000_9544-34-Caloundra-ed-1



1976_QG_Cadastral_Environs-Caloundra

1977_QG_Cadastral_25000-9544-34-Caloundra

1982_Topo_25000_9544-34-Caloundra-ed-2

1993_QT-M+P_Bathy_B801-021_1of4

1994_QG-TMR_PP Boating Safety Chart_NLA-3036351453

1995_QG_Topo_25000_9544-34-caloundra-ed-1

2.3.4 1980s – Pelican Waters (Henzell's)

Part 1 introduces observations from Riedel & Byrne 1979 (s.7.4). A narrative description of changes to the estuary over time based on analysis of aerial photos was included, but we noted that the accompanying figures were not included, as the document scan we sourced had low quality images. We have not been able to source the full Riedle & Byrne document, however, we have located a 2016 report that includes better quality images from the original report, *Pelican Waters Southern Lake – Tidal Prism Review* (Cardno). [211]

We were also able locate an additional earlier source, *Report on Tidal Dynamics of the Caloundra Estuary*, submitted in 1987 [212]. The 2016 report provides relevant information regarding tidal planes post-development and should be considered as part of any detailed planning that may eventuate. For the purposes of this review, the 1987 report provides more detailed insight regarding historic conditions.

The 1987 report notes that an Environmental Impact Study (EIS) was submitted in 1984 for "Henzell's Canal Development at Golden Beach, Caloundra" (Benzell's also appears in the document, but this appears to be a typo). The 1987 report is a revised submission, providing the results of 6-years of monitoring, including 3-years prior to the 1984 submission (the basis of the Riedel & Byrne 1979 report) that informed the 1984 EIS submission, as well as an additional 3-years of monitoring between 1984-87.

The report acknowledged various reviewers and contributors, including Prof. C.J. Apelt, University of Queensland and Mr. R. Jarvis, Department of Harbours & Marine. Gratitude is also provided to "Dr. P. Riedel for suggesting the use of orthogonal aerial photographs for establishing erosion tendencies on Bribie Island prior to the commencing of ground survey in 1980."

Overall, this report provides the most comprehensive and robust discussion of the dynamics of the northern Pumicestone Passage that we were able to locate. As will be discussed further in this report, the estuary dynamics are a critical component of this system, and we suggest they have been given inappropriately short attention in the literature we've been able to source. Considering the relevant importance of these processes, they should be central to future management planning. We provide the following excerpts:

- The most significant finding from analyses of the monitoring data is the magnitude of naturally occurring changes and the relative rapidity of these changes.
- This report makes a distinction between changes which are generally cyclic (such as shifting of the Caloundra Bar) and changes which appear to be irreversible (such as erosion on the Passage side of Bribie Island).
- The cyclic changes affect the tidal range in the northern part of Pumicestone Passage and thus tidal flow at the Bar.
- The recorded Spring Tide Range at the Caloundra Jetty in 1978 was about 28% greater than in 1985. The corresponding tidal flows at the Bar were not recorded, but their variation would have been of the same order as the recorded variation in tidal range.
- (In addition to these long-term changes there are the short-term changes due to the phases of the moon, with peak rate of flow during mean neap range being only some 50% to 60% of the peak rate of flow during mean spring range.)
- Four separate types of monitoring were carried out in the years 1980-1986 on behalf of the Applicant:
  - aerial photography
  - ground survey
  - tide gauging
  - hydrographic survey and flow measurements.
- *[Aerial photography]* was carried out largely by Cardno & Davies using charter aircraft, but aerial photographs flown by others were also used.
- Photographs of the northern end of the Passage were taken obliquely in such manner that streets at Golden Beach and landmarks at Caloundra and on Bribie could be used as references for orthogonal plotting of shoals and channels.
- In all, twelve flights were made by C&D during the six years of monitoring. *[Dates listed, generally 6-montly although with gaps, variations, etc., but coverage of different times/months of the year.]*

- *[Ground survey]* was carried out by T.H. Jensen & Bowers, Authorised Surveyors, under direction of Cardno & Davies.
- Survey marks were set on mainland beaches and on Bribie Island and were tied together by electronic measuring devices to permanent marks on the mainland.
- The correlation of the survey marks on Bribie to permanent marks on the mainland proved to be a prudent precaution as the marks set on Bribie were lost twice due to progressive erosion.
- Arrangements were made to monitor beaches on the mainland and on the Passage side of the island, but survey of the mainland beaches was not continued because works on and adjacent to the beaches made it impracticable to establish any coherent patterns.
- *[Seven survey dates are listed, generally annually, but none in 1982 nor 1984, and three in 1983.]*

The report includes the following discussion of the 1979 *Pumicestone Passage Water Quality & Land Use Study* (discussed in Part 1 [061]):

Regarding the Pumicestone Passage "Prototype & Model":

  - Pumicestone Passage is a tidal channel linking Bongaree to the Caloundra Bar, a distance of some 45 km.
  - It may be thought of as consisting of two estuaries joined at an area known as The Skids.
  - The southern (Bongaree) estuary responds to the tides in Deception Bay in a manner typical of a shallow estuary without a bar, but its behaviour at its northern end .near The Skids is modified by the connection to the Caloundra estuary.
  - The response of the northern (Caloundra) estuary to the ocean tides is governed by the Caloundra Bar, but is also influenced by its connection in the south to the Bongaree estuary.
  - The hydrodynamic model is a "fixed boundary" model, i.e. the geometry of Pumicestone Passage as determined by soundings and surveys, was coded and has become "The Model" proper. The once established geometry was not changed again during the investigation to simulate the behaviour of the mobile prototype. This representation of a mobile system by a fixed-boundary model is satisfactory for the purpose for which the model was set up but it is difficult to represent realistically hydrodynamic changes (be they natural or man-made) on the model since the prototype is mobile.

- *Regarding model "Calibration and Verification":*
  - The whole of Pumicestone Passage is relatively stable, with the sole exception of its northern end, i.e. the channels and shoals off Golden Beach and the Caloundra Bar.
  - All relevant figures in ref. 2. carry the notation: "Passage in 1978 condition", indicating that not only the calibration but also the findings of the model are applicable to the 1978 state of the Passage.
  - The caveat "Passage in 1978 condition" could therefore also be expressed as "Caloundra Bar in 1978 condition".
  - Monitoring of the northern end of Pumicestone Passage during the years from 1980 to 1986 indicates that the Bar has changed very considerably during that period and that the 1978 condition reported on in Ref. 2. represents very nearly one extreme in the cyclic movement of the Bar.
- *The "Summary of Findings of the Model Study" include:*
  - "The physical character of the Passage and differences between the tides at either end result in a nett tidally-induced flow through it, averaging about 1.8 million cubic metres per tidal day of 25 hours, and this is very important in terms of water quality." *[quoting finding from the 1979 study]*
  - "Increasing the tidal compartment at the northern end by the construction of extensive canal estates north and south of Bell's Creek would slightly decrease the computed nett flow and affect water levels north of The Skids by up to 60 mm. The effects on velocities at Caloundra Bar were not studied, but these would probably have been appreciable."
- The model was also used to simulate the effects of wind setups by raising the whole tide at either end of the Passage. A rise of the tide at Bongaree by 0.2 m, more than doubles mean nett flow in a northerly direction. A rise of the tide at Caloundra by 0.2 m however changes the normal nett mean flow to the north to a small nett mean flow in a southerly direction. These effects were achieved by raising the

whole tide by a certain amount, but no tests were carried out simulating a reduction in tidal range at one end but not at the other, i.e. the type of change observed.

Commenting further on the findings of the 1979 study the report includes:

- Effects canals would have on the model - as described in the Water Quality & Land Use Study - have been computed using a fixed-boundary model. These modelled effects are therefore not a realistic description of the actual effects canals would have on Pumicestone Passage.
- The primary modelled effect of the canals is a sizeable reduction in tidal range of the Caloundra estuary.
- The real processes are markedly different, for the following reasons:
  - (a) The cross sectional areas of tidal channels in the Caloundra estuary (which are for all practical purposes fully mobile) are determined:
    - by tidal flows during spring tides;
    - by the grain size of the in-situ material.
    - These two parameters are connected to each other by a certain velocity which lies at the limit between non-scouring and scouring velocity of the in-situ material.
    - It follows that a moderate increase in the tidal compartment (such as e.g~ the addition of a section of Henzell's canal) will cause - within a few tidal cycles - an increase in the cross sectional area of the tidal channels proportional (for all practical purposes) to the increase in tidal flow.
    - The actual responses of Pumicestone Passage to the addition of a canal differ from the computed responses of the fixed-bed model in the following manner:
      - In Pumicestone Passage the addition of a canal section will have the following effects:
        - the cross sectional areas of the tidal channels will increase approximately in proportion to the increase in tidal compartment;
        - tidal velocities in the tidal channels will remain approximately the same as before; the tidal range in the Caloundra estuary will remain approximately the same as before.
      - From the Model, on the other hand, the following effects were inferred:
        - the cross sectional areas of the tidal channels will remain constant following an increase in the tidal compartment;
        - tidal velocities will increase;
        - the tidal range in the Caloundra estuary will be reduced.
  - (b) As the tidal range in the Caloundra estuary will not be affected by the canal, in any noticeable way, neither will the nett through-flow be affected to any measurable extent.
  - (c) That changes in tidal velocities at the Bar due to the construction of Henzell's canal will be very small indeed, is confirmed by the computed velocities set out in Section 2.4 herein before.
- However, natural changes in the Caloundra estuary have been recorded in the past few years, which are several times the magnitude of the changes which will be due to Henzell's canal.
- In 1985/86 the tidal range in the Caloundra estuary was substantially smaller than it was in 1978 when it was measured and subsequently used for model calibration.
- Early indications in 1986/87 are that the process might be reversing and that the tidal range is again on the increase.

Discussion is provided regarding revised tidal modelling, with data from the 1979 study that was not available at the time of the EIS (although the EIS followed some years after the 1979 study the text notes that the data was not available at that time) improving the model parameters, and adjustment also made for the observed changes in the tide range that are described above.

Further advice from the report concerns consideration of mapping of shoals within the estuary, from historical aerial photos as well as aerial photos taken as described above, by Riedel & Byrne. These figures are provided below, refer to Figure 15 and Figure 16.

Regarding Figure 17, we have combined the 24 individual figures (each on a single page in the original report) into a “poster” and added additional text to accompany them. That additional text includes our estimate of size of the shoals shown in each figure and calculations based on those measurements to show the rate of change. That information is not provided in the original report and our measurements and calculations should be considered a ballpark estimate, rather than definitive. Regardless, the accuracy should be sufficient to conclude overall trends – a net increase in shoaling, most likely due to an import of sand (flood tide delta) although there are years where the system ‘flushes’, creating an increased ebb delta.

As summarised in the footer, during the 47.5 year period, the average rate of change in the mapped shoal areas was 2.1%/yr, with an estimated net increase of 332,000 m2, or about 30% by areal extent.

The discussion below from the report relates to the panels in Figure 16 that show the labels from the source (lower right corner) I/10 and I/20:

- in 1978 the main entrance channel to the estuary was short and wide, offering little resistance to tidal flow and resulting in relatively large tides;
- In 1984 the main entrance channel was long and narrow, causing relatively larger energy losses and hence smaller tides.
- These two configurations of the main entrance channel are not necessarily the extremes, but are likely to be nearly so.

Regarding “Irreversible changes” the report includes the following advice:

- A third type of change has been recorded, however, which appears to be irreversible, namely progressive erosion on the Passage side of Bribie Island.
- This erosion extends over a length of more than one kilometre, from approximately opposite Churchill Street in the south to approximately opposite McLean Street in the north
- Section H on Drawing No. 290/2-D is a good illustration of this progressive process:
  - The total erosion (measured at either the top or the bottom of the bank) is about 10 m between the first survey (15/10/1980) and the most recent one (11/7/1986), a period of some 68 months. The average annual rate of erosion is thus about 1.75 m.
  - However, as shown on Fig. 4, the rate of erosion appears to accelerate from a relatively moderate 0.85 m/y over the initial 2.5 years to 4.0 m/y between the last two surveys.
  - The highest rate of erosion of 5.6 m/y was recorded in 1983 and was probably caused by a flood of an estimated recurrance period of 1:20 years which occurred in about mid-1983.
  - The period of July 1985 to July 1986 was, however, quite calm and the erosion at 4.0 m/y would be caused almost exclusively by tidal flow alone.
- As the period of monitoring erosion by ground survey is relatively short (approximately 5.5 years) conclusions based thereon could be misleading. Consequently we have collected all available orthogonal aerial photographs, the earliest one having been flown in 1940. After correlating for scale, we have scaled the width of vegetation in an E-W direction at locations in the close vicinity of Section H on Drawing No. 290/2-D.
- The results are plotted on Fig. 7. and are quite astonishing:
- The width of established heavy vegetation (which is a reasonably reliable measure of the width of the island) has decreased from about 142 m in 1940 to about 44 m in 1986 at an average rate of about 2.1 m/y during a period of 46 years.
- The fastest decrease in width was measured between 1972 and 1974 and amounted to some 28 metres or an average of 14 m/y during two years, with a maximum rate of nearly 20 m/y in early 1974 (presumably due to cyclonic storms).

The figures referred to above are provided in Figure 17, Figure 18 and Figure 19. We also plotted those Cardno lines to compare them to the breakthroughs. Perhaps not surprisingly, as they were presumably measuring the narrowest width of the Island, the arc of the stations corresponds to the location of the first breakthrough, however the high correlation of the extent – with the arc nearly identical to the recent extent of breakthrough #1, is visually striking. Some photographic plates from the report are also included, refer to Figure 21 and Figure 22.

Regarding “Proposed Analytical Work” the report includes these interesting observations:

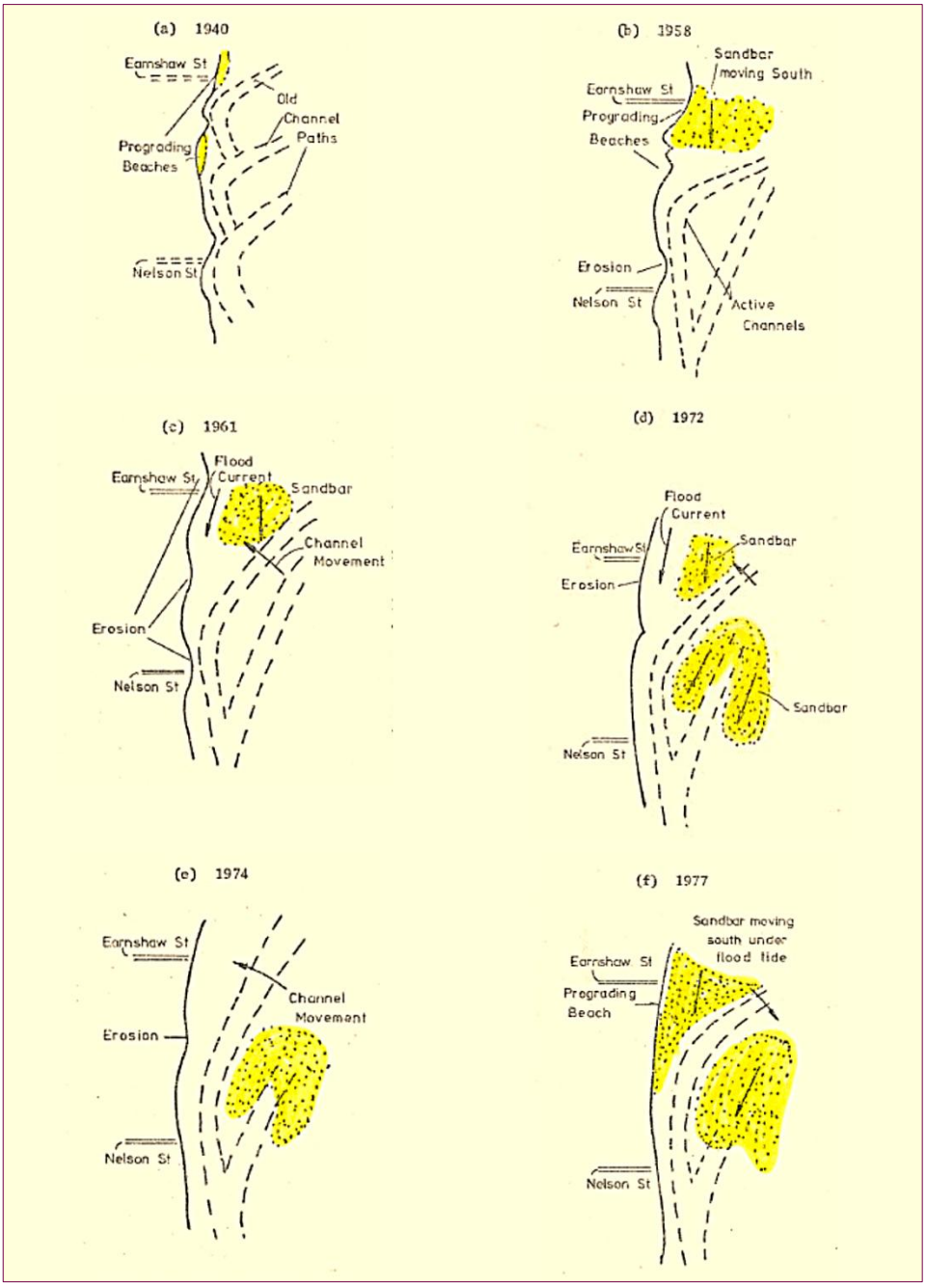
- Some apprehension may be felt about applying the simple but very nearly correct assumption that the cross sectional area of tidal channels within the estuary generally will increase approximately proportionately to increases in tidal flows, also to the eastern channel which is situated adjacent to Bribie Island and causes the erosion.
- Velocities in the eastern channel were measured at two stations, marked E and F in Appendix II. On Fig. 5 are plotted the velocities measured at Stations E and F at a depth of 0.5 m below the surface. On Fig. 6 are plotted velocities measured at depths ranging from 1.5 m to 4.0 m below the surface.
- Both plots show that on the flood tide the higher velocities occur at Station E (i.e. in that part of the channel remote from the island) and on the ebb tide the higher velocities occur at Station F (i.e. in the part of the channel closer to the island). This phenomenon indicates that the assymetrical velocity distribution in the eastern channel is more likely to be due to the configuration of the approach channels at both ends, rather than to the curvature of the eastern channel itself.
- If this explanation were found to be correct, the erosion on the island would be due predominantly to high but generally one-dimensional flows, rather than to the helical flows associated with curved channels. In this case, the increases in tidal flows due to the canal would result in approximately proportional increases in the waterway area of the eastern channel, in the same manner as elsewhere in the estuary.
- In any case, it is considered that - irrespective of whether the canal is constructed or not - some remedial measures will need to be taken in the not too far future to prevent further erosion on the island.

The final “Conclusions and Comments” summarises a number of the points included above and contrasts the findings of the original EIS with revisions arising from changes to assumptions and incorporation of new information from further studies. For the purposes of this report, the following excerpt is included:

- Erosion on Bribie Island – Works preventing further erosion, including possibly also some restoration and stabilization, appear necessary, irrespective of whether the canal is constructed or not.

a) "In 1940 the coastline consisted of three crenulated bays. Each bay was aligned parallel to an historic channel path. It did not appear in 1940 that any of the channels was actively moving or was carrying a significant part of the tidal current.

b) "By 1958 the middle channel was an active ebb channel and another ebb channel had formed to the south. All traces of the northern channel had been obliterated by the slow movement south of a large sandbank under the influence of the flood current. This caused the southern most point (south of Jellicoe Street) to erode, and the beaches opposite Earnshaw Street to advance.



c) "Between 1958 and 1961 the flood channel had migrated to the left and was still scouring the southern point. The flood tide was moving the sand bar south and straightening the beach between Earnshaw Street and Beattie Street. The large sand bar is being moved south by the flood tide. As the sand spills over into the ebb channel it is swept back out towards the passage entrance.

d) "By 1972 the main ebb channel had moved north and had rotated further to the left. The secondary flood channel still existed but was less well defined because of the southerly movement of a large sandbank under the influence of the flood tide.

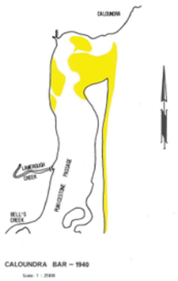
Figure 15: Illustrations Describing Golden Beach Shoreline Change Associated with Tidal Channel Migration between 1940 and 1977, with accompanying explanatory text from the report [212]

e) "In 1974 the ebb channel was continuing to move to the left and was causing a general straightening of the beach. It had eaten into most of what was left on the northern sand bar. The secondary channel still existed, but the sand bars were making it less well defined. Natural movements of the beach are now restricted because of rock placed at the eroding parts of the beach.

f) "By 1977 the main channel had started to veer to the right and sand was building up opposite McLean Street. The apparent reason for this is that as the main entrance bar has moved north, Bulcock Channel has taken more of the flood tide, and there has been a resurgence of the sand bar opposite McLean Street, fed by the flood tide from Bulcock Channel. The increased sand had deflected the ebb channel to the right. This has allowed the beaches to grow between Beattie Street and Earnshaw Street."

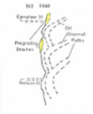
Movement of the Caloundra Bar, 1940-1987, figures from Pelican Waters Southern Lake - Tidal Prism Review (Cardno, 2016), Appendix B, with original source cited as Report on Tidal Dynamics of The Caloundra Estuary (Cardno & Davies, 1987). Quantity take-offs and estimated changes (preliminary) by RPS/ICM for Bribie Island Breakthrough and Erosion Review.

Estimated intertidal zone area (yellow):
(Bribie Island & Pumicestone Passage)
1,112,079 m2 (1940 'baseline')



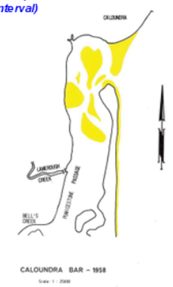
CALOUNDRA BAR – 1940

FIG. 1/1



Width of the band of thick vegetation on the island approximately 144m (1940)

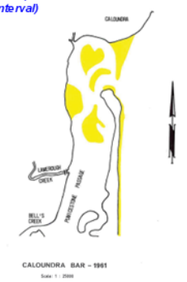
Estimated intertidal zone area:
1,171,323 m2
+5.3% (c.f. 1940)
+0.3%/yr (interval)



CALOUNDRA BAR – 1958

FIG. 1/2

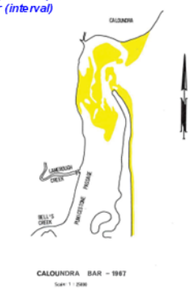
Estimated intertidal zone area:
1,180,066 m2
+6.1% (c.f. 1940)
+0.2%/yr (interval)



CALOUNDRA BAR – 1961

FIG. 1/3

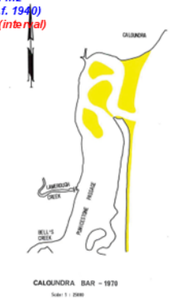
Estimated intertidal zone area:
1,306,844 m2
+17.5% (c.f. 1940)
+1.8%/yr (interval)



CALOUNDRA BAR – 1967

FIG. 1/4

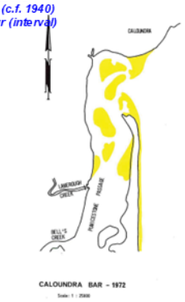
Estimated intertidal zone area:
1,173,774 m2
+5.3% (c.f. 1940)
-3.4%/yr (interval)



CALOUNDRA BAR – 1970

FIG. 1/5

Estimated intertidal zone area:
1,229,922 m2
+10.6% (c.f. 1940)
+2.4%/yr (interval)



CALOUNDRA BAR – 1972

FIG. 1/6

Estimated intertidal zone area:
1,323,180 m2
+19.0% (c.f. 1940)
+7.6%/yr (interval)

CALOUNDRA BAR – 1973

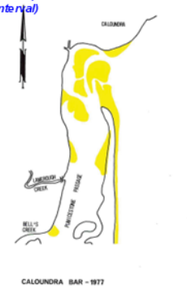
FIG. 1/7

Estimated intertidal zone area:
1,341,737 m2
+20.7% (c.f. 1940)
+1.4%/yr (interval)

CALOUNDRA BAR – 1974

FIG. 1/8

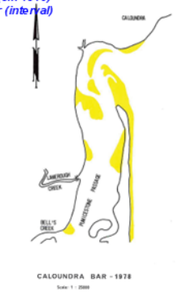
Estimated intertidal zone area:
1,354,438 m2
+21.8% (c.f. 1940)
+0.3%/yr (interval)



CALOUNDRA BAR – 1977

FIG. 1/9

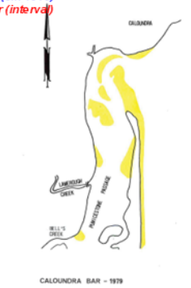
Estimated intertidal zone area:
1,355,994 m2
+21.9% (c.f. 1940)
+0.1%/yr (interval)



CALOUNDRA BAR – 1978

FIG. 1/10

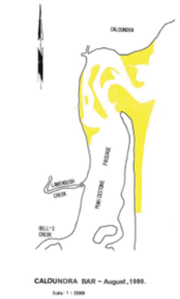
Estimated intertidal zone area:
1,300,224 m2
+16.9% (c.f. 1940)
-4.1%/yr (interval)



CALOUNDRA BAR – 1979

FIG. 1/11

Estimated intertidal zone area:
1,443,872 m2
+29.8% (c.f. 1940)
-5.4%/yr (interval)



CALOUNDRA BAR – August, 1980.

FIG. 1/12

Estimated intertidal zone area:
1,472,678 m2
+32.4% (c.f. 1940)
-2.1%/yr (interval)

CALOUNDRA BAR – May, 1981

FIG. 1/13

Estimated intertidal zone area:
1,471,205 m2
+32.3% (c.f. 1940)
-0.4%/yr (interval)

CALOUNDRA BAR – July, 1981

FIG. 1/14

Estimated intertidal zone area:
1,440,221 m2
+29.5% (c.f. 1940)
-2.8%/yr (interval)

CALOUNDRA BAR – May, 1982

FIG. 1/15

Estimated intertidal zone area:
1,459,707 m2
+31.3% (c.f. 1940)
+2.7%/yr (interval)

CALOUNDRA BAR – November, 1982

FIG. 1/16

Estimated intertidal zone area:
1,495,630 m2
+34.5% (c.f. 1940)
+7.5%/yr (interval)

CALOUNDRA BAR – March, 1983

FIG. 1/17

Estimated intertidal zone area:
1,509,487 m2
+35.7% (c.f. 1940)
+1.9%/yr (interval)

CALOUNDRA BAR – JULY, 1983

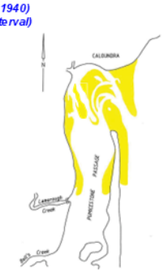
FIG. 1/18

Estimated intertidal zone area:
1,464,001 m2
+31.6% (c.f. 1940)
-6.0%/yr (interval)

CALOUNDRA BAR – DECEMBER 1983

FIG. 1/19

Estimated intertidal zone area:
1,526,304 m2
+37.2% (c.f. 1940)
+5.7%/yr (interval)



CALOUNDRA BAR – AUGUST, 1984

FIG. 1/20

Estimated intertidal zone area:
1,565,788 m2
+40.8% (c.f. 1940)
+2.6%/yr (interval)

CALOUNDRA BAR – SEPTEMBER 1985

FIG. 1/21

Estimated intertidal zone area:
1,503,017 m2
+35.2% (c.f. 1940)
-8.0%/yr (interval)

CALOUNDRA BAR – APRIL, 1986

FIG. 1/22

Estimated intertidal zone area:
1,504,302 m2
+35.3% (c.f. 1940)
+0.3%/yr (interval)

CALOUNDRA BAR – JULY, 1986

FIG. 1/23

Width of the band of thick vegetation on the island approximately 44m (1986)

Estimated intertidal zone area:
1,443,872 m2
+29.8% (c.f. 1940)
-5.4%/yr (interval)

CALOUNDRA BAR – FEBRUARY 1987

FIG. 1/24

Net change, 1940-1987 (~47.5 yrs) ≈ +331,793 m2 ≈ 7,022.07 m2/yr average ≈ 2.1%/yr average || Western shore of Bribie Island - Average rate of recession (46-yrs) ≈ 2.1 m/yr || Average rate of erosion (ground survey) ≈ 1.75m/yr || 1986 short-term erosion rate ≈ 4.0 m/yr || 2009 vegetation width ≈ 45m (similar to 1986) || 'Currently' (2016?) width ≈ 40m

Figure 16: Movement of the Caloundra Bar, 1940-1987, complied and annotated as poster (various sources, see title above, and text for detail)

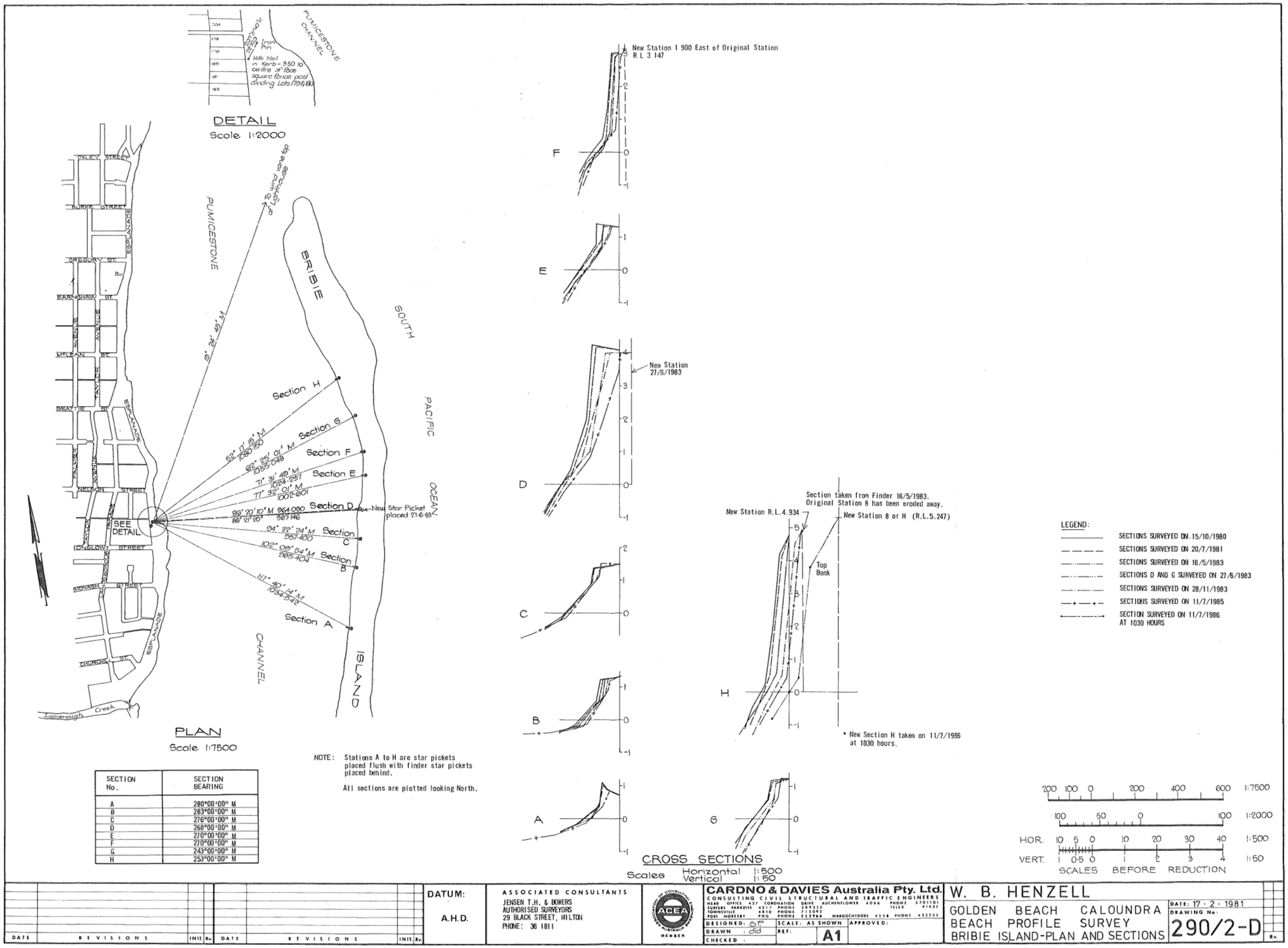


Figure 17: Monitoring locations on Bribie Island (A-H) and corresponding cross-sections [212]

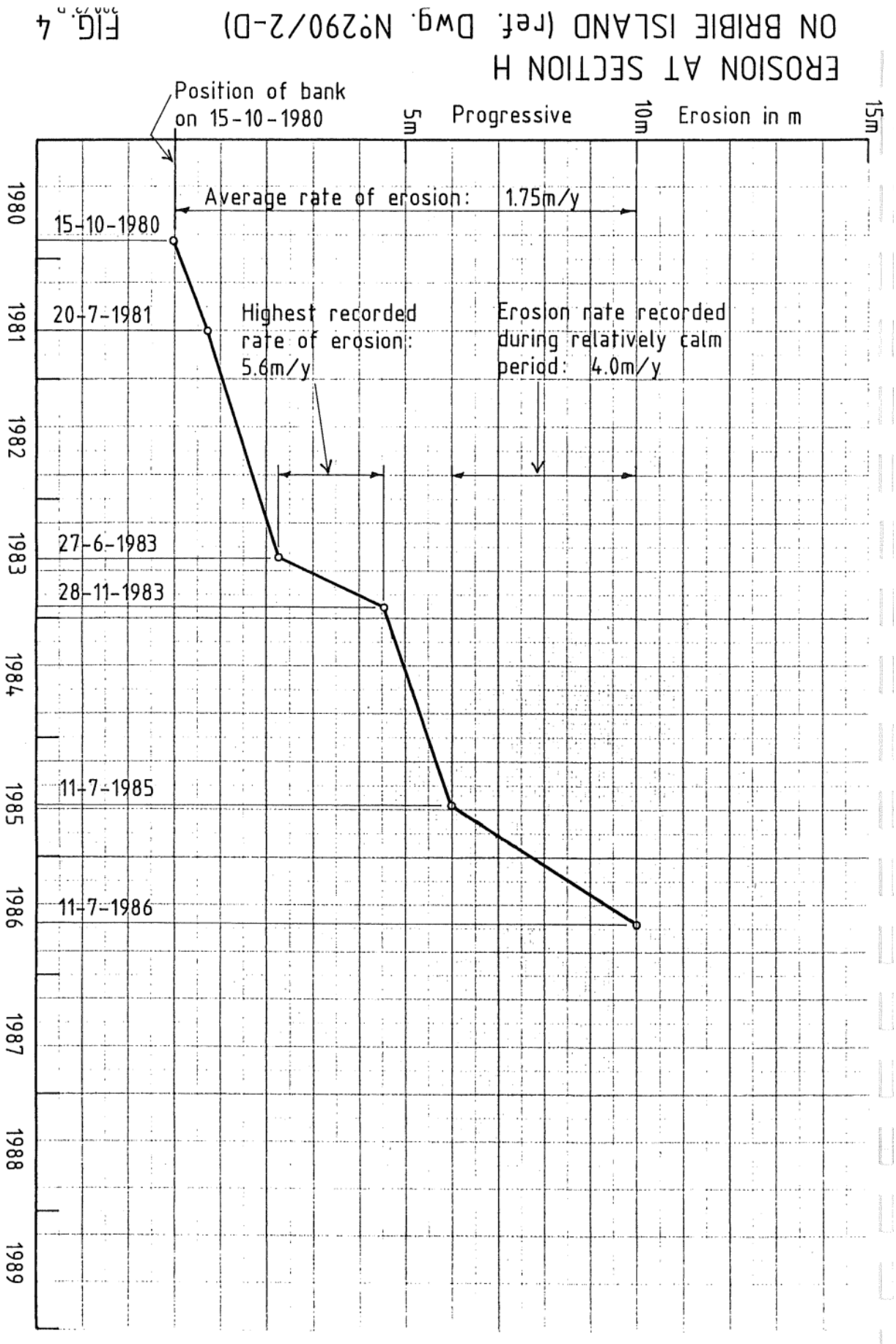


Figure 18: Plot of changes observed at station H (see Figure 17) where erosion was severest [212]

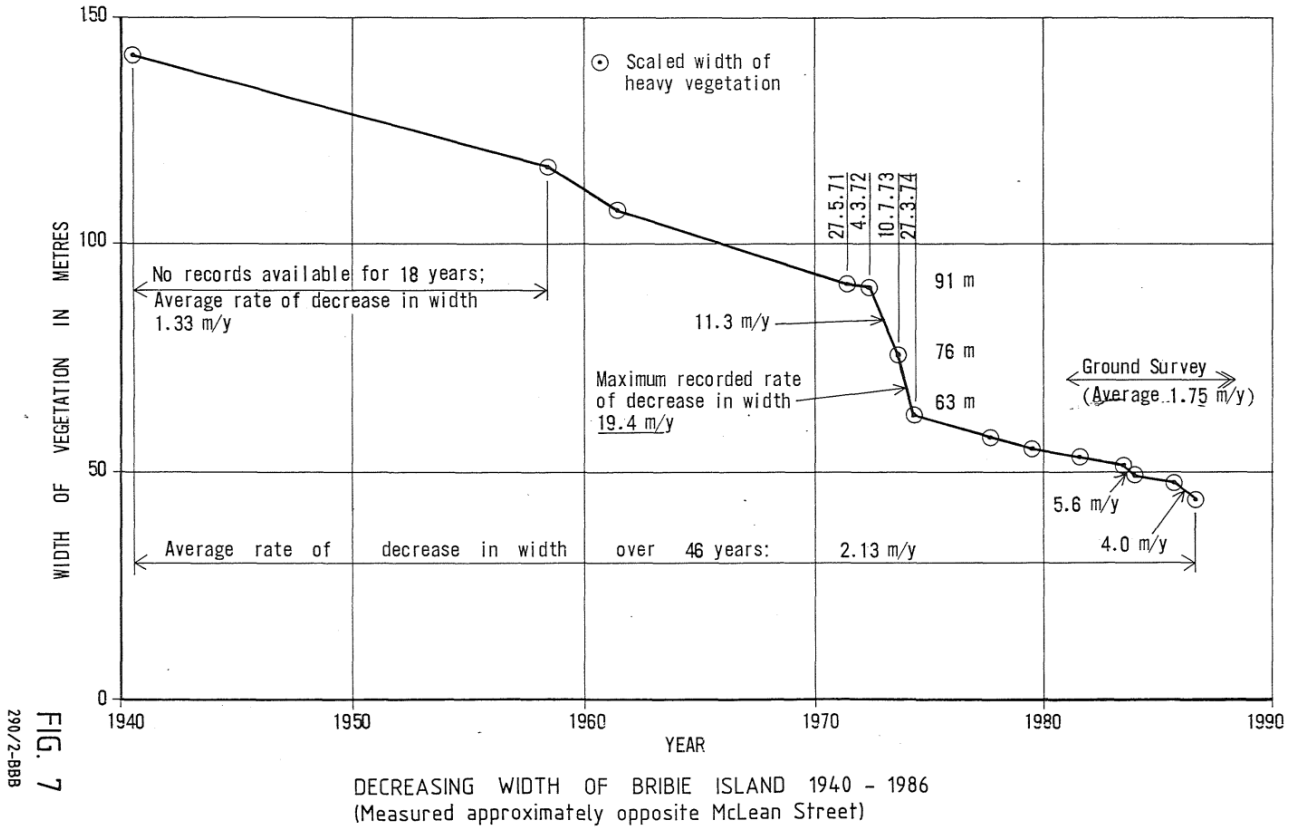


Figure 19: Plot of decreasing width of Bribie Island – 1940-1986 [212]

Figure 20: Cardo cross sections, overlain on 2025-05-23 Nearmap imagery and AHOENC

PLATE 1

PLATE 2

Figure 21: Oblique aerial photographs, July 1986 [212]

PLATE 3

PLATE 4

Figure 22: Erosion on Bribie Island, October 1986 [212]

2.3.5 Beach Protection Authority

The DHM *History* includes the following information:

"The Beach Protection Act of 1968 was enacted following the severe erosion which occurred along the Queensland coastline in the 1960s, when it had become apparent that there was an urgent need to have an expert technical organisation, established at State Government level, capable of investigating coastal erosion problems and providing advice on beach protection methods to Local Authorities. The Authority was given powers of control within designated areas, particularly over new subdivisions and buildings. The role of the Authority was not confined to dealing with areas where erosion problems were already apparent, it had the competence to provide sound comments on proposals for future development of the coastline, especially town planning schemes. Since 1971 the technical and clerical staffing have been provided by the Department." (p.591)

Part 1 notes that whilst our research identified plans/drawings, there was a notable lack of accompanying reports, or similar information that we'd expect to find in the record. We did subsequently identify and source a report that provides salient insight, a 1974 report by BPA Executive Engineer D.C. Patterson, entitled *Beach Erosion Control District Schemes, Landsborough Shire* (51 pages) [213]. The report advises that there are two Beach Erosion control Districts (**BECD**) in Landsborough Shire (**LSC**), with BECD No. 1 including the project area.

The scheme attached to the report includes the following information:

- The Governor-in-Council by Order in Council made on 20th September, 1969 declared that part of the coast of Landsborough Shire extending from its southern boundary on Bribie Island north to Currimundi Creek to be a Beach Erosion Control District (No. 1).
- Surveys at elected areas Within the beach erosion control district have been carried out commencing in 1970. To date this has involved profiling and limited sediment size distribution analysis and does not constitute a detailed investigation of the beach processes in the area. A detailed three year investigation programme is planned to commence in 1973 following which a further report will be prepared and recommendations made on any changes considered necessary to the scheme.
- A report has been prepared in May 1973 to accompany this scheme. Information in that report is based on the surveys carried out to date, previous reports based on inspections by Departmental officers, and aerial photography of the area. The report outlines the concepts on which this scheme is based.
- Kings Beach has experienced realignment landward following growth of the spit southward from Deep Water Point. At the same time, the natural dunes have been levelled and developed for residential and recreational purposes.
- The undeveloped sections of coastline on Bribie Island and between Caloundra and Currimundi present no erosion problems. Normal periodic erosion is accepted by the existing dunes and natural restoration. occurs subsequently. Under the influence of differential longshore sand transport, a net long term erosion may be occurring.
- The scheme provides for –
  - (a) Direct nourishment of Kings Beach with sand taken from outside the zone of beach sediment transport;
  - (b) The construction and/or improvement of dunes to act as a reservoir of sand for cyclonic erosion;
  - (c) The stabilization of all dunes with suitable vegetation to prevent undue losses by wind erosion;
  - (d) The protection of the stabilizing vegetation;
  - (e) Restrictions on building and subdivision to all to allow adequate buffer- zone free of development; and
  - (f) The construction of a sand retaining groyne at Kings Beach.
- For Bribie Island –
  - (a) Maintenance of sand dunes;
  - (b) Control of development.

- Sand must not be retained at one area at the expense of the downdrift areas. The beach updrift of the proposed groyne at Kings Beach must be filled with sand to allow immediate by-passing of sand. The source of this sand must be outside the active beach system.
- Financing of the works outlined in this scheme is the responsibility of the Landsborough Shire Council. At present, a subsidy of 20% is payable by the State Government on all capital works for beach protection and this subsidy is increased to 33-1/3% where the works may subsequently be used in conjunction with navigation requirements.

A copy of the attached plan for Kings Beach, showing the alternative groyne locations was included, refer to Figure 31. The overall scheme plan sheet includes the following notes regarding Bribie Island:

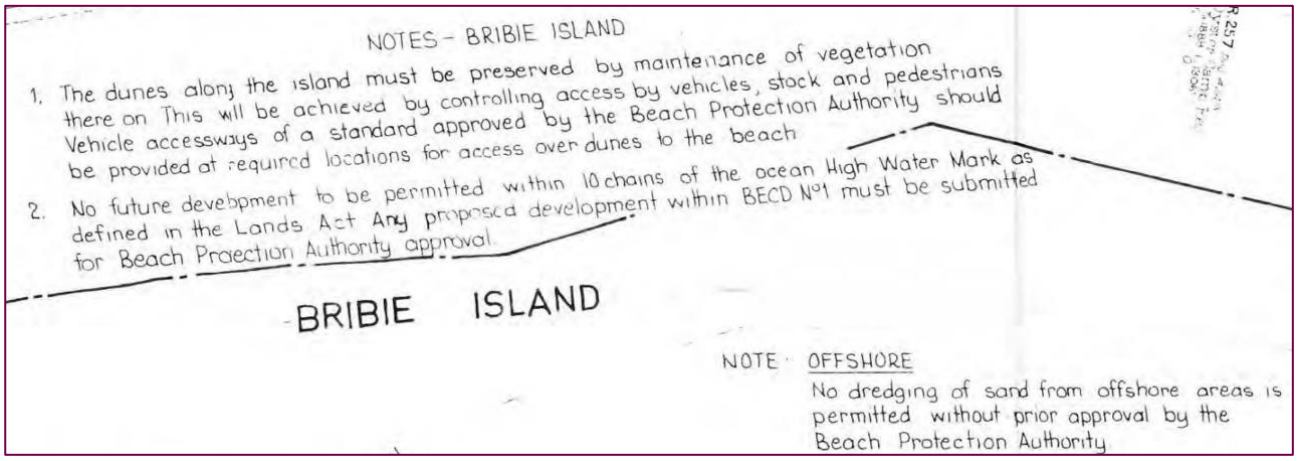


Figure 23: Detail from BECD No. 1 scheme providing notes regarding Bribie Island

The report provides further details regarding the **basis of the scheme declaration**:

- While no major investigation has been carried out to date, several surveys at selected areas are available. These, together with a summary of local knowledge, inspections by Departmental officers and general beach process principals form the basis of this report. In certain areas various features of the Gold Coast beach behaviour can be applied.
- **Caloundra headland** is the major control point for the beaches in the area as a whole.
- Pumicestone Channel entrance separates Bribie Island from the mainland immediately south of Caloundra Head. The channel is tidal, accessible by only small craft through a highly variable entrance, and connects with Moreton Bay 35 km to the south.
- **Beach processes** such as littoral transport, transverse sediment movements and sand supply have not been investigated.
- The beaches and dunes of **Bribie Island** are in their natural state despite some minor interference with dunes by vehicle traffic. Periodic storm erosion is adequately accepted by the existing dune system, and natural dune rebuilding and revegetation occurs. Some local areas exhibit wind blows possibly brought about by man's interference. If these are allowed to become worse at the northern end, overtopping by cyclone waves may cause a breakthrough of the island.
- **Swell waves** arriving from the south-east quarter are refracted around Moreton Island and over the relatively shallow area which extends for some distance offshore. They therefore are of decreasing height from north to south along the island. North-easterly waves generated locally are usually less than six feet in height.
- **Net littoral transport**
  - Appears to be to the north at the northern end adjacent to Pumicestone Channel entrance.
  - Further south the net littoral transport is probably negligible, becoming southerly still further south.
  - The resulting loss of sand from the island may be compensated by mass transport from offshore.
  - Any long term accretion or erosion trend may be verified only by detailed surveys over a long period of time.

  - Evidence in the form of erosion of old trees and a wartime gun emplacement suggests a long term erosion.
- Conclusion: The area does not present problems at present. It is necessary to ensure maintenance of the dune system, and an investigation to determine the long term behaviour should be carried out.
- **Kings Beach** consists of:
  - a northern portion (Kings Beach) with no dune but backed by a boulder wall to protect development behind. This extends some 700 m south from Caloundra headland.
  - a southern portion (The Spit) in the form of a spit which grows southwards from Deep Water Point. It has natural dunes that are semi-stable with respect to the wind erosion und are accessible to increasing pedestrian traffic. The length of the spit varies as Pumicestone Channel entrance moves.
- **Net littoral transport along these beaches is southwards**, Kings Beach being fed by mass transport shorewards across a shallow rocky shelf which extends 1,000 metres offshore.
- **Wave refraction** at the southern end is affected by the shallow banks formed adjacent to the channel entrance. Refraction and diffraction affected by the reefs offshore from the rest of the beach often creates a confused wave system.
- Kings Beach suffers severe erosion to the boulder wall in the worst affected area though it is fortunate that the shoaling effect of the **reefs offshore** reduces the wave attack on the beach. The quantity of sand removed from the beach during storms is small though no detailed surveys have been undertaken to measure it.
- **A small rock groyne** has been constructed in front of Dingle Avenue some 700 m south of Caloundra Headland, and forms a minor control point which is most effective immediately after erosion when the quantity of sand on the beach is small. This leads to accretion of Kings Beach and corresponding erosion and realignment of The Spit immediately south.
- **Deep Water Point** now engulfed by the Spit has formerly been part of the north bank of the channel entrance. In this situation, Kings Beach was wider with an alignment in plan more convex to seawards than at present but less suitable for surfing because of dangerous currents. Movement of the entrance southwards by growth of the Spit has moved away this control for the beach allowing realignment further landward. This is evident on the aerial photographs SC 1284 attached. Rocks offshore which are completely exposed now were covered with sand at the time of the 1940 aerial photography.
- Conclusion: Kings Beach is inadequate to accommodate the present demand for beach use during the holiday period particularly after cyclone erosion. Future increase of user demand is certain, and beach improvement here is essential if a suitable beach is to be provided to meet the demand. Preliminary estimates indicate that beach widening by 30 metres is required.
- Regarding the concept of the scheme and works, the following advice is included:
  - Where insufficient width exists, widening by sand nourishment or resumption is proposed. Where there is an insufficient volume of sand in the buffer zone, nourishment to the dunes is proposed. Where accompanying works are required to maintain the required width or volume of sand, these are proposed and may include dune revegetation, pedestrian and/ or vehicle control, groyne construction etc.
- Beach nourishment has been carried out with varying success in other areas of the world. In the Kings Beach area it is considered that nourishment would be effective provided a retaining structure such as a groyne is constructed at the southern end of the nourished section of beach. The required groyne length and the volume of nourishment sand necessary has been calculated for two possible designs in Appendix A and depends on the groyne location. This in turn will be determined by the likely effects of the structure on the Spit and channel entrance. A decision on the requirements for the Spit would have to be made jointly by Council and the Crown.
- **Alternative A** requires a shorter groyne than **alternative B** and costs less, but provides fewer overall advantages. Selection of groyne location will depend on finances available, entrance training requirements, timing of the works and results of an investigation into likely effects of the proposals.
- It is anticipated that following the major investigation into the beach processes taking place along these beaches, detailed report will be prepared and the scheme amended to accord with available knowledge.

Details regarding cost estimates are included in the appendix. Repeating them here is not considered to add value, however, they may be of interest to those undertaking any future planning that may be progressed. It is worth noting that alternative B was nearly five times the estimated cost ($260k vs $1.17M). As LSC was responsible for 80% of the cost (or perhaps 66% if alternative B was deemed to provide navigational benefits) the additional cost may have been a significant factor in the apparent decision to progress option A. A subsequent report ~1976-77 may provide more insight, but to date, we have not been able to locate one.

Whilst the BPA scheme appears to have required LSC to maintain the dunes on Bribie Island, the estimated cost was low ($1,000/yr). LSC was also required under the scheme to maintain the dunes on the southern/Spit section of King's beach, as well as other dunes from Caloundra to Currimundi (est. $15,000/yr), and rebuild dunes at Shelly Beach.

Included provisions regarding General Management stipulated that:

- Sand must not be removed from the active beach system. This includes the offshore profile down to approximately RL -15 metres and the beach and dune system.
- Sand must not be retained at one area at the expense of the downdrift areas. The beach updrift of the proposed groyne at Kings Beach must be filled with sand to allow immediate by-passing of sand. **The source of this sand must be outside the active beach system**.

The report did comment on the LSC practice of scraping sand following erosion up onto the beach and advised that it provided short-term remedy, but neither good nor harm in the longer-term. The likely interpretation of the first restriction above is that scraping does not remove sand from the active beach system – it is still available to 'slump' again.

The requirement to source "external" sand for nourishment of Kings Beach, and requirement to keep it full so that it could allow immediate bypassing – i.e. not interfere with transport of sand from offshore (or nearshore) to the south (or north, but less likely with the headland influence), suggests recognition, or at least a preliminary theory to be reviewed upon further investigations, that supply of sand to the southern portion was important, or at least necessary to avoid the principle of not unduly interfering with coastal processes – transport to downdrift areas.

It could of course also simply be an application of general policy, without any particular origin or linkage to site-specific conditions (although southward transport is advised – towards Deepwater Point / Bribie Bar & Island, but there is also one reference above to northward transport). It would be interesting to know the BPA's preferred 'borrow areas' for nourishment exercises.

Select photographic plates from the report, with original captions, as well as the scheme plan for the alternative groyne locations is attached, refer to Figure 24 through Figure 31.

Figure 24: KINGS BEACH - Aerial Oblique 4-9-72 [213]

Figure 25: Erosion scarp approx. 1 mile from 'Northern Tip of Island (16/5/72) [213]

Figure 26: Erosion scarp at Blockhouse approx. 3 miles from Northern Tip of Island (16/05/72) [213]

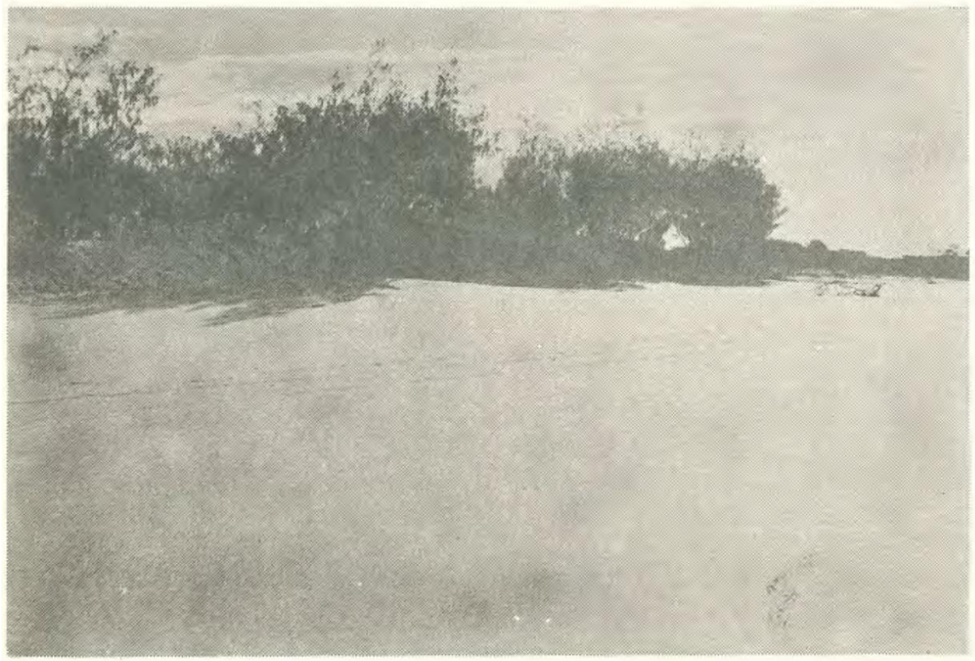


Figure 27: Beaches in good condition only three months after serious erosion. Note frontal dunes adequately providing sand to the beach leaving a prominent erosion scarp (16/05/72) [213]

Figure 28: View of Caloundra from Northern Tip of Island. Approx. 19 miles from Woorim (16/5/72)

Figure 29: Looking north from end of A.P.M. Forest Track, approx. 4 miles from Northern end of Island and 15 miles from Woorim (16/5/72) [213]

Figure 30: Looking south from the same position as the photo above (16/5/72) [213]

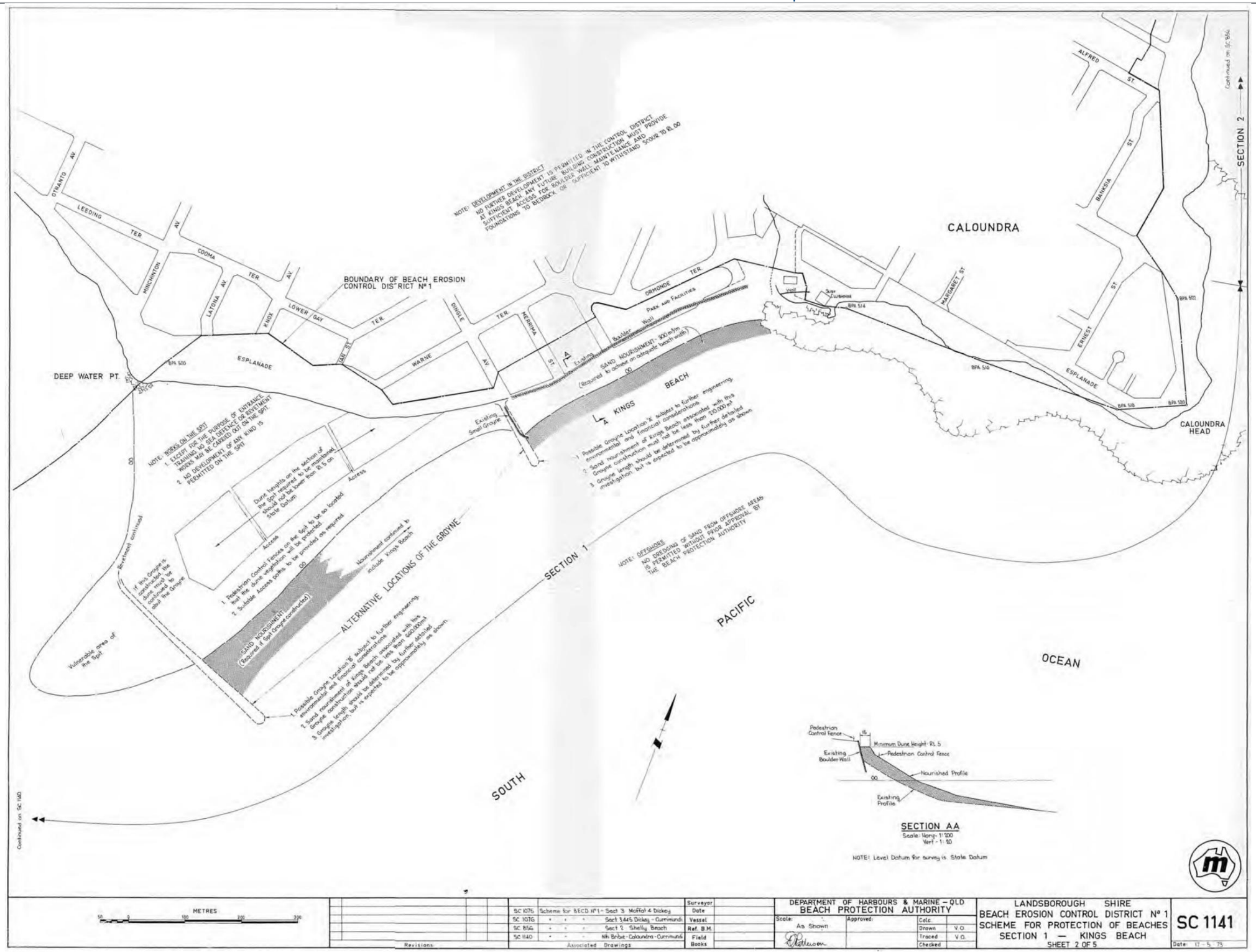


Figure 31: Kings Beach plan from BECD No. 1 scheme, showing alternative groyne locations [213]

The Beach Protection Authority (**BPA**), as noted above, was formed in 1968 with technical and administrative staff potentially supplied by the DHM continuously, however oversight/control under the Coordinator General initially, but transferred to DHM through legislative changes in 1970, with the Coordinator General still involved, but DHM taking over as Chair.

The *Marine Safety Act 1994* (now *Transport Operations (Marine Safety) Act 1994*) included repeal of the Queensland Marine Act 1958, and associated amendment acts. It also included amendment of the *Beach Protection Act 1968* to omit the "Marine Board" from the definitions and one section (34(1)a), as well as amendments to the *Harbours Act 1955*.

The Explanatory Notes, as well as Cabinet documents that have been released from both 1994 (Decision No. 03489) related to the associated Bill, as well as from 1992 (Decision No. 02191) provide background advice, notably regarding the *Report on the Review of the Marine Board and Maritime Safety Administration in Queensland - December 1991*. That advice includes:

- Although the Board has statutory responsibility for the administration of all maritime safety matters within the State's jurisdiction, the Department of Transport actually performs these duties with several of its employees specifically designated as Marine Board officers.
- Although both the Marine Board and the former Department of Harbours and Marine were subjected to separate reviews during the early and mid-1980s, neither of these reviews included a critical assessment of the overall maritime safety administration system in Queensland and to what extent the two agencies inter-related and overlapped. These reviews were restricted to issues of an operational nature.
- Upon establishment of the amalgamated Department of Transport in December, 1989, the role and functions of the Marine Board and its relationship with the new Department came under increasing examination, against the background of a number of public sector reform initiatives.
- A related Review of Queensland's Port System was undertaken at Cabinet's direction by the Department of Transport in 1990 and acceptance of that Review's recommendations for reform of the port administration system by Cabinet highlighted the potential advantages of undertaking a similar complementary review of maritime administration.
- The Review also recommends that maritime safety administration be clearly separated from the various coastal management functions which are currently combined in the present legislative responsibilities of the Marine Board of Queensland.
- It also noted that the overall policy and regulatory framework for maritime safety administration in Queensland is relatively weak and needs to be refined and strengthened where appropriate. The potential for increased self regulation needs to be fully explored in conjunction with moves towards greater cost recovery for maritime safety administration activities.

Advice regarding consultation includes generally favourable support, with some qualified support as well as a minority "unfavourable" response. The Port of Brisbane Authority provided "Qualified support" with the following specific comments/requests included:

- "Expressed a need to maintain the Marine Board to take advantage of private sector input into decision-making. Also expressed concerns about the future role of Government in development approvals for areas below high water mark in port areas."

Several other port authorities, as wells as a port authority board member are listed:

- Mackay Port Authority – Neutral – No general comment – Disagrees with Recommendation 6
- Colin Wood, Board Member, Mackay Port Authority – Qualified agreement
- Gladstone Port Authority – Favourable – "Concerns expressed that the coastal development approvals system needs to be refined to ensure a minimal delay."
- Townsville Port Authority – Neutral

Recommendation 6, referenced above in the Mackay Port Authority, relates coastal management:

- "Responsibility for decision-making on coastal management approvals as provided for in the Harbours Act and Canals Act be totally separated from the maritime safety administration task and assigned to the Department of Environment and Heritage with the Department of Transport retaining the expert advisory role in navigation and related maritime issues."

Further explanation in the Review report (attached to the Cabinet minute, water-marked “Draft”) includes:

- Under Section 86 of the *Harbours Act*, the Marine Board sanctions structures below the high water mark. Although this section is now administered by the Department of Environment and Heritage, under current legislation the Marine Board is still the authority for recommending the approval of such structures to the Governor in Council. Approvals are determined on the recommendation of Department officials with regard to structural integrity, the structure's position in relation to the navigable waters and possible associated dangers to marine activities, and coastal management considerations.

The details and date of transfer of the BPA from the transport to environment portfolio are not available in the materials we reviewed, however, the following information indicates it was around 1989:

- The *Appropriation Act 1988–1989 (No. 2)* includes the Beach Protection Authority Fund ($2.512M) under “Water Resources and Maritime Services”.
- The *Appropriation Act 1989–1990 (No. 2)* includes the Beach Protection Authority Fund ($3.036M) under “Policy Area 07 – Transport.”

Policy shifts appear to have commenced at an earlier date, by 1984:

- Beach Protection Act of 1968, No. 17 long title:
  - An Act to Provide for the Protection of Beaches against, and for the Restoration of Beaches from, Erosion or Encroachment by the Sea and for those Purposes to Establish an Authority and an Advisory Board and to Confer and Impose upon them certain Functions and Powers
- Beach Protection Act and Another Act Amendment Act 1984, No. 65 long title:
  - "An Act to provide for the regulation of and the provision of advice in respect of certain activities affecting the coast, to protect the amenity of the coast and, subject thereto, to minimize damage to property from erosion or encroachment by tidal water and for those purposes to establish an Authority and to confer and impose upon it certain functions and powers ".
  - This act also provided for declared BECDs to become a “coastal management control district”.

The *Beach Protection Act 1968* was repealed on 20 October 2003. The BPA origins from the Queensland coastal investigations that began at least as early as the 1965 Delft report, with management involving Coordinator General → DHM → Transport → Environment, and subsequent transitions to a new coastal policy framework, are contextually relevant, at least historically, to the management of erosion issues in the project area.

As a conclusion to this section, images are provided below from the 1992 BPA publication Northern Bribie Island and Pumicestone Passage Photogrammetry 1940-1992. This document was mentioned in Part 1 and included in the bibliography [091].

The document includes aerial photographs from seven time periods, selected following a methodical review of available material. Coastlines were outlined to show the 0m contour as well as contours above that level in half metre increments. A note of caution we provide is that the 0m contour uses the Australian Height Datum (**AHD**), as opposed to a tidal datum, such as Lowest Astronomical Tide (**LAT**). The 0m AHD contours drawn on the photos would be about Mean Sea Level, so exposed at low tide, but potentially covered by water at high tide. As intertidal areas, they would have provided some resistance to tidal flows, but not a complete barrier.

Table 2 presents the seven BPA photographs, along with an additional aerial photo from 2004. All of the images are cropped similar to the approach described above – Military Jetty to Kings Beach Groyne, and blue lines have been added to highlight flow paths suggested by visible channels (noting there would also have been overland flows at higher tides across sandbanks, as suggested by the absence of vegetation. File naming is similar to that described above, however, following the date is the tide level as advised in the BPA publication, with most being low tide (LT), two unknown tide (UT) and one mid-tide (MT). Acronyms for the image origin used that are not referenced previously in this report include MRD (Main Roads) and RAAF (Royal Australian Air Force).

Table 3 presents the same BPA images, but we have digitised the 0m contour shown on the original images so as to better illustrate the shape of the island, and also rendered the black and white photos, and done a bit of layering. The same styling was used for each photo, however the pixel values (black → white on a scale of 0-255) would have naturally varied based on time of day, season, cloud cover, etc. at the time of the photo, as well as other factors, so interpretations should be made with caution. The point of the exercise is to

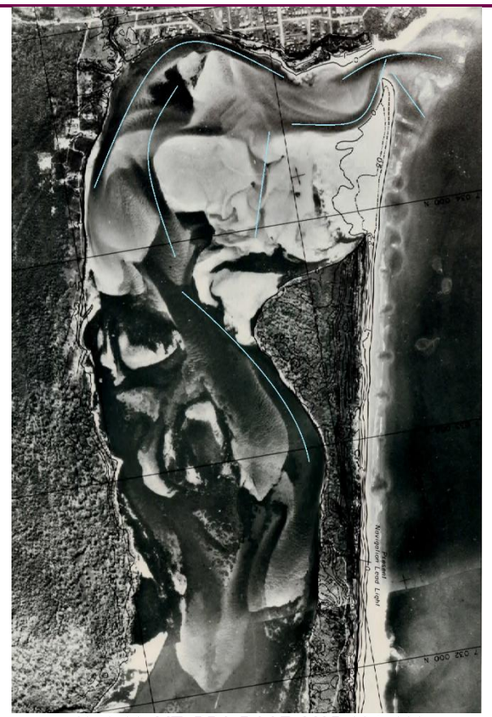
simply present the images from a different perspective, in the hope that some readers may find the contrast insightful. The eighth image in this panel is replaced by one that shows all of the contours from each photo, with a recent post-breakthrough aerial underneath. On each image, except for the first (1940) and the last (all contours) the contour from the previous year is included for comparison.

The overall message is that “sand moves”. In doing so, flow paths change, with the entrance position shifting north to south between Deepwater Point and Bribie Island. Figure 15 provides both illustrations and narrative descriptions of these changes, but the time periods they use are different, so their narrative provides complementary information. Regarding these photos below we provide the following notes, with the intent to highlight certain features, rather that provide a detailed or comprehensive assessment:

- 1940 – the entrance channel is pointing east and located to the north, close to the shoreline at Deepwater Point, although the beaches to the east appear to have a reasonable sand supply. The outline of the “island” as shown by the 0m contour, includes a large sand spit, unvegetated, so it did not completely block tidal flows.
- 1961 – the entrance is to south, and pointing southeast, with the tip of the island that was vegetated in 1940 apparently eroded. A sand spit now extends from Deepwater Point southwards, and the 0m contour mapping includes a portion of that spit along the western flank. Also, some small 0m contours are shown on the large sandbar in the northwest part of the passage.
- 1971 – the entrance channel points east again, appears to have ‘centred’ between the two previous extremes, and is potentially wider, with the Island 0m contour retracted to the south, and the Deepwater Point spit to the north. The 0m contour outlines several sandbars, including the large one in the northwest of the Passage, and 0.5m contours are also shown, suggesting the height of these has increased.
- 1972 – those elevated sandbars are not shown, suggesting scour; changes to the entrance and both spits appears to be relatively minimal.
- 1979 – the Bribie spit above the 0m contour is noticeably extended, in a northwest direction, and the northern spit has eroded a bit, with the entrance channel pointing southeast. Sandbar contours above 0m are again shown. An interesting ebb delta is evident and clearly shown in the black and white photo.
- 1982 – the entrance channel has meandered a bit more to the south and still retains an overall southeast orientation, but a more easterly outlet. The sandbars have scoured again, and a channel is evident in an area mapped 3-years prior as being above the 0m contour, through the large northeast sandbar.
- 1992 – the Bribie spit has scoured significantly, with multiple channels (resembling a braided floodplain) appearing across the area formerly mapped as that spit, and the northwest sandbar, as well as others, again shown above the 0m contour. The entrance channel follows a southeast alignment.
- 2004 – A ‘secondary’ channel is still indicated between the Island and the northwest sandbar, and vegetation is evident across the Bribie spit, as well as the northwest sandbar. Entrance faces southeast.

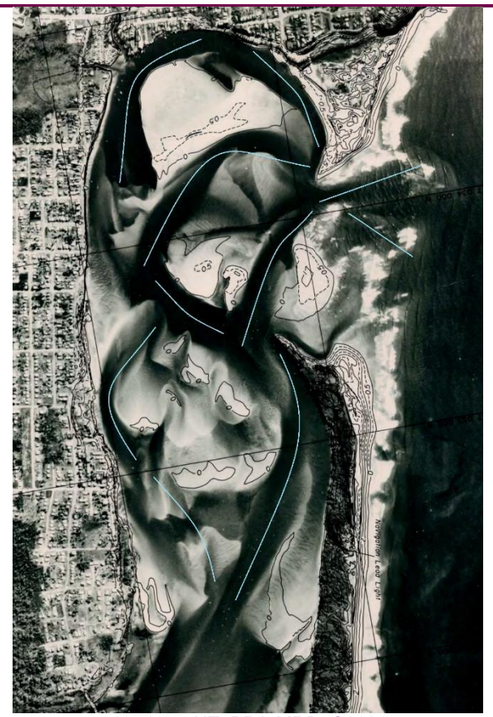
The predominant southeast transport of sand from Kings Beach is evident from the shape of the coastline and ebb delta throughout the sequence, with the tendency towards a southeast entrance channel also consistent with southward transport, due to the deflection of southeast swell by Caloundra Headland, as described above by D.C. Patterson.

Table 2: Chronological collection (1940-2004) of aerial images (northern Bribie Island and Pumicestone Passage), annotated to show likely tidal flow paths (various sources, see text for further description of included content)

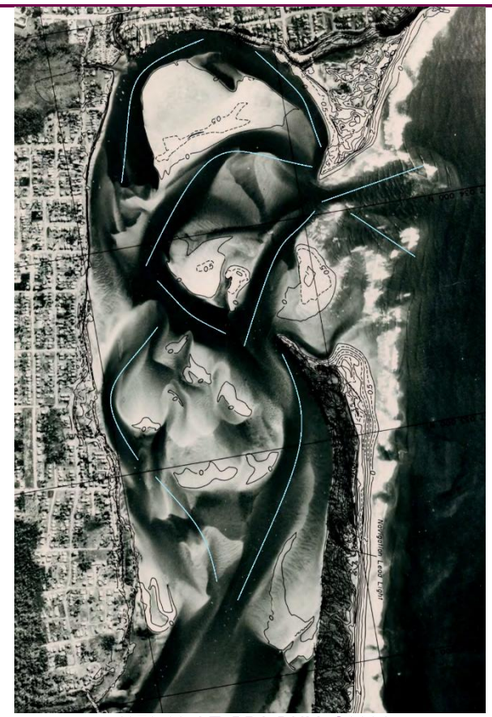


1940-06_MT_BPA-RAAF_MAP 634+638

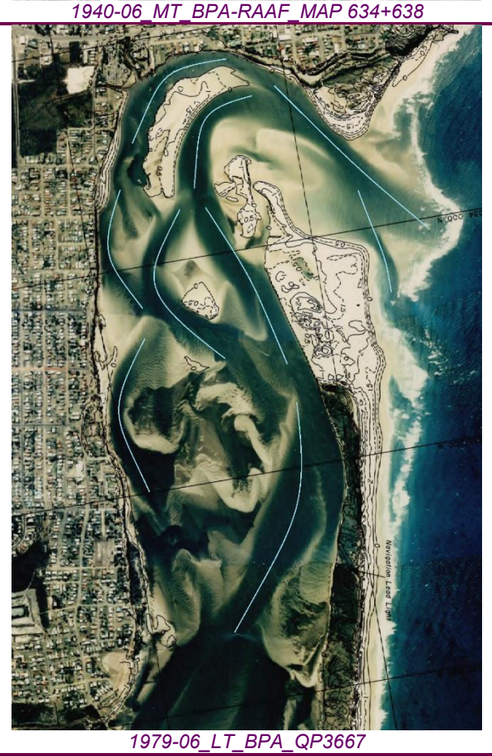
1961-05_UT_BPA-LANDS_Q1131



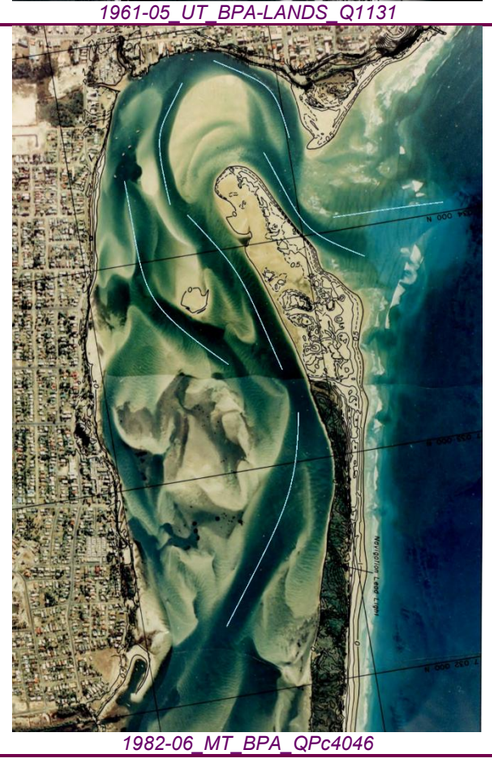
1971-05_UT_BPA-MRD_Q2230



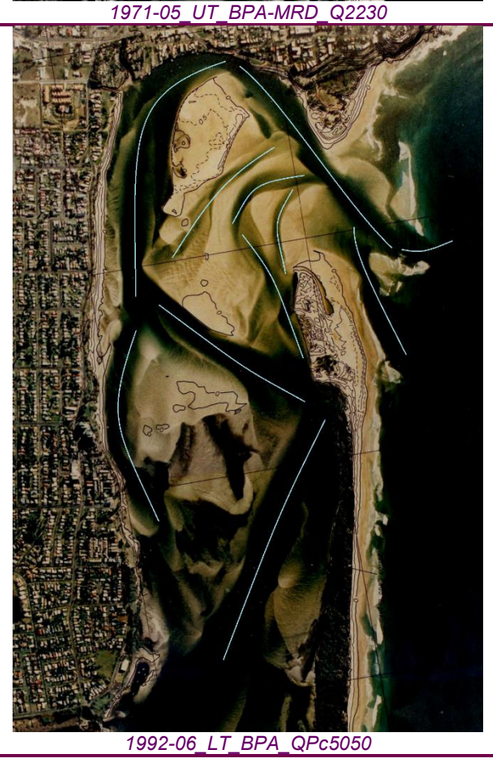
1972-03_LT_BPA-DHM_Q2391



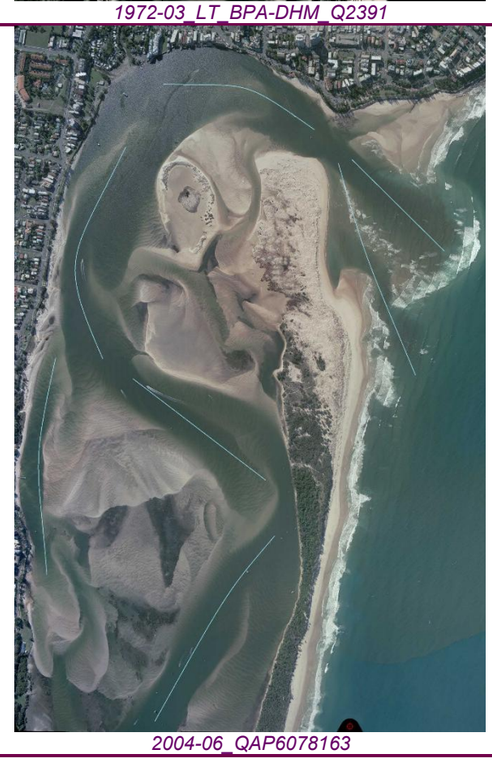
1979-06_LT_BPA_QP3667



1982-06_MT_BPA_QPc4046

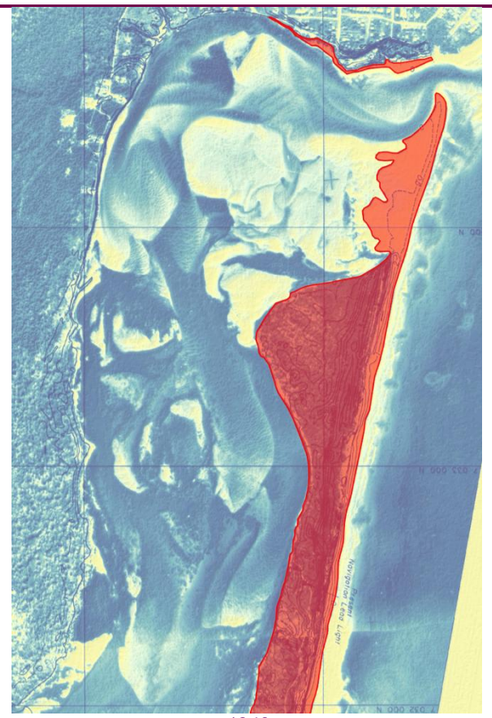


1992-06_LT_BPA_QPc5050

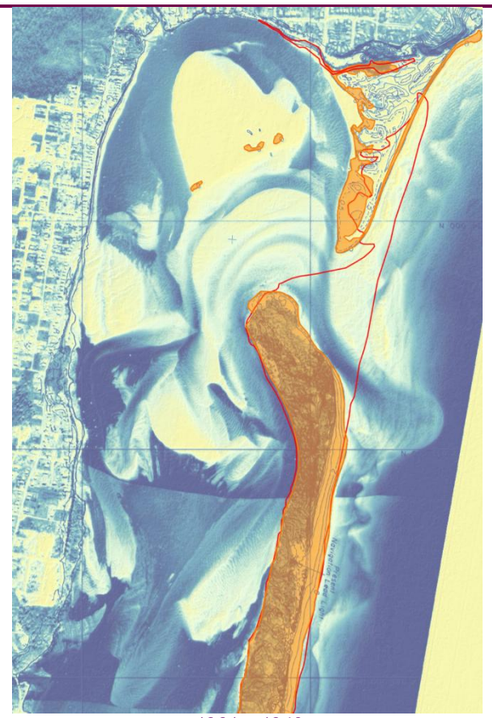


2004-06_QAP6078163

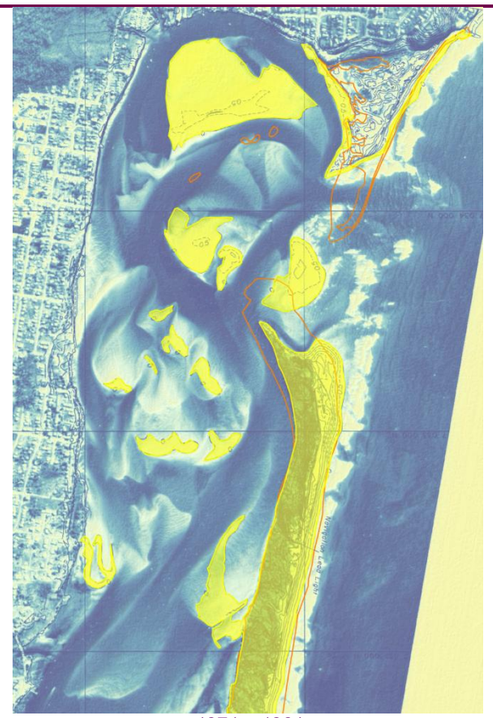
Table 3: Chronological collection (1940-1992) of aerial images (northern Bribie Island and Pumicestone Passage), rendered with 0m AHD contour for present (solid) and previous (outline) year (BPA, see text for further description of edits)



1940

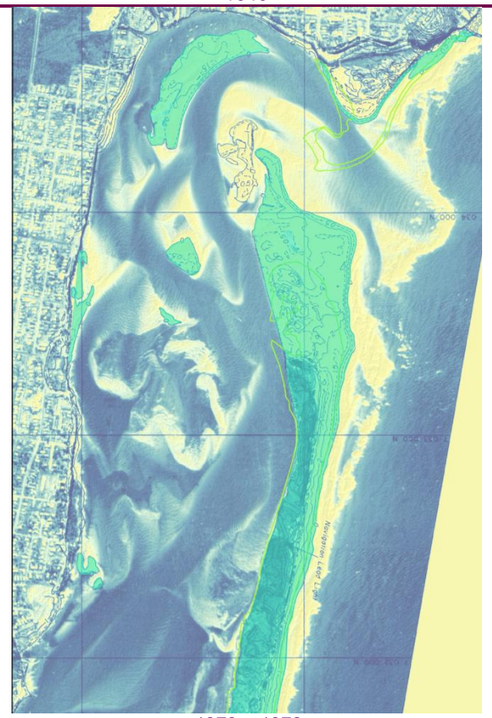


1961 – 1940

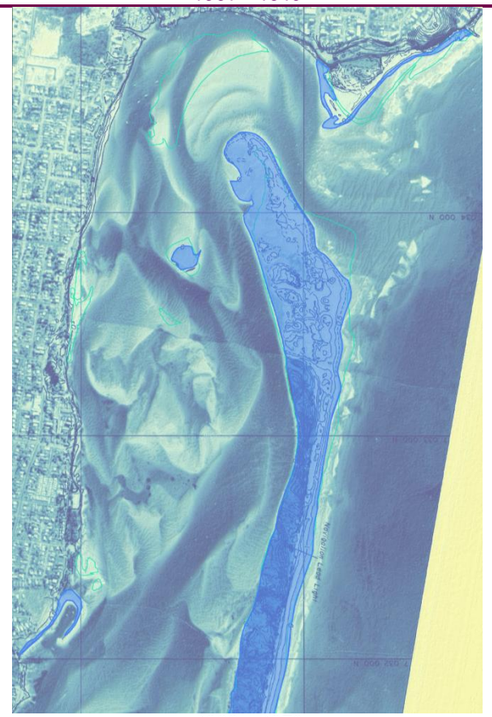


1971 – 1961

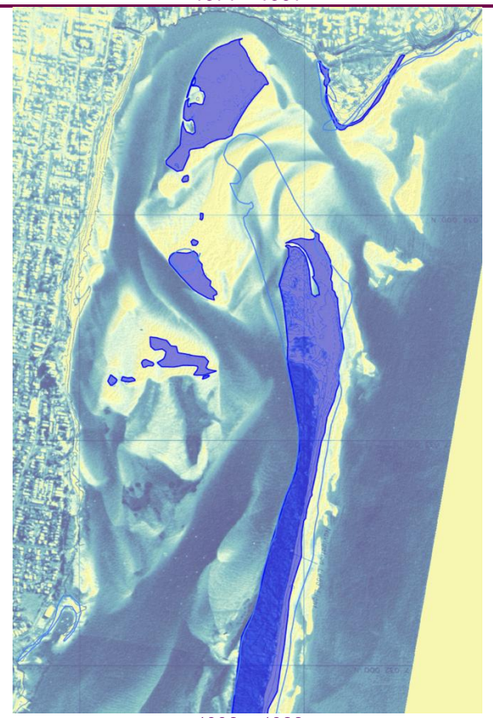
1972 –1971



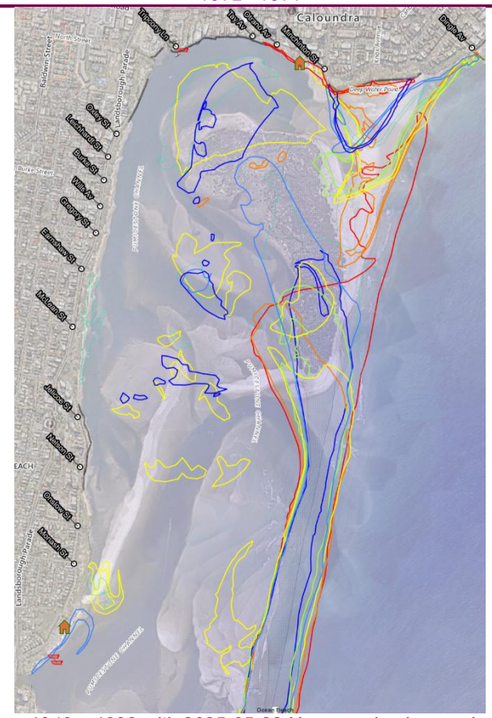
1979 – 1972



1982 – 1979



1992 – 1982



1940 – 1992 with 2025-05-23 Nearmap background

2.3.6 Aerial photography (1940-2025)

Figure 32 shows 1967 imagery overlain on current imagery. This image was produced on Queensland Globe, which includes several historical layers that can be loaded and added to a map (other historical imagery can be identified, but not loaded, as the images have not been fully georeferenced or orthorectified, so Queensland Globe only provides a link to the image on QSpatial). The intent of the figure is to illustrate the alignment of the 1967 flow path, shown as a dark meander, relative to present day conditions. It is evident that the former channel is now vegetated land. The 'current' imagery is post-breakthrough, being the latest available imagery available on Globe, however overlaying the images makes it difficult to see the breakthroughs, as the land from the 1967 photo obscures them.

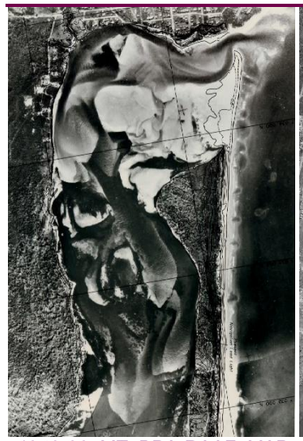
Table 4 provides nearly the complete collection of Queensland Government imagery publicly available for the project area (a few images were excluded due to either quality or close proximity to another included image that conveys similar information). All images have been cropped to the area described above – Military Jetty to Kings Beach groyne (insofar as possible – in some cases the photo frame may have excluded part of the area and we did not attempt to join overlapping frames).

This collection is presented largely for reference. No detailed commentary/analysis is provided, however, the collection may be useful to actions that may follow from this review, and interested stakeholders may appreciate the assemblage. The first part of the images is from QSpatial, with later images available through Queensland Globe. The collection also includes the 1967 image that appears in Figure 32.

Whilst no detailed commentary is provided, the reader is directed to note the changes to the shape of the Island over time, particularly the westward expansion of the northern tip of the Island, including vegetative colonisation and effective merger with the sand shoal that is present through the series in the northwest corner of the Passage. This evolution is discussed more fully in subsequent sections of this report.

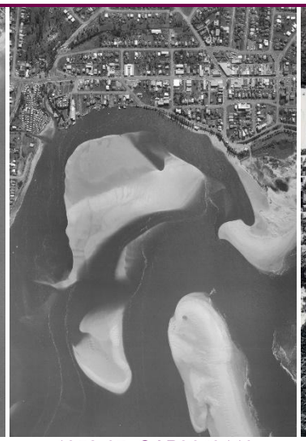
Figure 32: 1967 aerial imagery overlaid on current imagery, showing historical channel (QLD Globe)

Table 4: Chronological collection (1940-2025) of aerial images (northern Bribie Island and Pumicestone Passage) showing channels, shoals and entrance variations (various sources, see text for further description of included content)



1940-06_MT_BPA-RAAF_MAP 634+638

1958-05_QAP0770038



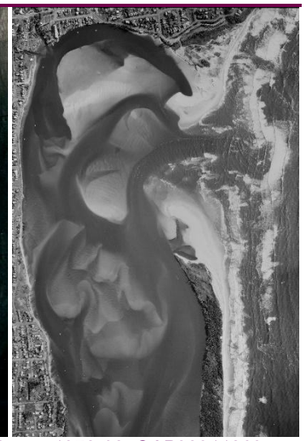
1958-07_QAP2649110

1961-05_UT_BPA-LANDS_Q1131

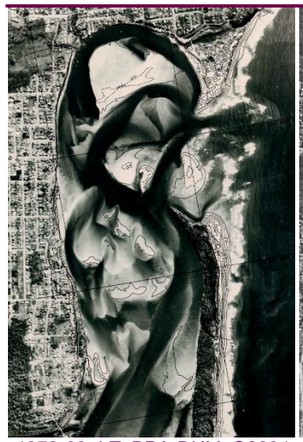
1967_Caloundra_75cm_RHAP

1967-07_QAP1746008

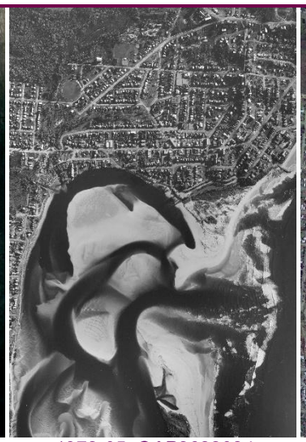
1971-05_UT_BPA-MRD_Q2230



1972-03_QAP23911369



1972-03_LT_BPA-DHM_Q2391



1972-05_QAP2622034

1974-02_QAP27714687

1974-03_QAP29864482

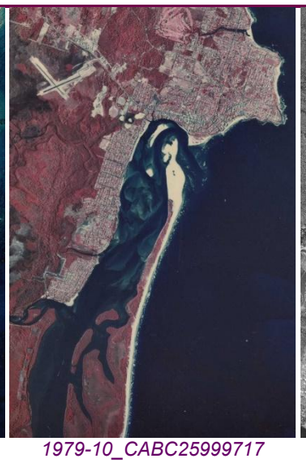
1974-07_QAP27844402

1977-07_QAP33639473

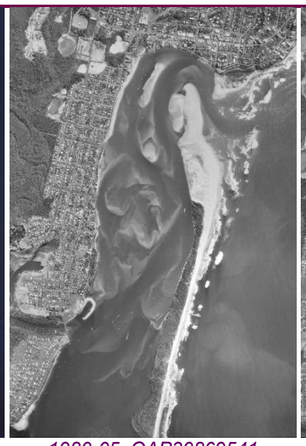
1979_Caloundra_20cm_RHAP

1979-05_QAP36672817

1979-06_LT_BPA_QP3667

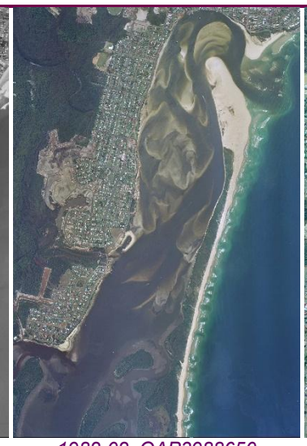


1979-10_CABC25999717



1980-05_QAP30869541

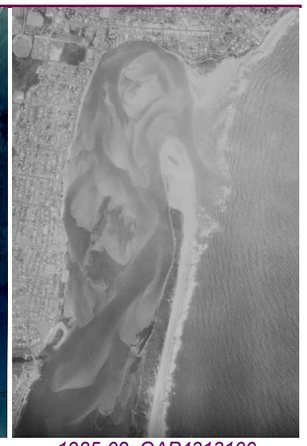
1981-07_QAP38576106



1982-02_QAP3988650

1982-06_QAP4046196

1982-06_MT_BPA_QPc4046



1985-02_QAP4313100

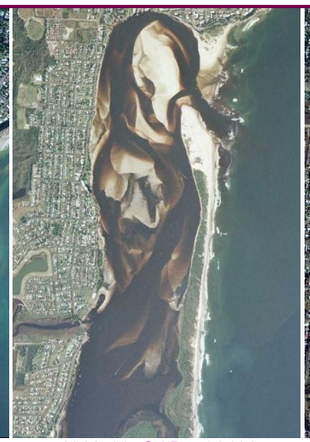

1985-05_QAP4411073


1985-12_QAP4450014


1986-10_QAP4603043


1987-07_QAP4348228


1988-06_QAP4093145


1989-06_QAP4790123


1989-08_QAP4905141

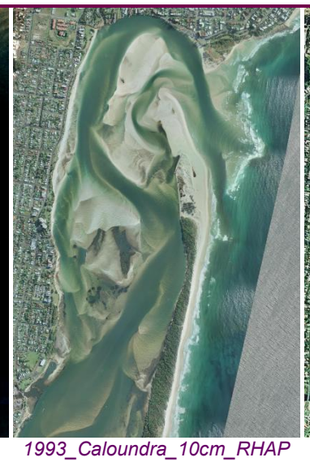

1991-06_QAP4955160


1991-07_QAP4991108


1992_Caloundra_10cm_RHAP

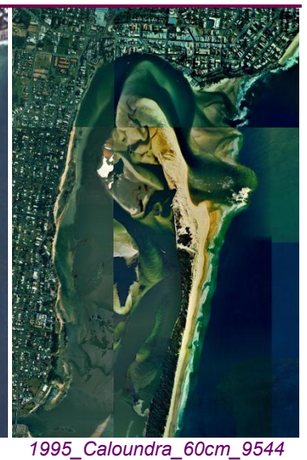

1992-06_QAP5062028

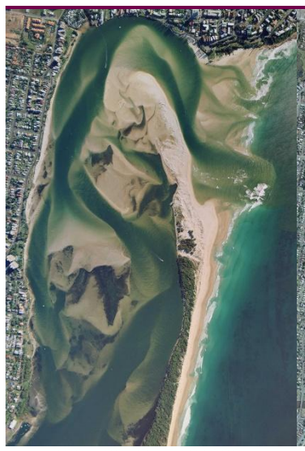

1992-06_LT_BPA_QPc5050


1993_Caloundra_10cm_RHAP


1994_Caloundra_250cm_9544


1994-05_QAP5247015


1995_Caloundra_60cm_9544


1995-06_QAP4646007


1996_Caloundra_20cm_RHAP


1996-05_QAP5280116

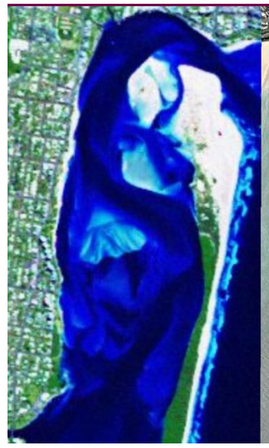

1997-08_QAP5564199


1999-07_QAP5723020


1999-07_QAP5724138


2004-06_QAP6078163


2005_Caloundra_25cm_PeriUrban


2006_SEQ_Burnett_Mary_250cm_SPOT5


2008_2009_SEQ_50cm_SISP_PeriUrban

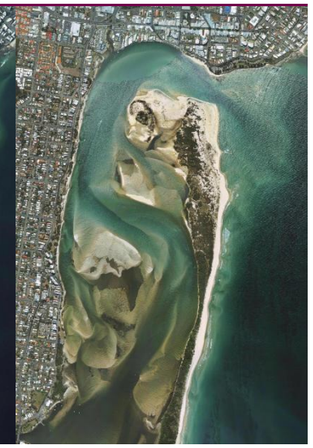

2009_QLD_2p5m_Spot

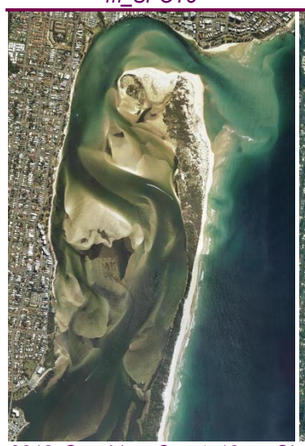

2011_Sunshine_Coast_10cm_SISP_LGA_Jul_Sep

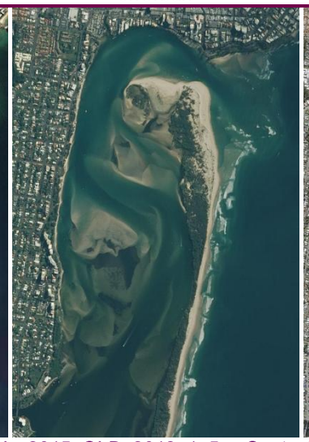

2011_Sunshine_Coast_10cm_SISP_Urban_Oct_Dec

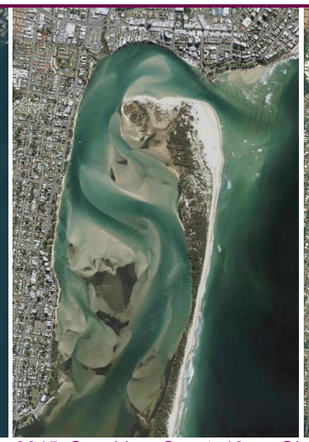

2012_QLD_2p5m_Spot

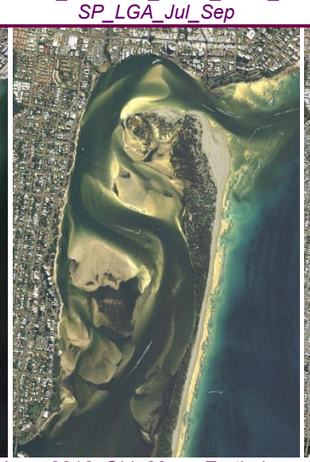

2012_Sunshine_Coast_10cm_SISP_Urban_Jan_Mar


2012_Sunshine_Coast_10cm_SISP_LGA_Aug_Dec

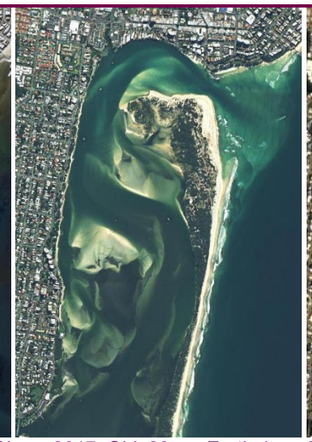

2013_Sunshine_Coast_10cm_SISP_LGA


2015_QLD_2013_1p5m_Spot

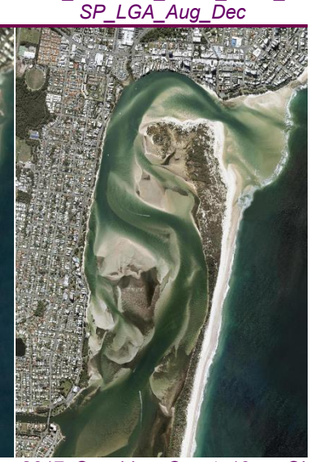

2015_Sunshine_Coast_10cm_SISP_LGA

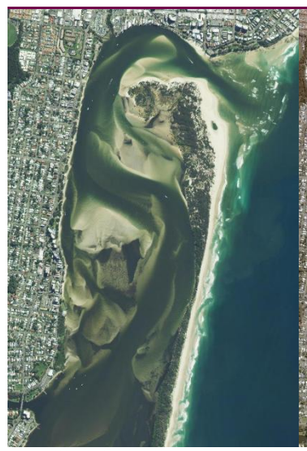

2016_Qld_80cm_Earth_i


2016_Sunshine_Coast_10cm_SISP_LGA


2017_Qld_80cm_Earth_i


2017_QSat_240cm_Planet_Q3_v2


2017_Sunshine_Coast_10cm_SISP_LGA


2018_Qld_80cm_Earth_i


2018_Sunshine_Coast_10cm_SISP_LGA


2019_Sunshine_Coast_10cm_SISP_LGA


2020_Sunshine_Coast_10cm_SISP_LGA


2021_Sunshine_Coast_LGA_10cm_SISP


2022_Sunshine_Coast_LGA_10cm_SISP


2025-05-25_Nearmap

2.3.7 BMT Coastal Processes Study for SCC (2013)

The Coastal Processes Study includes the following information regarding the area between Bells Creek and Caloundra Bar:

- Aerial photos show that on a regional scale the changes to the mainland shoreline within Pumicestone Passage have been relatively small, with the exception of the shoreline between Nelson Street and Earnshaw Street that has been subject to erosion/accretion associated with the migration of the main flood and ebb channels (refer below). Other notable localised changes and/or responses to structures include (historical photographs presented in Appendix C):
- Mangrove clearing and land reclamation works between Bells Creek and Lamerough Canal appears to have commenced in the late 1950s. This relatively low lying land is now dominated by residential development and is part of the Pelican Waters community.
- Dredging of the Bells Creek entrance has occurred since 1970 and provides deep water shelter for small boats. During the 1970s some of the material was used for land reclamation. Surplus dredge material was pumped to the north of the entrance and created a large shoal which has remained relatively stable.
- Dredging in 1973 and 1974 created the anchorage at the Caloundra Power Boat Club (north of Lamerough Canal). The dredge spoil was used as reclamation material to extend Woorim Park. Mangrove habitat was removed to the south of the Club and replaced with narrow sandy beaches (Riedel and Byrne, 1979).
- Rapid construction of the Pelican Waters canals took place in the early 1990s however aerial photos show the initial canal construction actually commenced in the early 1980s.
- Mangrove clearing and land reclamation works occurred in the early 1980s to create the land where the TS Onslow Naval Reserve is now located. Today this area suffers shoreline erosion problems.
- During 2007 and 2008, concrete blocks were used to defend the shoreline at the Naval Reserve. This material type is inappropriate and likely to accelerate local shoreline erosion problems.
- The area north of Oxley Street including Leach Park has been protected by a rock wall since the mid 1960s. Geofabric groynes have been unsuccessful in stabilising a beach in this area. These groynes have recently been formalised by rock however it remains unlikely that a beach will form in this area until the main channel migrates offshore (possibly driven by morphological change at the entrance).
- Bulcock Beach has remained relatively stable due to the control provided by the rocky outcrop around Deepwater Point. Bulcock Beach is observed to widen and extend to the east when the channel entrance migrates toward the south.

2.3.8 Satellite Derived Bathymetry (2022-2025)

Maritime Safety Queensland (**MSQ**) commissioned Satellite Derived Bathymetry (**SDB**) as part of its investigations regarding options to address post-breakthrough navigational access. As discussed in Part 1, modelling indicated a dredged channel would likely shoal in a short time period, and ongoing change – movement of sand – restored reasonable access (at least relative to the immediately post-breakthrough configuration) so no actions were taken.

SDB involves identifying suitable satellite images and applying various techniques to derive a bathymetric ‘surface’, a 3D representation of the sea bottom, or Digital Elevation Model (**DEM**). MSQ procured their SDB from EOMAP, which has established expertise, provided documented methodology, as well as estimates of error (vertical uncertainty).

An advantage of SDB, or any products derived from satellite data, is the vast repository of information available, most of which is freely available. Landsat is the oldest continuously operating program, having commenced in 1972. A good launching pad for those that want to view imagery is Visible Earth; a categorical option is NEO; Worldview snapshots is a lightweight tool for creating imagery layers, and a web-map interface is provided by NASA Worldview. A deep dive into sensor and platform technology is available through eoPortal, operated by the European Space Agency (ESA).

MSQ initially procured ‘surfaces’ for three dates, one pre-breakthrough #1 (2021-05-16) and two post (2022-08-18 and 2022-10-31). Subsequent to breakthrough #2 they procured two 2025 surfaces (2025-01-14 and

21025-03-17). Those five surfaces, as presented by EOMAP in the deliverable as map outputs, are provided in Figure 33 through Figure 37. All of the surfaces are presented in “Chart Datum” (CD), which is approximately equivalent to Port Datum or LAT (EOMAP used local tide gauge data – Military Jetty – for datum translation).

For the initially delivery of three surfaces, EOMAP also provided difference surfaces – these are produced by applying ‘spacemath’ to two surfaces, or DEMs. A DEM is a raster image, which means it is a gridded surface, with each grid cell having certain numerical values, such as elevation. A photograph is a raster image where the cells, or pixels, each have numerical values for red, blue and green (RGB). Each of these colour bands can contain a value between 0 and 255, with various values for each RGB component providing the ability to describe a spectrum of colours. A raster image can also be presented as greyscale, with a single band rendered on a spectrum of white to black (or vice-versa), as described above.

For a DEM difference surface, the math is simply computing the difference in elevation between the two surfaces, for each grid cell. Just as a photographic image can range between low and high quality, a raster image works in a similar way. In each case, the size of the grid cell is a key parameter – finer mesh, higher quality image, much like a television screens or computer monitors. The EOMAP products delivered to MSQ included both 2m and 5m DEMs (e.g. 2m x 2m grid cell size). These are relatively high quality outputs. To produce these, with reasonable confidence, you need a certain number of values for each grid cell, which are then averaged (there are a number of techniques, such as ‘nearest neighbour’ to address data gaps and provide a smoother surface by correlating adjoining grid cell values).

Figure 38 is a difference surface we produced for this report, comparing the surfaces EOMAP provided for the pre-breakthrough #1 (2021-05-16) and latest post-breakthrough #2 (2025-03-17) surfaces. As noted above, the deliverables report documents methodology, which included selecting the ‘best’ imagery (high-quality, 2m resolution, cloud free, etc.) and applying various processing and quality control/assurance techniques.

The report advises that under ideal scenarios, including on-site information, EOMAP’s SDB data is accurate to 0.5 m LE90 (meaning that 90% of the data fall within the stated depth uncertainty). Absent on-site information, the uncertainty is typically between 0.5 m and 1.0 m LE90 and a depth dependent factor between 10 and 15% of water depth. Water clarity is an important factor, so in general better accuracy is typically achieved for shallower depths. The relatively shallow depths within the Passage would in general provide favourable conditions for achieving high accuracy, noting that post-breakthrough conditions include periodic disruptions to water quality, including turbidity and other factors that attribute to clarity.

This means that changes shown on any of the surfaces which are ‘low’ (e.g. 0.5-1.0m) may be within the margin of error or uncertainty, and larger values, whilst also potentially uncertain, would still be likely to accurately express a trend – deeper (scour) or shallower (shoaled/accretion).

As the SDB and the difference surface are comprised of gridded numerical values, spacemath can also be used to calculate the changes and express them volumetrically. Table 5 provides estimated changes to accompany the visual presentation in Figure 38.

The first row of data is for the entire SDB difference surface, showing an increased volume of ~2.6M m3. That volume includes offshore/nearshore areas – open coast. The following two rows ‘clip’ the difference layer so as to exclude the coast and express the changes only in the estuary/Passage, showing that ~1/3 of the net volume change is coastal and ~2/3 estuarine. The difference between the two clipped areas is that one includes a small part of the entrance. The cadastral boundary for the Passage roughly aligns to Deepwater point; the additional entrance component includes additional coastline along Bulcock Beach (to about Ian Street).

A further general caution about these estimates is that it is evident on the figures below that the SDB surfaces have ‘gaps’. For example, Bribie Island is excluded pre-breakthrough (only shown as a grey/uncoloured outline). For the final post-breakthrough surface that was used to calculate differences, the breakthrough is included, the northern tip of the Island has a different footprint, and some of the new sandbars that have formed are excluded. Regardless, the data and calculations provide approximate visual and quantitative comparisons that add further insight regarding the changes that have occurred – sand movement.

Table 5: Estimated surface changes pre→post breakthrough (RPS) from SDB surfaces (EOMAP)

Surface	Volume (m3)	Pixel count	Area (m2)
Difference	2,556,519	1,091,713	4,366,852
Clipped – PP + entrance	1,510,672	747,476	2,989,904
Clipped – PP cadastral	1,452,377	740,267	2,961,068

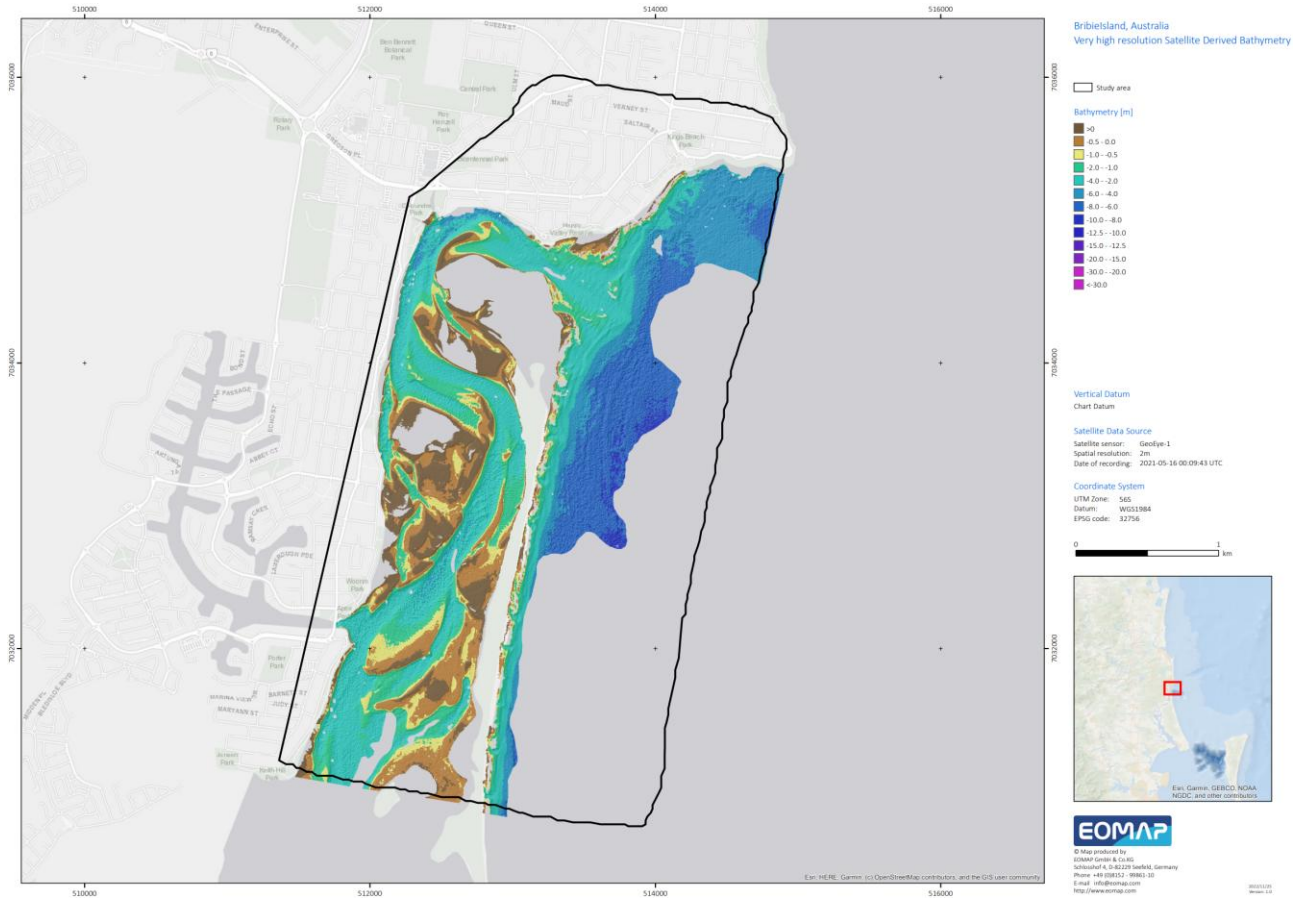


Figure 33: Pre-breakthrough #1 (2021-05-16) Satellite Derived Bathymetry (EOMAP)

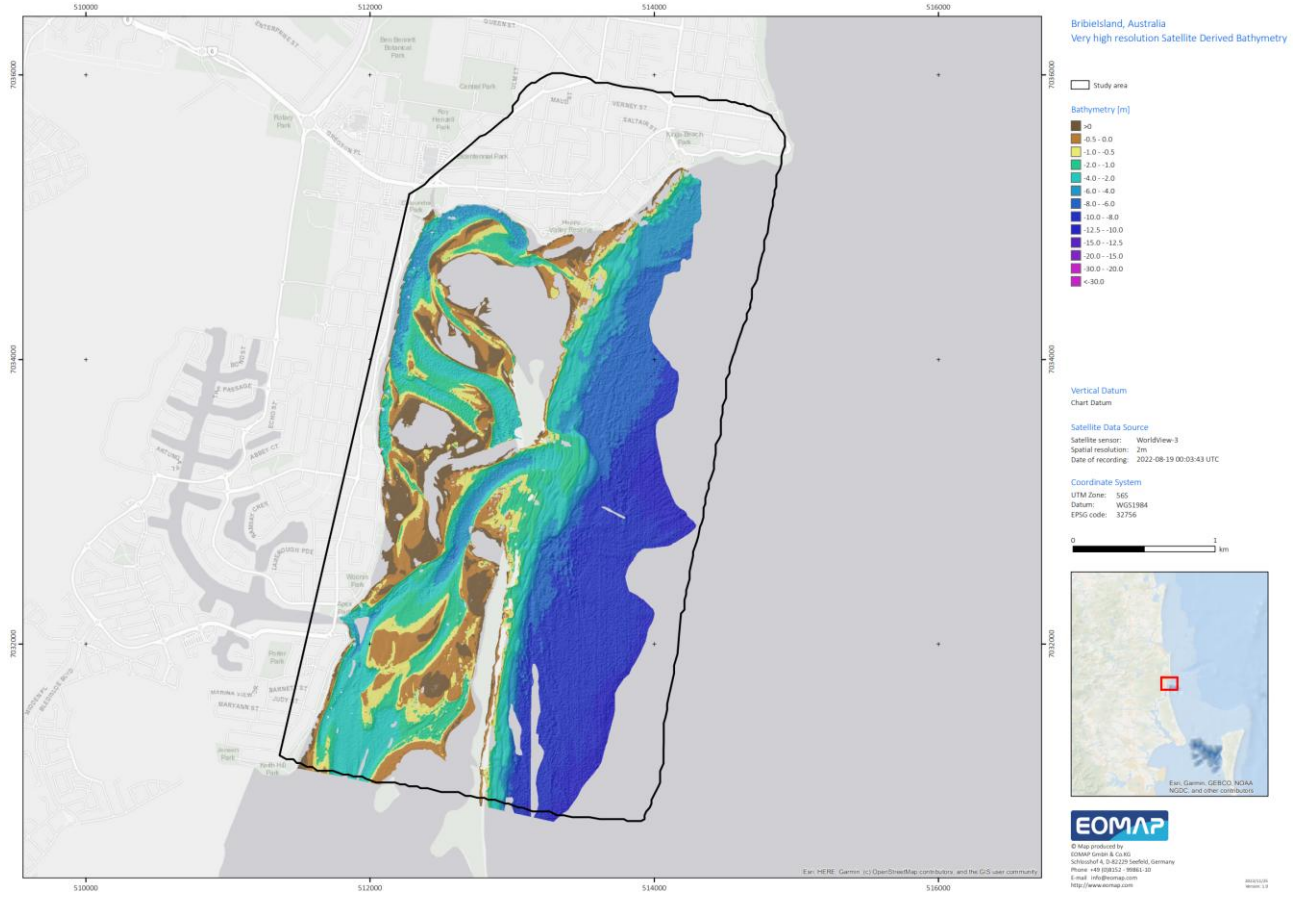


Figure 34: Post-breakthrough #1 (2022-08-19) Satellite Derived Bathymetry (EOMAP)

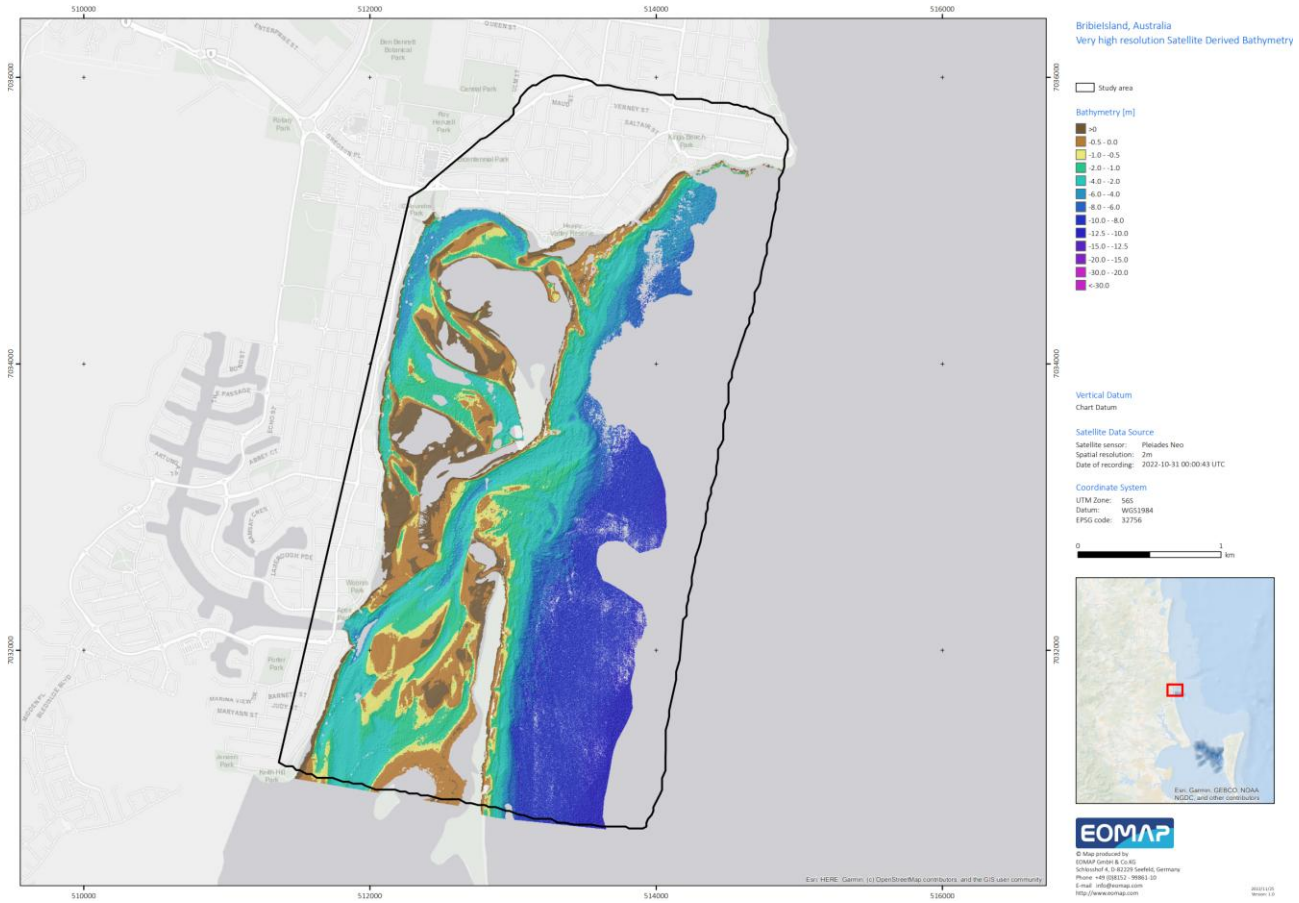


Figure 35: Post-breakthrough #1 (2022-10-31) Satellite Derived Bathymetry (EOMAP)

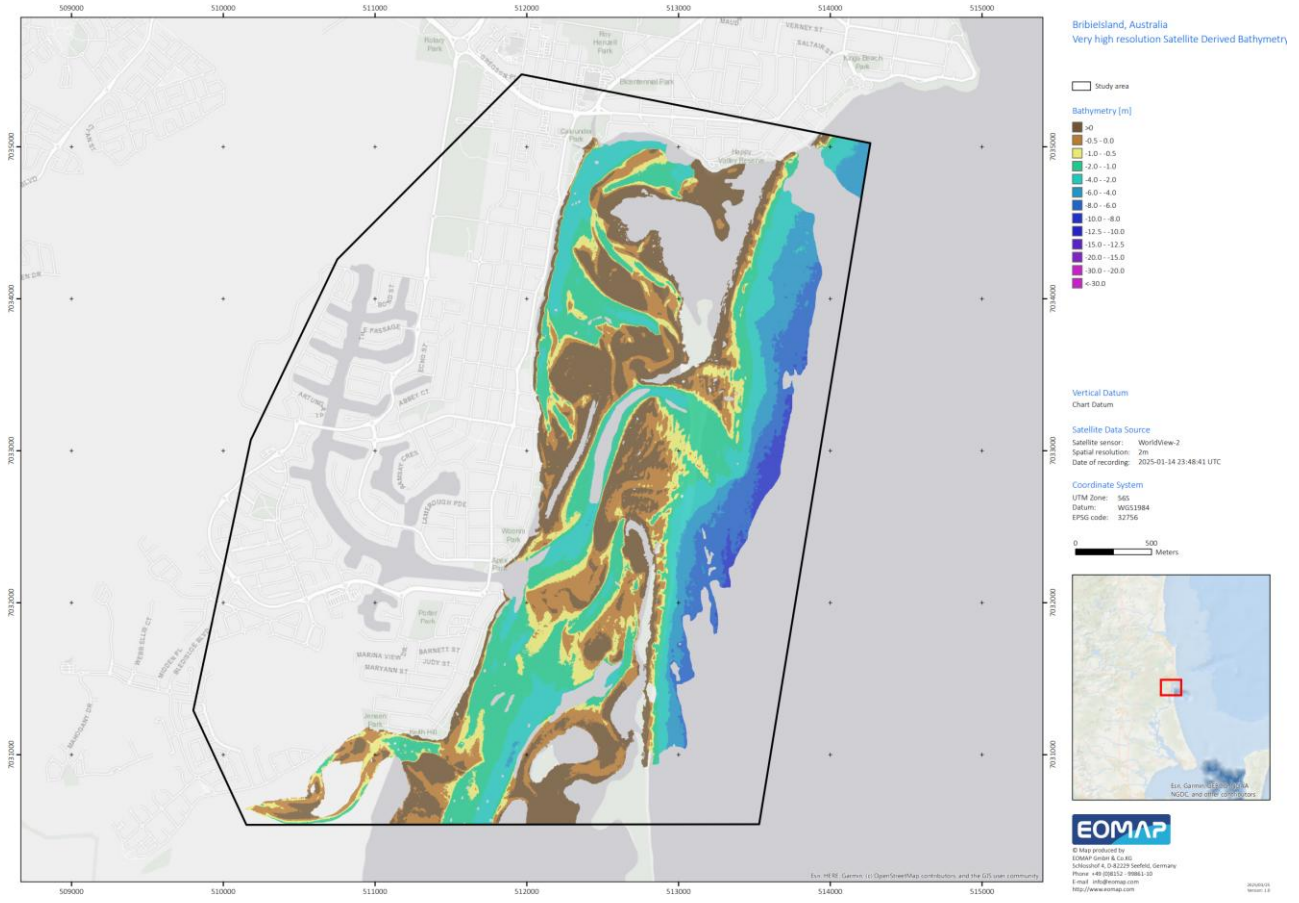


Figure 36: Post-breakthrough #2 (2025-01-14) Satellite Derived Bathymetry (EOMAP)

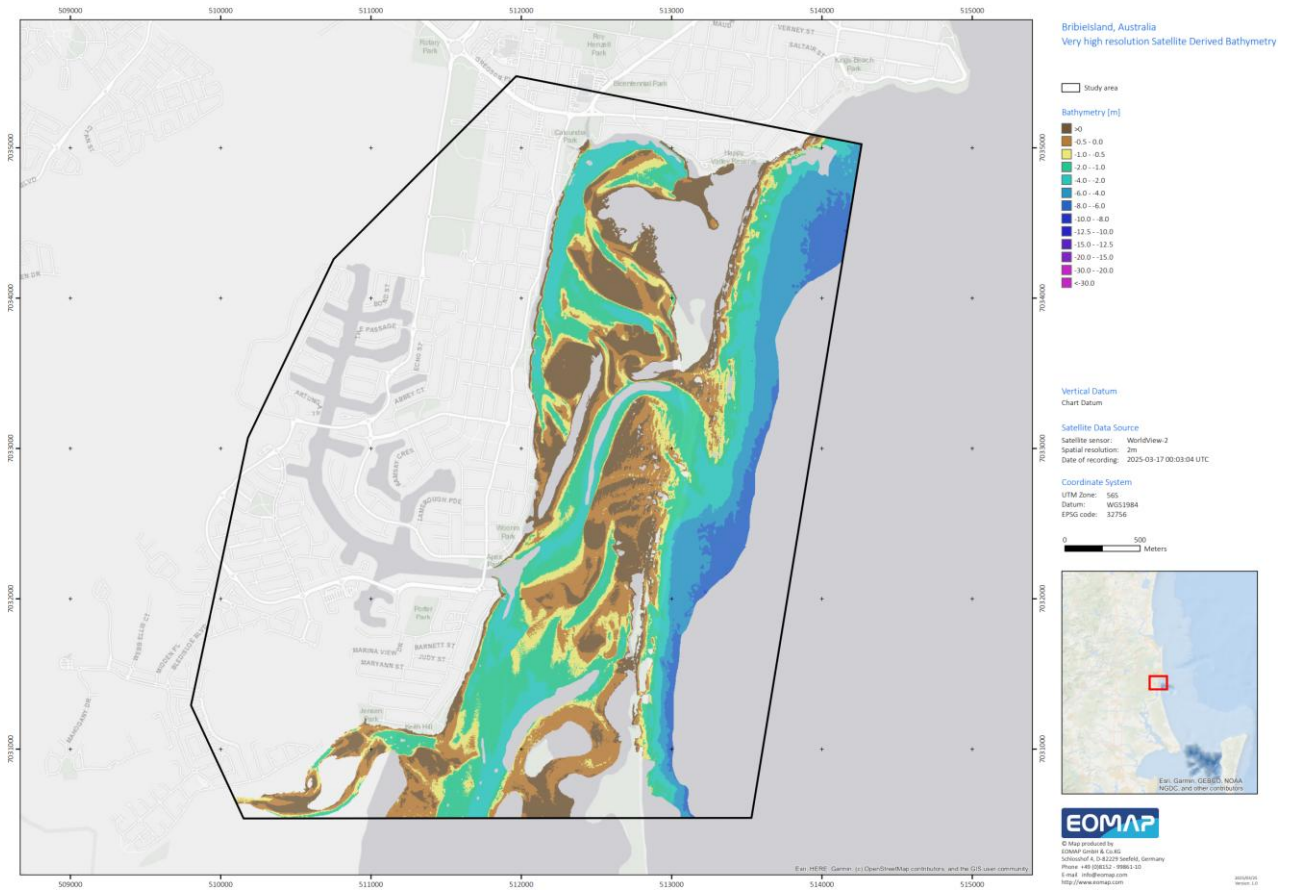


Figure 37: Post-breakthrough #2 (2025-03-17) Satellite Derived Bathymetry (EOMAP)

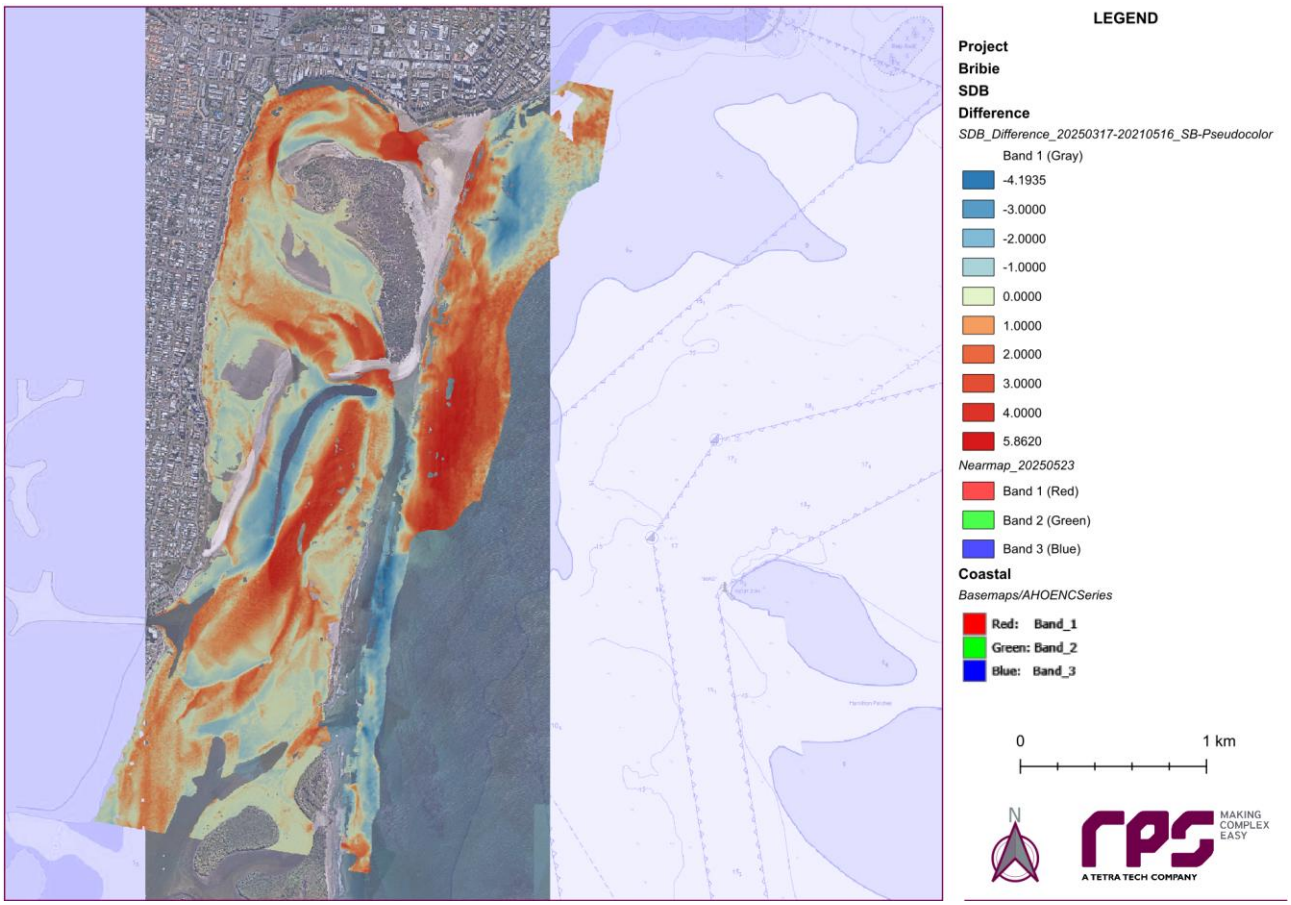


Figure 38: Difference surface, by RPS from EOMAP SDB surfaces (as labelled, see text for further description)

2.3.9 Digital Earth Australia

An introduction to DEA is provided in s.2.2.4, with discussion there focused on the DEA coastlines product. A relatively new addition is DEA Intertidal. Available layers include: Elevation; Elevation uncertainty; Exposure (%); Clear observation count; and Extents, a categorical dataset that classifies coastal areas into five classes, including the satellite-observed extents of the exposed (i.e. non-vegetated) intertidal zone.

The class definitions of the Intertidal Extents layer as provided on the DEA platform are as follows:

- **Ocean and coastal waters (1)** — Pixels that are wet in 50% or more of satellite observations and are located within the coastal mask (a cost-distance connectivity mask combining elevation with distance from the ocean).
- **Exposed intertidal - low confidence (2)** — Pixels that have a correlation between tide height and NDWI of at least 0.15, and are located within the coastal mask (see Ocean and coastal waters).
- **Exposed intertidal - high confidence (3)** — Pixels that are included in the intertidal elevation dataset.
- **Inland waters (4)** — Pixels that are wet in more than 50% of satellite observations, and fall outside of the coastal mask (see Ocean and coastal waters).
- **Land (5)** — Pixels that are wet in less than 50% of satellite observations.

The intertidal datasets are produced annually from a 3-year composite of input data, combining Sentinel-2 and Landsat DEA satellite 'imagery' (the satellite data includes multiple streams, including visible light as well as wavelength outside the visible spectrum). The time series commences in 2016, with the datasets labelled by the middle year of data (e.g. the 2017 layer combines data from 2016, 2017, and 2018). Accordingly, the layers show longer-term averaged changes, improving reliability of the estimates, but for the relatively short-term changes that have occurred post-breakthroughs, excluding more detailed insights.

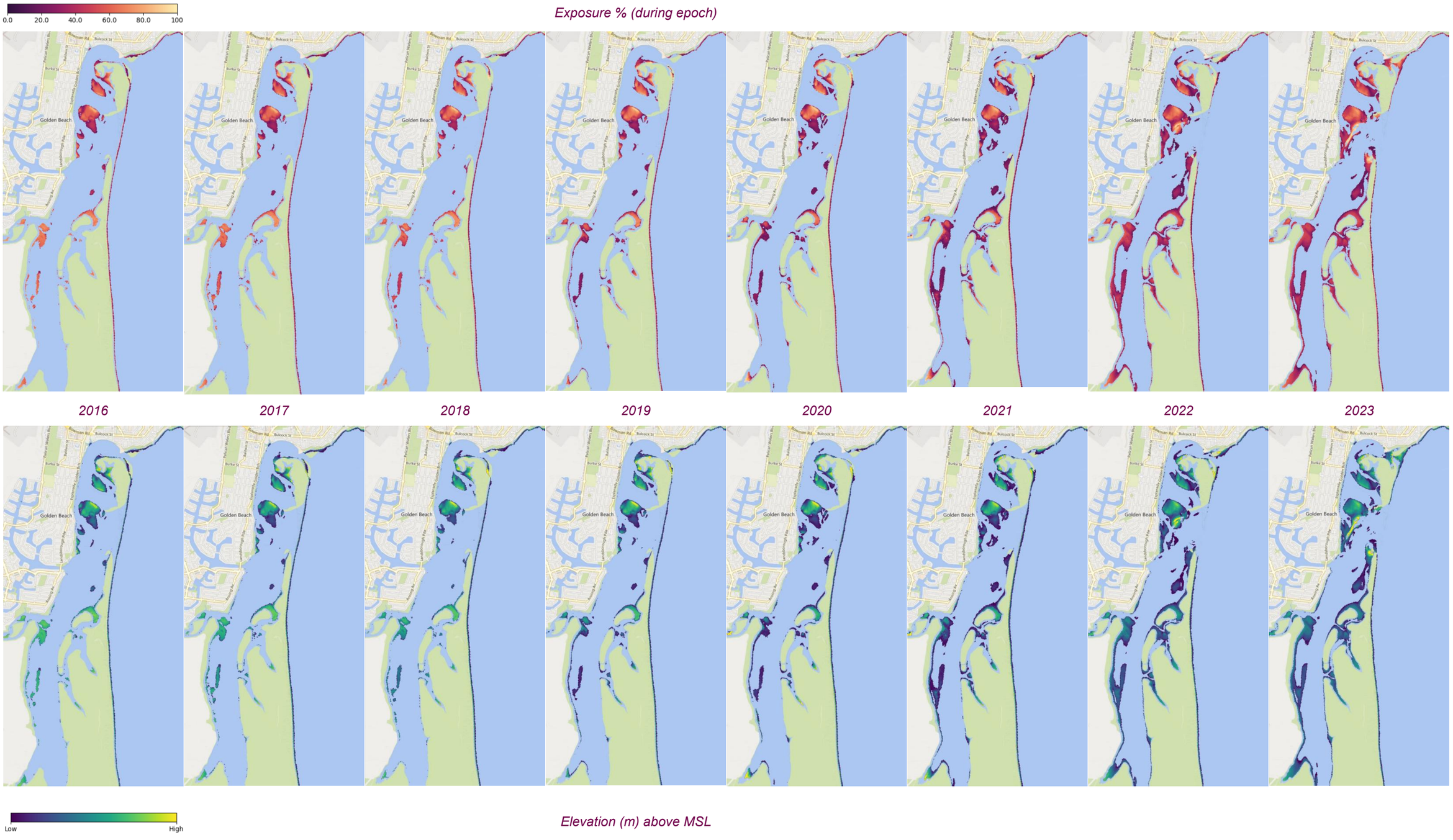
Table 6 presents images from DEA Intertidal, including exposure % (time) and elevation or height. Legend scales for each set of maps are included above and below the respective rows.

A general observable trend is an increase in intertidal areas within parts of Pumicestone Passage. These images have been clipped to include more southerly parts of the Passage (compared to early boundaries used, where Military Jetty was the southern extreme) as the sequence shows changes in those southerly areas. Logically, the more southerly (and larger) 'Bribie Bar', particularly following BT#2, appears to be moving sand further into the Passage faster and/or at increased volumes than the former Caloundra Bar.

A share link to a DEA map we created is provided below, however, your internal firewalls may block access (based on our experience). If you do get access and get prompted to see a story, click "maybe later" to retain the view we created that is focused on Bribie Island. If the share link doesn't work, use the second link below to see information about DEA, or the third link to jump to the mapping layer (possible firewall issues as well); from there, view the story and then zoom to your area of interest and explore the available layers.

- Shared map link
- DEA website
- DEA maps

Table 6: **DEA Intertidal (Sentinel-2 and Landsat) time series 2016-2023, Exposure (% time) on top row, Height (m above MSL) on bottom row (Digital Earth Australia)**



2.3.10 Bathymetry – 1967, 1971 and 2021

Available historical bathymetry for Pumicestone Passage that we were able to locate is limited to a single bank-to-bank survey, undertaken by DHM in 1967. There are potentially other surfaces, for example that used for the modelling associated with the land used investigations water quality component and/or work undertaken for Pelican Waters approvals. We did confirm that available DHM/MSQ bank-to-bank bathymetry is limited to this single survey (other surveys undertaken have a smaller extent or footprint, typically focused on navigational channels, or boating facilities such as boat ramps or jetties).

That 1967 survey was georeferenced – aligned within a GIS system. The streets shown on the survey provided a reliable cross-reference to the current cadastral road boundaries. We did not fully 'digitise' the survey, i.e. create points for each sounding with elevation values from the survey for each point. Doing so would allow a DEM to be created for 1967 and allow additional comparisons to be made of volumetric changes. The effort would not be extensive, so the investment would probably be worth the additional insight (digitising the contour lines as well may be required to generate a sufficiently detailed DEM).

Regardless, georeferencing the survey enabled us to create images that layer the charted bathymetry with other information that is discussed above. The two images produced are described below:

- Figure 39 – layers the 1967 bathymetry with the 1971 BPA imagery and shows the digitised 0m contour line that we created based on that shown on the 1971 image. Note that the 1967 height values are in LAT, whereas the 1971 is in AHD, as discussed above.
- Figure 40 – layers the 1967 bathymetry with the pre-breakthrough SDB. This image clearly shows how the 1967 channels and flow paths correspond to pre-breakthrough elevations, notably areas with elevations above the Highest Astronomical Tide (**HAT**) – land, as opposed to intertidal surfaces. The 1967 survey includes positive elevations (denoted by an underscore). For example, the sandbar in the northeast Passage shows heights of ~4m LAT, above HAT. The 1967 survey includes detail to show banks (0m LAT) suggesting both sandbars and channels.

Collectively, these images illustrate the historically broad entrance/flood delta that provided a large surface area with multiple flow paths. The sand bar/island in the northwest part of the passage shows positive values, but with the highest values being ~4.5 ft, this area would still be below HAT (~6 ft). The delta restricted flows to some extent, attenuating tide levels, but did not fully block flows. Present day topography, indicated by the gaps in the SDB, completely blocks flows, with the dogleg and tip of the Island elevated and vegetated. Additional images are provided and discussed in s.3.5.1 to further illustrate this transition.

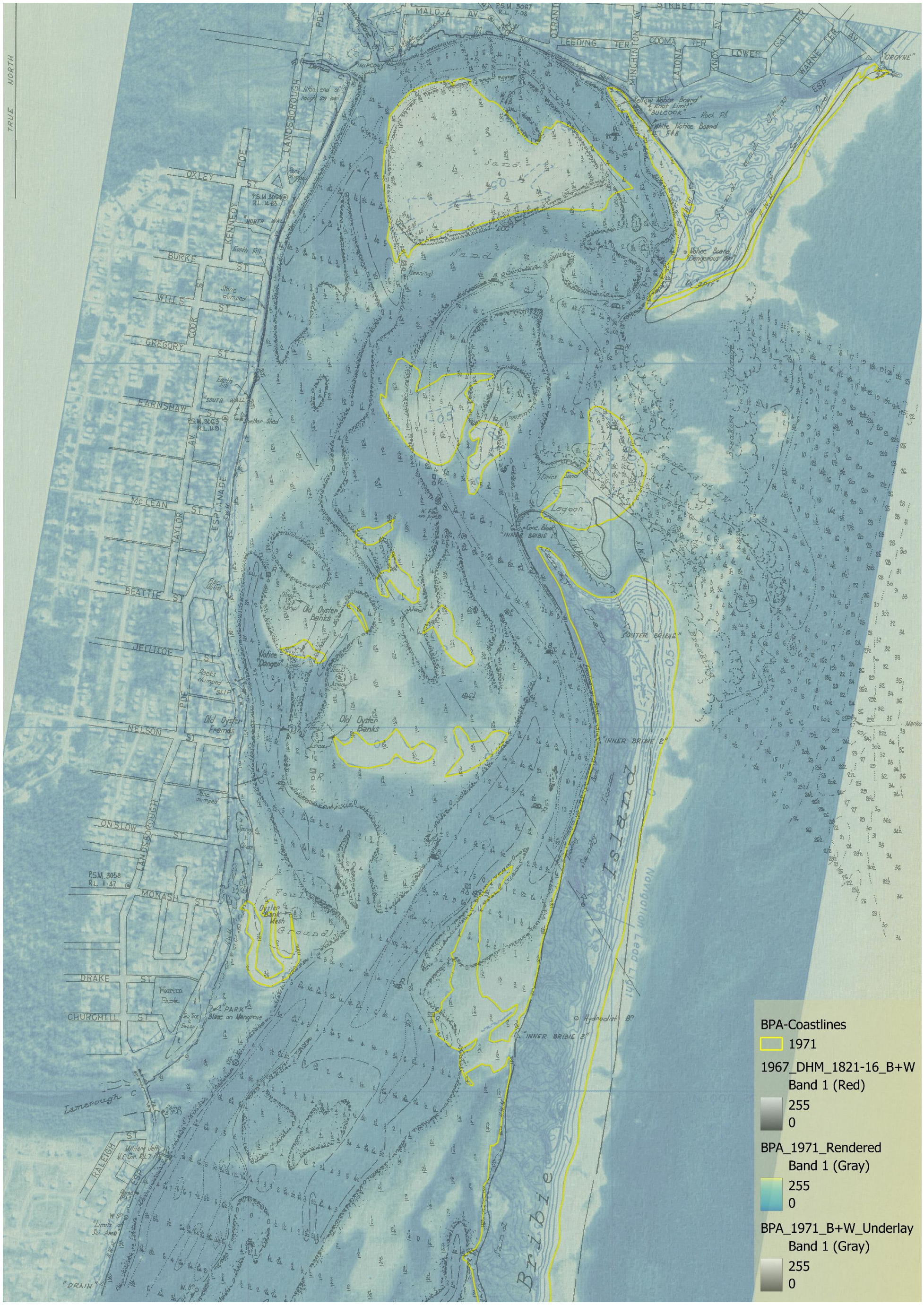


Figure 39: DHM 1967 bank-to-bank survey, overlain on BPA 1971 aerial with 1971 digitised coastline (RPS, from sources as noted – additional notes in text)

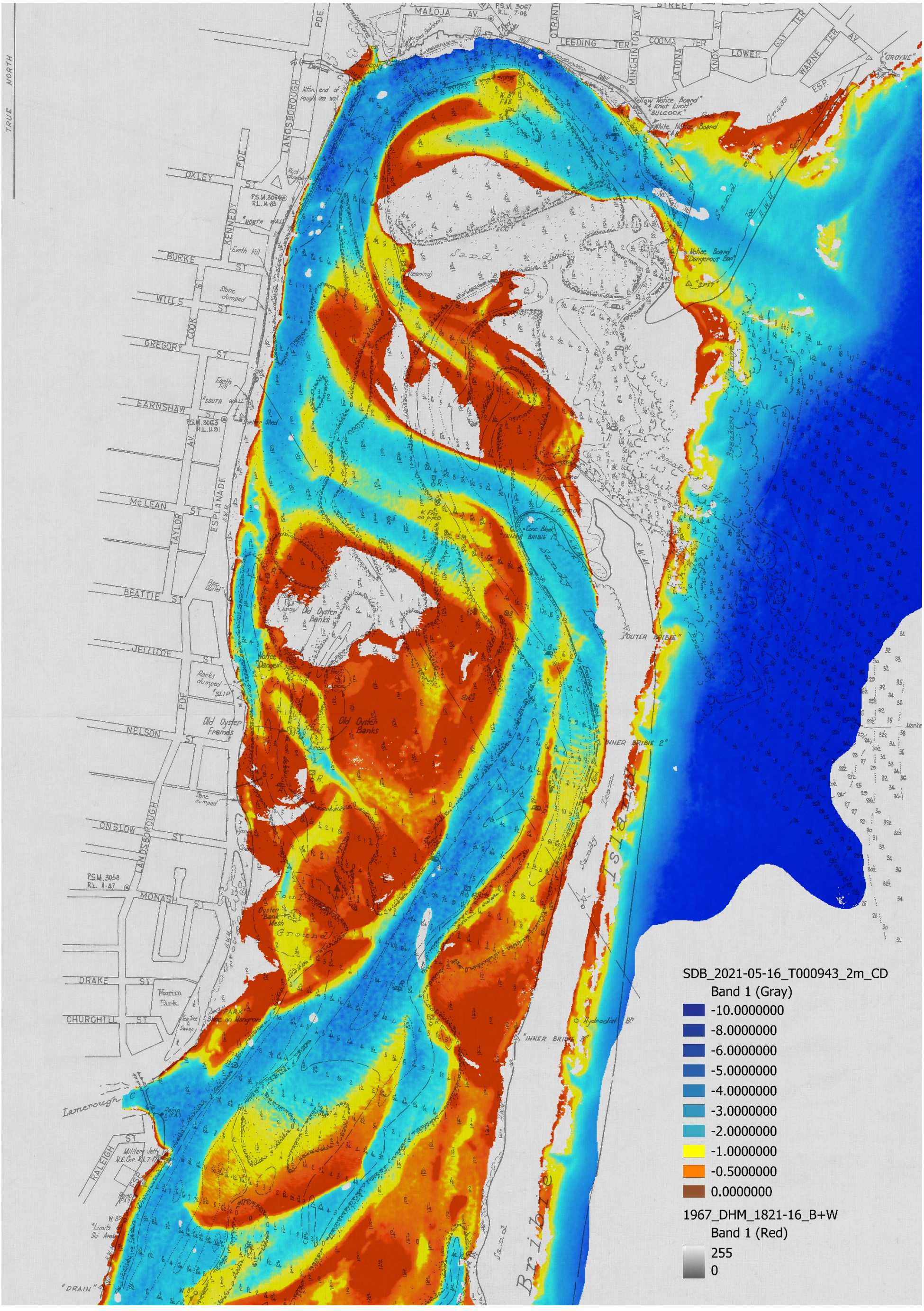


Figure 40: DHM 1967 bank-to-bank survey, overlain on 2021-05-16 SDB

2.4 Conceptual model

2.4.1 Processes

Sand moves, including through **natural processes**, such as:

- **Tides** –
  - Flow in and out of **Pumicestone Passage**, with
    - Northerly (from/to the ocean) and
    - Southerly (from/to Moreton Bay)
    - Components meeting and 'cancelling out' to create a tidal nullpoint in the vicinity of
    - The Skids, noting that this point may shift over time, with
    - The northern entrance delta (ebb and flood) and bar variable and
    - Tide ranges in the northern Passage are shown to vary significantly (~30%) as sand moves
    - The net observable trend suggested is progressive shoaling, a flood delta, more sand
    - Quantity take-offs from Reidel & Byrne suggest:
      - During the 47.5 year period, the average rate of change in the mapped shoal areas was 2.1%/yr, with an estimated net increase of 332,000 m2, or about 30% by areal extent
    - Erosion of the Island – see further below – was accompanied by accretion in the estuary:
      - Jones [084] for the period 1958-1972 estimated estuary accretion of 125-130k m3
      - Lester [106] for the period 1978-1993 estimated estuary accretion of 144k m3/yr
  - As well as along the **Bribie Island coastline**
    - Tidal flows are considered to be the dominant influence on the coastline in this area
    - The northwest channel, a suggested natural feature on early bathymetry suggests this tidal shaping influence, as does the alignment of the western side of the banks
    - The offshore northern banks are considered to have ebb and flood components
    - The combined effect is a general conservation of sand on the banks (circular transport)
    - Accordingly, sand supply from the banks to the adjacent coastline is considered minimal
    - However, northward transport is suggested in NW Channel bedforms and in Hamilton Patches
    - Suggested long-term erosion trends arise largely from net tidal scour and minimal supply
    - Tidal sand transport along the coast likely includes both north (ebb) and south (flood) transport
    - A net southerly transport of 15k m3/yr was suggested by Jones in 1992 [084] –
      - From 1958-1972, ~3-400k m3 of sand was released by erosion of northern Bribie Island
      - Accretion of ~125-130k m3 (25-30%), mainly intertidal banks in the estuary occurred
      - The unaccounted for ~220k m3 suggests a potential southward littoral drift of 15k m3/yr
      - Southward transport towards Skirmish Point (accreting) as per Jones likely destination
      - Jones also noted the Kings Beach groyne interference with littoral drift (wave and/or tide)
    - Erosion and loss between 1978-1993 was much higher according to Lester in 2000 [106] –
      - Outer Bribie experienced erosion at a rate of approximately 144k m3/yr (vs 21-28k m3/yr)
      - Accretion of ~144k m3/yr, primarily in the flood delta occurred (~80% vs ~25-30%)
      - Unaccounted for loss doubled to 30k m3/yr
      - North West Channel transport into Moreton Bay also suggested as a possible mechanism
      - Storm activity was similar between the two periods and dismissed accordingly

- **Waves –**
  - **Swell waves** –
    - Predominantly arrive from the southeast
    - Approximately 500,000 m3/yr of sand arrives from the south
    - An estimated 200,000 m3/yr is deposited on the Moreton Bay delta south of Moreton Island
    - That leaves 300,000 m3/yr arriving along Moreton Island (western shoreline mostly accreting) and bypassing onto the northern banks, some of which is transported into the inner banks
    - Net northerly transport is minimal for the Sunshine Coast, but does or did supply Fraser Island
    - The northern banks offshore of Bribie Island dissipate much of that swell energy
    - Accordingly, shoreline erosion from wave energy is likely limited to periodic large storm events
    - This potentially limits likely transport from the banks towards the Island shoreline
    - The Caloundra Headland deflects/refracts the southeast swell to the west and south
    - Sand may be transported from northwards onto Kings Beach and entrance delta/spits
    - Overall, this produces a net southward transport of sand (including into the Passage)
    - However, the curving coastline, offshore reefs, exposed coffee rock and shifting spits and sandbars creates a 'confused' and variable pattern; gross transport processes potentially include significant transport in various directions, but overall, more sand moves south
    - The outer shape of the offshore banks suggests this progressive transport, along an alignment between Cape Moreton/North Point and Caloundra Headland (as well as Point Cartwright and Noosa Heads), and potential wave domination as suggested by Stephens
  - **Wind waves** –
    - May be a contributor to erosion on the open coast, as well as shaping Passage intertidal areas
    - However, wind waves are likely to be a lesser contributor, but data is relatively limited
- **Wind, vegetation and wildlife** –
  - Wind transports sand
  - Cape Moreton lighthouse provides one of the closest weather data sources
    - *Caloundra airport may have useful comparison data, but we did not locate a data repository*
  - Winds from the southeast dominate (annually), more variable at 9am and more predictably at 3pm
  - Wind transport is potentially predominantly into the Passage
  - Animals may transport seeds or other vegetative material and deposit them on sand banks
  - Roosting birds also add fertiliser in the form of excrement that may assist vegetative colonisation
  - Vegetation may trap wind blown sand, as well as sand transported by tides by influencing currents
  - Over time, islands may form (and periodically erode) transforming parts of estuaries to land
  - Included photos and maps document progressive islandisation, with the northern tip of Bribie
    - transforming from the narrow north/south shape suggested on early maps,
    - to the 'hockey stick' northwest trending peninsula evident on recent aerial imagery
    - That land extension blocks historical flow paths and creates a virtual diversion dam

Sand movement in this area also includes likely **anthropogenic influences**:

- **North West Channel and other channels and banks –**
  - Whilst the North West Channel appears to have existed naturally, dredging has occurred
  - Progressively widening and deepening the channel is likely to have enhanced tidal sand transport

  - The channel is a potential 'conveyor belt' transporting sand into the bay and northwards
  - Northeast transport is likely from the 'dog-leg' shape of the channel near NW2 beacon
  - The configuration of Hamilton Patches potentially influences the extent which northwards tidal sand transport may be diverted by Caloundra Headland to the south, or bypass it and move north
  - Dredging of banks in the Bay may create accommodation space, shifting the balance of north/south transport along the channel to the south, with the Bay effect as a sand sink potentially enhanced
  - Extraction of ~1M m3/yr has occurred for the last ~20-years under the MBSES, with additional historical extraction for capital projects and commercial extraction prior to the MBSES
  - This is approximately twice the estimated volume arriving annually from the south (including the estimated 200k m3 that is deposited on the south delta)
  - Conceptual models or other information regarding how this apparent deficit balances within the broader system, including the northern banks, but also extending northwards to Fraser Island are not evident, and modelling for the approved extraction did not extend past southern Bribie Island

- **Kings Beach and Deepwater Point –**
  - Supply of sand from Kings Beach to the south (downdrift) appears to be a significant factor
  - The groyne has the potential to disrupt transport processes
  - Early BPA recommendations required ongoing nourishment from external sources
  - Recommendations also included maintaining dunes around the Deepwater Point spit
  - Alternative groyne configurations suggest an interest in options to increase the sand 'reserve'
  - The northern spit potentially benefits navigation by keeping the entrance south, avoiding rock reefs
  - Configurations in this area may affect popular surf breaks (positively or negatively)
- **Bribie Island –**
  - Declaration of protected areas included prohibitions, or severe restrictions, on dredging, effectively precluding or limiting management interventions that may have been considered or proposed, reinforcing progressive natural changes, notably shoaling – flood delta growth in the Passage
  - Anecdotal evidence suggests community group(s) and/or individuals may have planted vegetation (notably *Casuarina spp.*), with protections potentially influencing those contributions; this may have enhanced islandisation, shortening time-frames
  - Maintenance of dunes was required under the BPA scheme, but there is no clear record of whether LSC or its successors undertook works, or whether following declaration of the National Park, the State managed dune erosion (noting that there are some vehicle restrictions)
  - Whilst erosion of the Island appears to have been predominantly coastal, the Island also eroded on the western foreshore – discussed further below
- **Pumicestone Passage –**
  - Oyster leases, discussed further later and shown on the 1967 survey, potentially contributed to a channel meander towards the Island
  - The location of that channel is associated with documented erosion of the Island in the Passage
  - The horizontal foreshore retreat is greater on the coastal side than the Passage side of the Island
  - However, bathymetry and cross-section data show a near vertical profile in the Passage
  - Use of the channel by vessels potentially contributed wake erosion
  - Flow velocities in the channel potentially precluded mangrove colonisation of the foreshore
  - Oyster leases may have also been present on the western side of the Passage, but the evidence is less clear and, as such, the potential influence is uncertain
  - Reclamation, removal of mangroves and foreshore protection works also potentially contributed various influences

- Catchment influences, such as clearing, agriculture, and urbanisation are potential contributors, however, indications are that sediment inputs are minimal.
- Catchment management may be significant with respect to water quality, and development does typically compress runoff times and flood peaks, including intensity, but morphological influences are potentially minimal

2.4.2 Model

Sand moves, trends or patterns can be ascribed, but variability and fluctuation is inherent. Predictability is potentially less certain for longer-term trends, including 'decadal' processes – large movement of sand in a short time period, typically associated with periodic severe storms, as well as contemporary transitions associated with climate change, which include intensification of extremes such as storms.

Coastal

The coastal erosion has been consistently attributed to a deficit of sand supply in the nearshore zone –

- Moreton Island diverts/bends the swell, diverting sand supply from the south into the Bay.
- Ebb tides move sand on the outer eastern side of the North Banks northward and potentially deliver sand from the banks in the Bay onto the North Banks.
- However, flood tides, including conveyance through the North West Channel, move sand south, including on the western side of the North Banks.

The net result is the circular pattern Stephens described that conserves or traps that sand in the greater Moreton Bay delta. He also noted the edge effect of that circulation as an erosional force (in the absence of sand supply from the north) on Bribie Island, with the location of the breakthroughs being the point where both the North Banks and the North West channel are closest to Bribie Island. So that erosional scour, with a southward transport, is potentially concentrated on the part of the Island where the breakthroughs occurred.

However, coastal sand transport dynamics in this location are complex. The north banks narrow at the location of the breakthroughs, so swell energy potentially exerts more influence, having a shorter distance of banks to cross (or no banks possibly as you move further north). Patterns in the sand on this northern tip of the banks suggest northward transport, distinct from the ebb/flood circulation pattern to the south. Hamilton Patches, to the north of tip of the North Banks, is also reported as moving northward.

Sand that is transported northward, if intercepted by Caloundra Headland, is converted to southward transport, onto Kings Beach. In the absence of a groyne, it would move towards Deepwater Point, possibly accumulate as a spit, contribute to the ebb delta/bar and southward nearshore coastal transport, and/or enter the Passage and add to the flood delta. Historical dredging of the North West channel and Hamilton Patches adds complexity regarding both northward transport towards Caloundra Headland, as well as southward transport. So this area had complex dynamics that provided a natural navigation channel, which we have since altered.

The area of the breakthroughs is a nodal point, where several different processes come together, transition and interact. The combined effects are likely to be variable, including seasonal and periodic. Net trends may emerge, which do not necessarily reflect the entirety of gross transport. The net estimates could be small volumetrically whilst gross transport could be significant if is multi-directional.

The dynamics are complex, conceptual studies regarding sand transport process in this area are dated, mostly >30-years old, and there are potentially significant data gaps. Those studies make it clear that the complex dynamics present in this area require further studies to improve understanding. Yet those studies, whilst foreshadowed for BPA investigation, do not appear to have been progressed.

Nominally, the absence of studies may arise in part from the State Government policy that the erosion of Bribie Island was due to natural causes. This position might be sufficient if dredging had not occurred to enhance the North West Channel and to extract sand resources; extraction greatly exceeding the estimated sand supply from the south. If that extraction had been accompanied by studies that advanced understanding of dynamics in this area beyond those early models – addressing their explicit uncertainties, that might suffice to rule out, or at least quantify, adverse anthropogenic contributions to erosion. However, the modelling boundary, as discussed earlier in this chapter, lies well to the south.

Whilst the MBSES included further investigations, those investigations, as documented, are incomplete regarding conceptual sand transport processes. This includes adequate understanding regarding the effects of dredging for sand extraction/navigation on sand transport processes. Evidence presented earlier advises that the North West Channel initially required significant maintenance dredging, however, more recent indications are that volumes are minimal; has there been a change and, if so, what are the mechanisms?

Replenishment, supporting theories regarding accommodation space and sand sinks arising from extraction, is documented, but the source of the replenishment and how that may impact overall transport processes (pre vs post dredging) is not fully documented or, likely, understood. This includes a larger scale frame of reference that provides appropriate extended boundaries. The 1998 *Moreton Bay Marine Park Extractive Industry Strategy Sand Resource Study* [204] by PPK does include the following advice –

Middle Banks presents a slightly different case to the other banks. They are slightly deeper than the other banks and a large part of the eastern margin of the bank has clearly been regenerated since dredging for the Brisbane airport construction (Figures 18 and 19). Harris et al., (1990) reported that approximately 14 Mm3 in 1983, of sand was dredged to a depth of 17m, seismic and echo sounding showed that the bank was rebuilt by July 1989. Harris et al., (1992) interpreted that the immediate source of sand was the immediately adjacent East Channel to the north. (sic)

Estuarine

Whilst the Passage transitions are consistent with expected natural succession processes, anthropogenic influences are likely to have accelerated the transitions that may have occurred eventually.

Bribie Island eroded, with coastal erosion being the predominant focus of studies, reports, etc. However, erosion of the western side, inner Bribie Island, was also documented, notably by Cardno, who also provided advice about the progressive net growth of shoals within the Passage. Roy and Lester contributed further advice supporting a long term trend of sand accumulating within the Passage.

That accumulation of sand is evident today in the form of land, the northern tip of Bribie Island and the east/west trending peninsula, with that area clearly intertidal in the 1967 bathymetric survey. The entrance historically had a large flood delta, which accumulated/stored sand delivered by tides and waves. It also, slowly and/or periodically (e.g. at times of elevated tides from catchment flooding and/or storm surge), returned sand to the ocean ebb delta, feeding southward transport. Our quantity take-off figures for Reidel & Byrne's shoal mapping show that the net growth was accompanied by periodic loss.

This transition – intertidal areas to land – blocked historical flow paths, constraining tidal movement, narrowing and concentrating flow paths, which tends to increase velocities and scour potential. It is plausible that the oyster leases diverted the main tidal channel to the east, promoting erosion of Inner Bribie. The obstruction and constriction of the flow path to the entrance by the growth of land is likely to have added 'back pressure', supporting channelisation, foreshore erosion and bed scour at the bend, kink or meander. So, the narrow part of Bribie was sandwiched between coastal erosion and inner foreshore erosion.

The reduction in surface area – intertidal flood delta – restricted the movement of sand as well. Vegetative stabilisation adds resistance to erosion and also provides a trap for wind blown sand, promoting growth of the land area, vertically and horizontally. That immobilised and elevated sand becomes unavailable for tidal transport. Whilst the net effect of historical transport was into the estuary, sand also moved out, potentially periodically (decadal/event driven) and likely fed southward transport, nourishing the coastal foreshore.

The entrance location historically migrated from north to south. This migration was suggested to be an observable seasonal pattern in the 'history' compiled by the community group in the early 1960s, which was provided to the Delft engineer who noted the usefulness of their advice in his 1965 report.

It is possible that the seasonal relocation included changes in littoral transport. A more northerly entrance, absent Kings Beach Groyne, potentially promoted flood delta growth, trapping/storing transport diverted by Caloundra Headland. A southerly entrance, often seen in the photos as pointing southeast, potentially signals periods of southerly transport, including coastal transport along the ebb delta, bypassing the entrance, as well as possibly gradual and/or periodic export of sand from the flood delta to supply the Bribie coastal shoreline.

This chapter should be viewed as a starting place, rather than a conclusion, assembling elements that should be considered as part of forward work that may arise to fill knowledge gaps and further refine understanding. Several figures are provided below to illustrate aspects of this conceptual model.

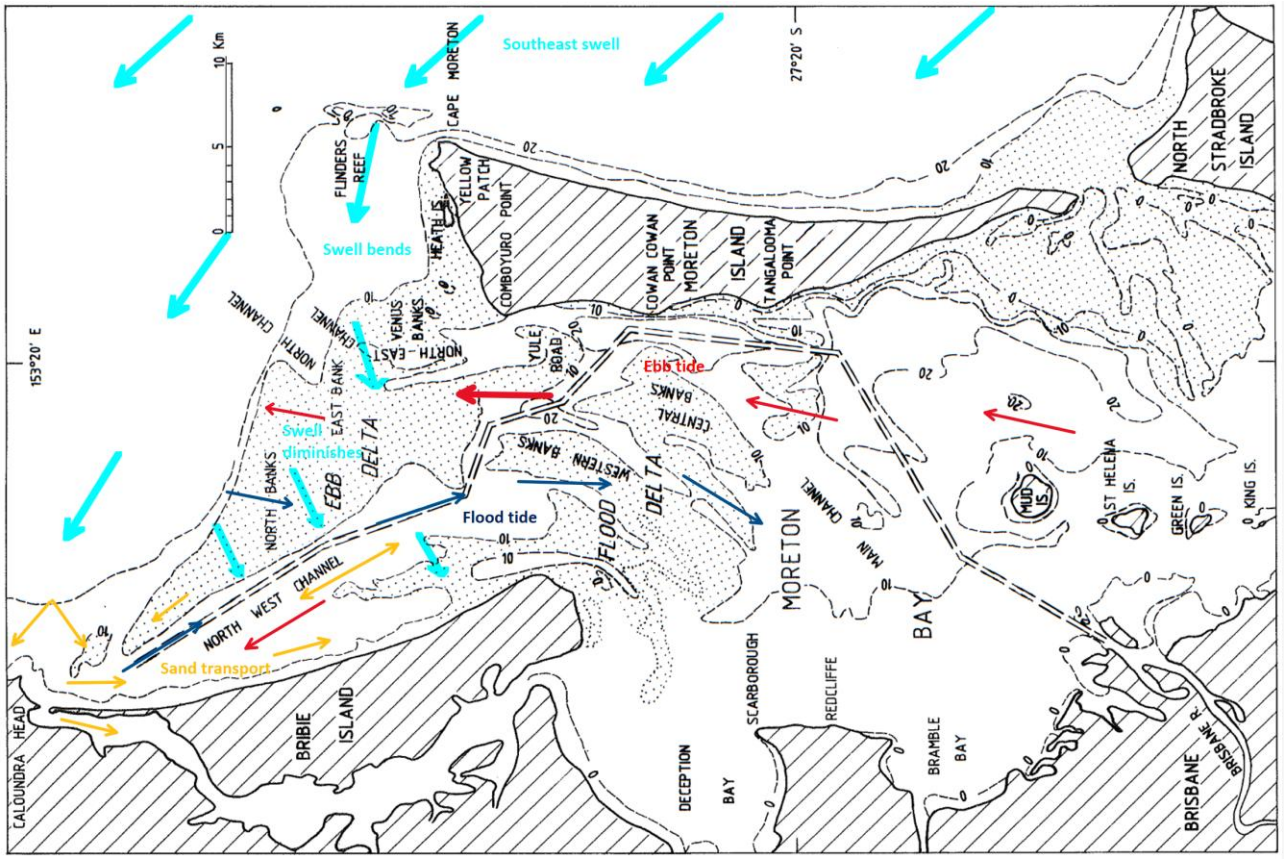


Figure 41: Coastal conceptual model (RPS overlain on Stephens 1983 [064] Figure 1)

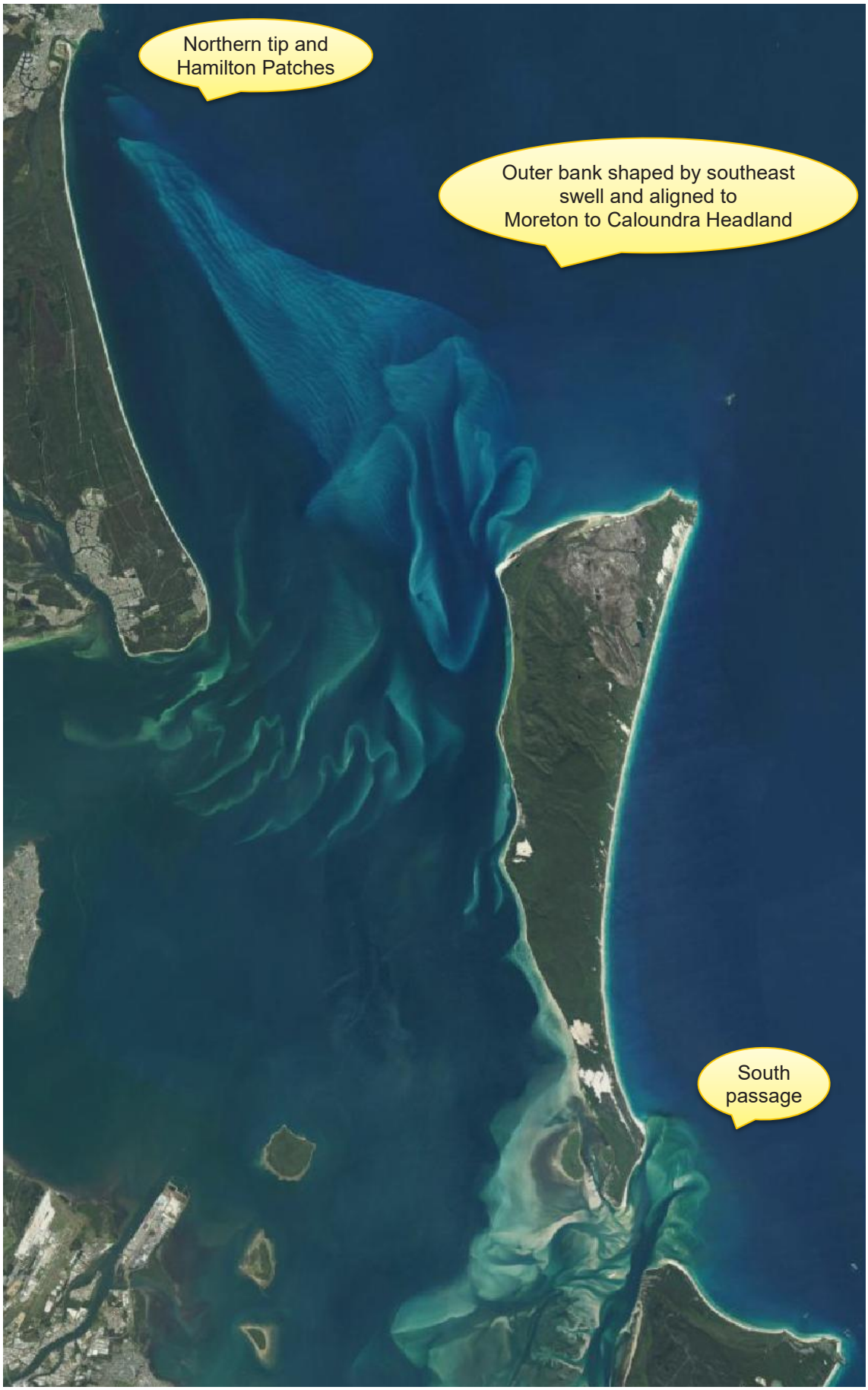


Figure 42: Moreton Bay delta sand banks – indicating swell and tide influences (QLD Globe)

North Banks ebb delta

- Linear shoal providing longshore transport pathway
- Ripples suggest ebbflow sand transport along shoal
- Possible divergence of nett flow at northern end
- Linear shoal protection from waves reduced at breakthrough end of Bribie

Figure 43: Possible northward transport and ebb/flood transport pathways (Rodger Tomlinson)

- Similar characteristics at South Passage

Linear ebb delta shoal

Erosion at Kooringal

Figure 44: Northward transport characteristics also suggested at South Passage (Rodger Tomlinson)

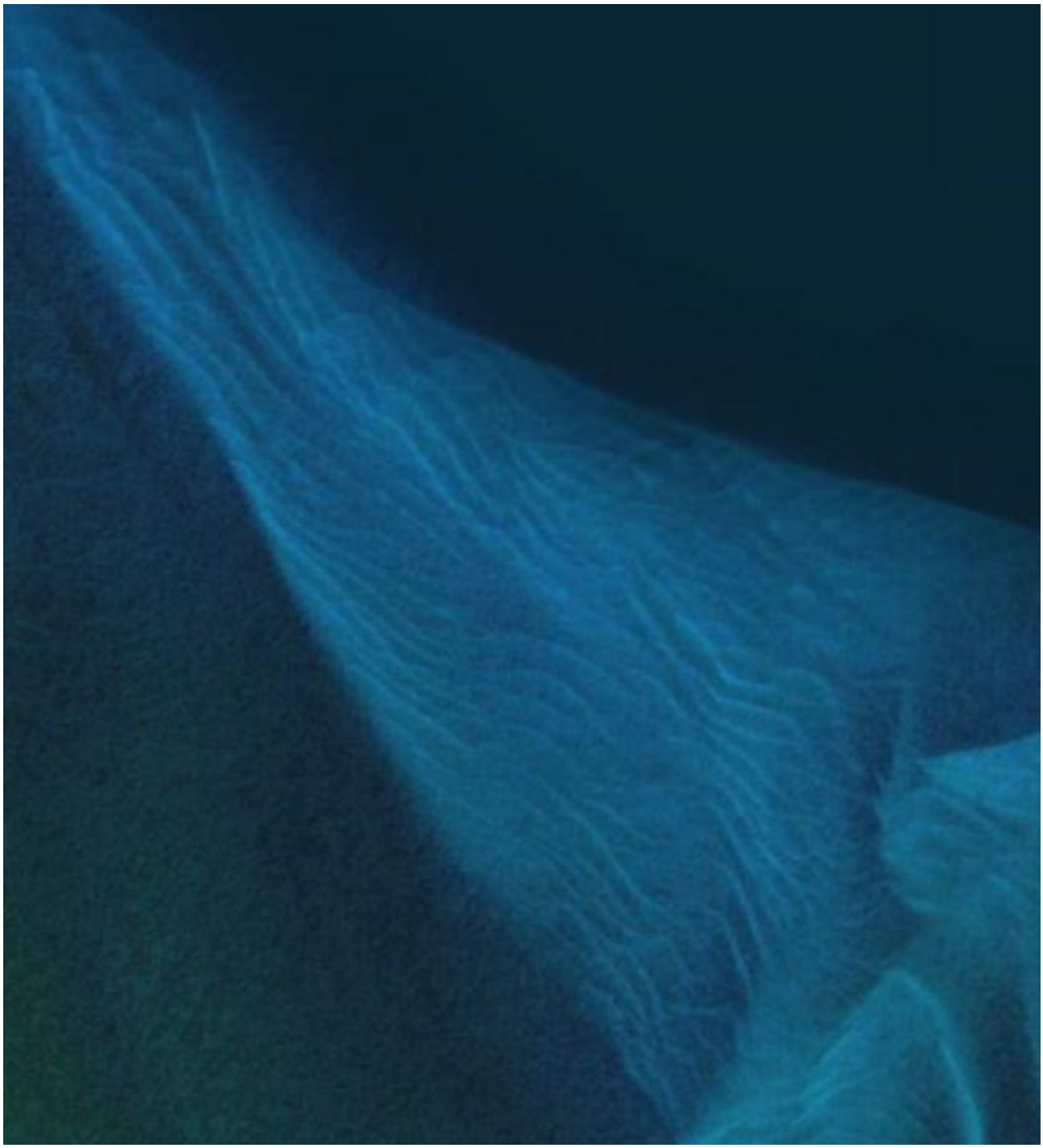


Figure 45: Ebb (right) and flood (left) influenced sand ridges on North Banks (QLD Globe)

Figure 46: Northward transport pattern suggested for tip of North Banks and Hamilton Patches (Qld Globe)

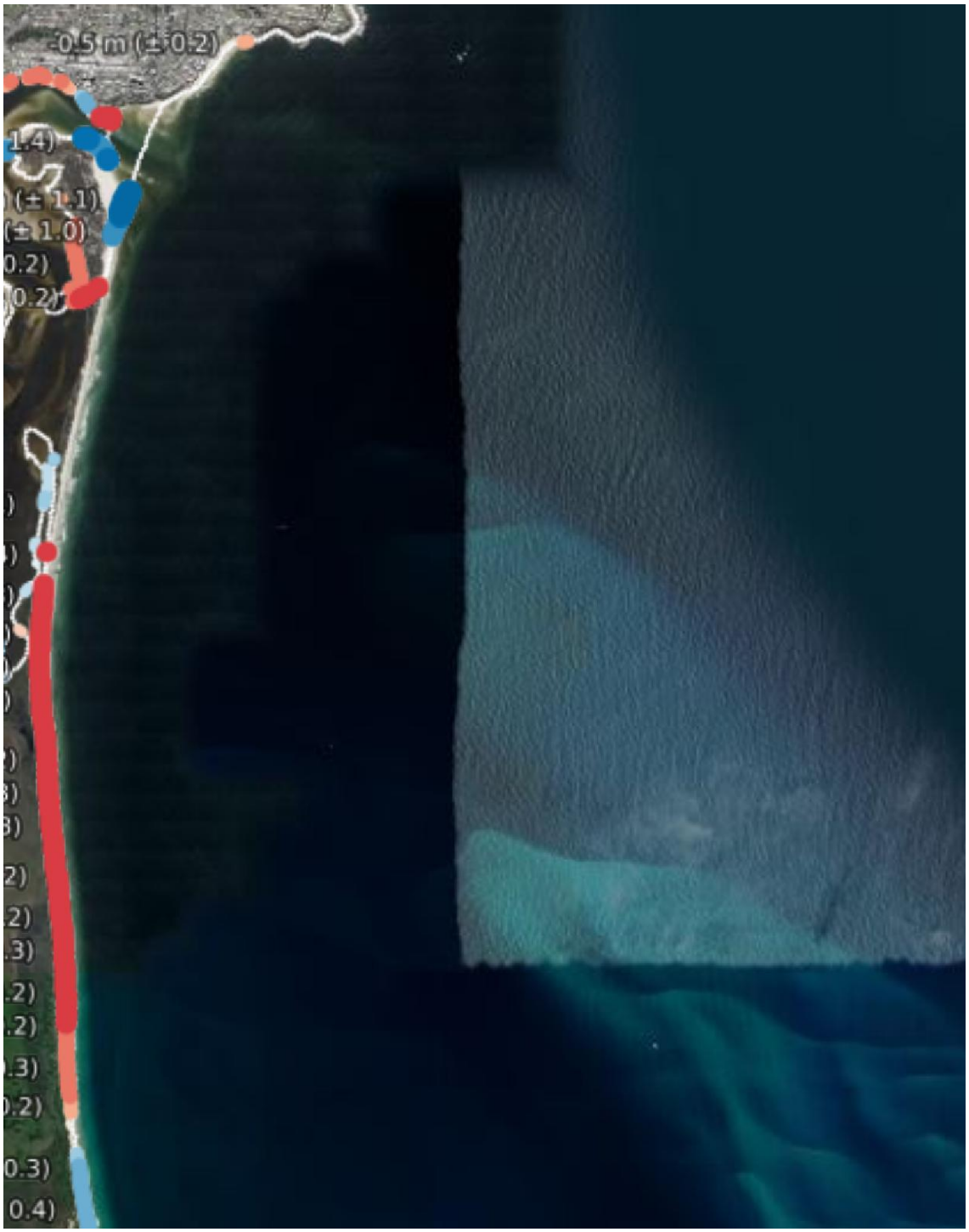


Figure 47: DEA erosion (red) in relation to North Banks and Hamilton Patches

- Wave refraction over ebb shoal resulting in near shore parallel direction at Bribie

  East-West navigation channel focusses waves towards breakthrough

Figure 48: Possible wave refraction in relation to offshore banks and breakthroughs (Rodger Tomlinson)

- Channel dredging

  Asymmetry in velocity profile leading to tidal flow induced erosion along shoreline

  Dredge channels focussing waves

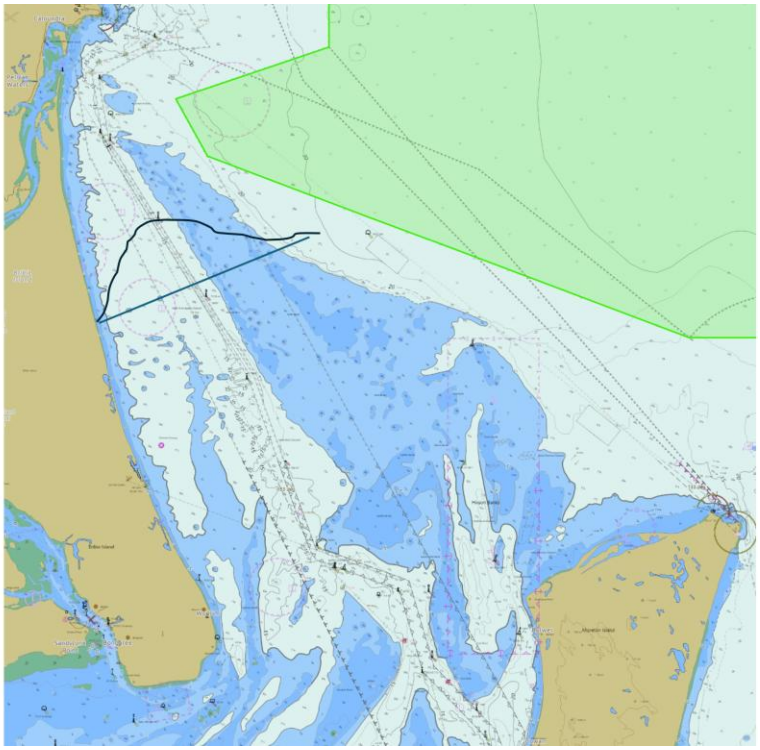
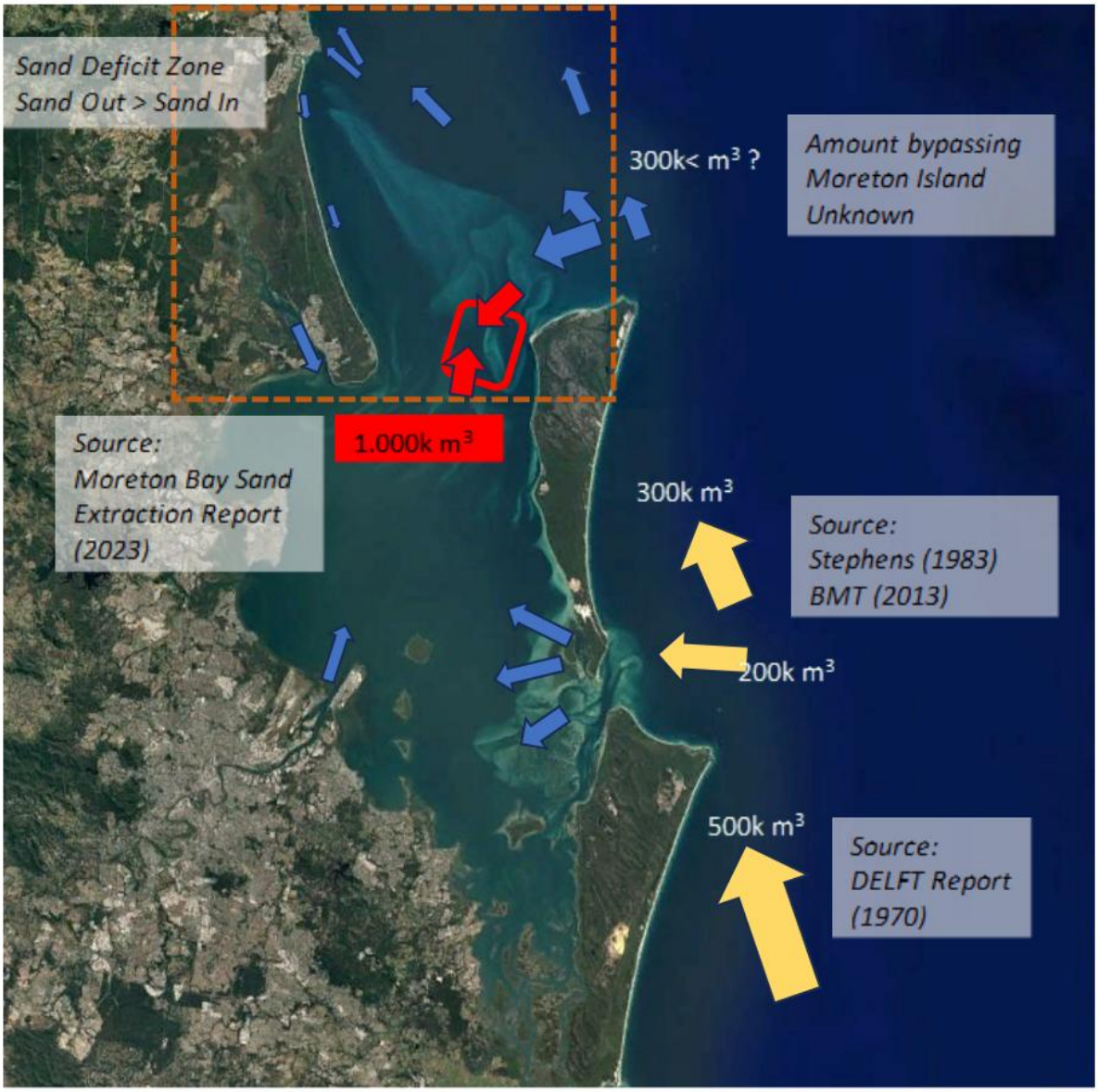


Figure 49: Potential North West Channel dredging influence on waves, tidal flows and erosion (Rodger Tomlinson)



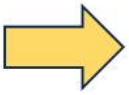
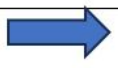
Key	Definition
	Established conceptual model directions and volumes (annual)
	Conceptual estimation of sand movement and volume (scale relative to size)
	Main Sand Extraction Area

Figure 50: Littoral drift components and extraction

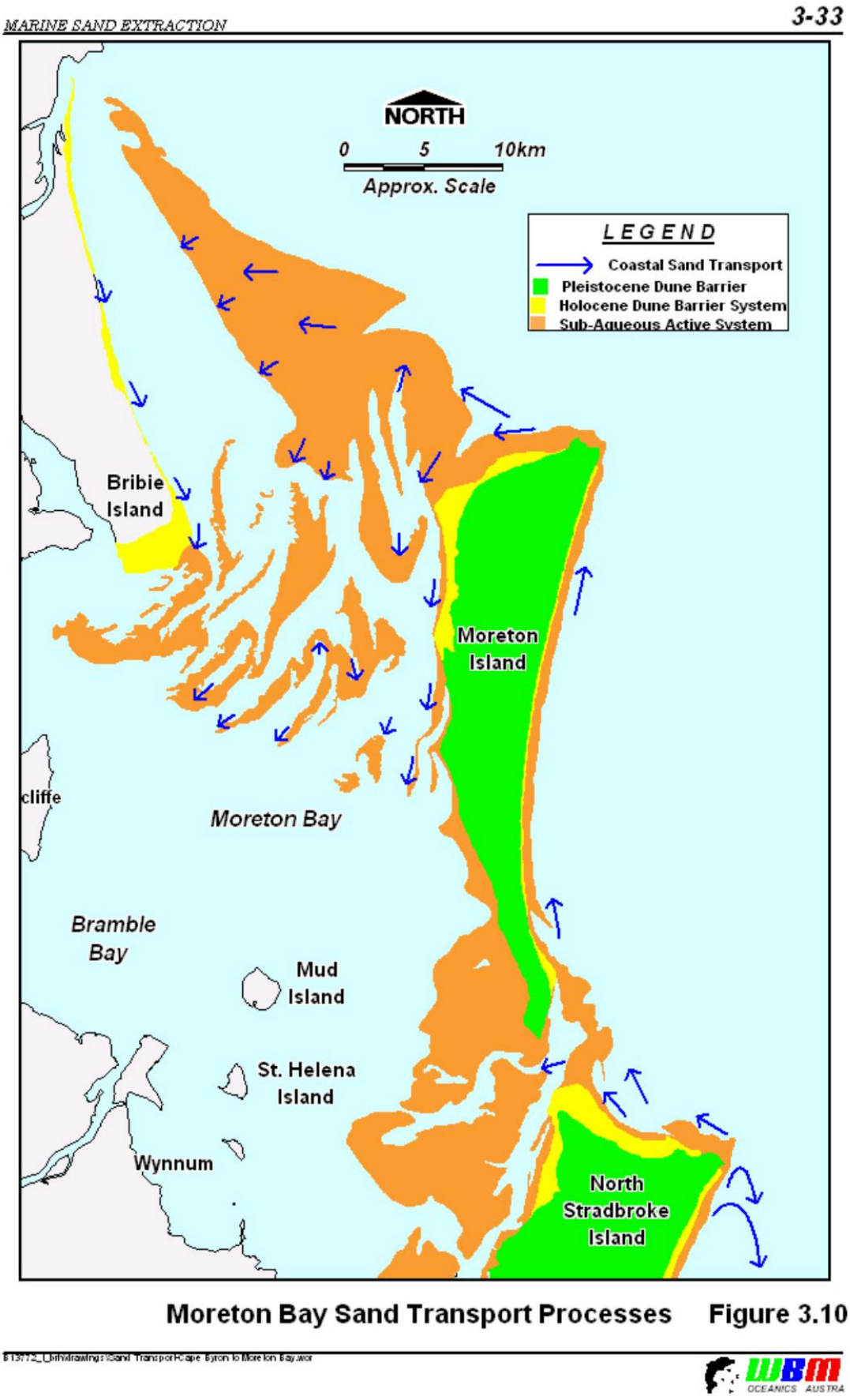
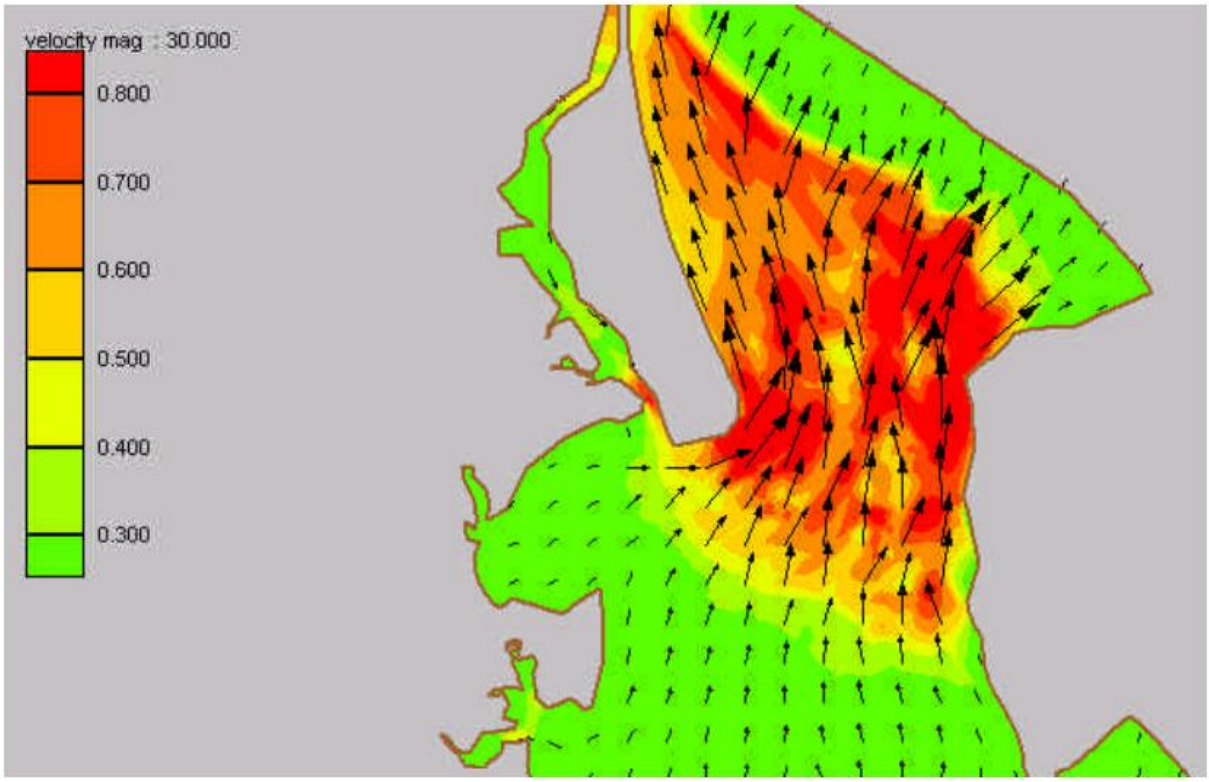


Figure 51: MBSES sand transport – none shown for northern area [205]



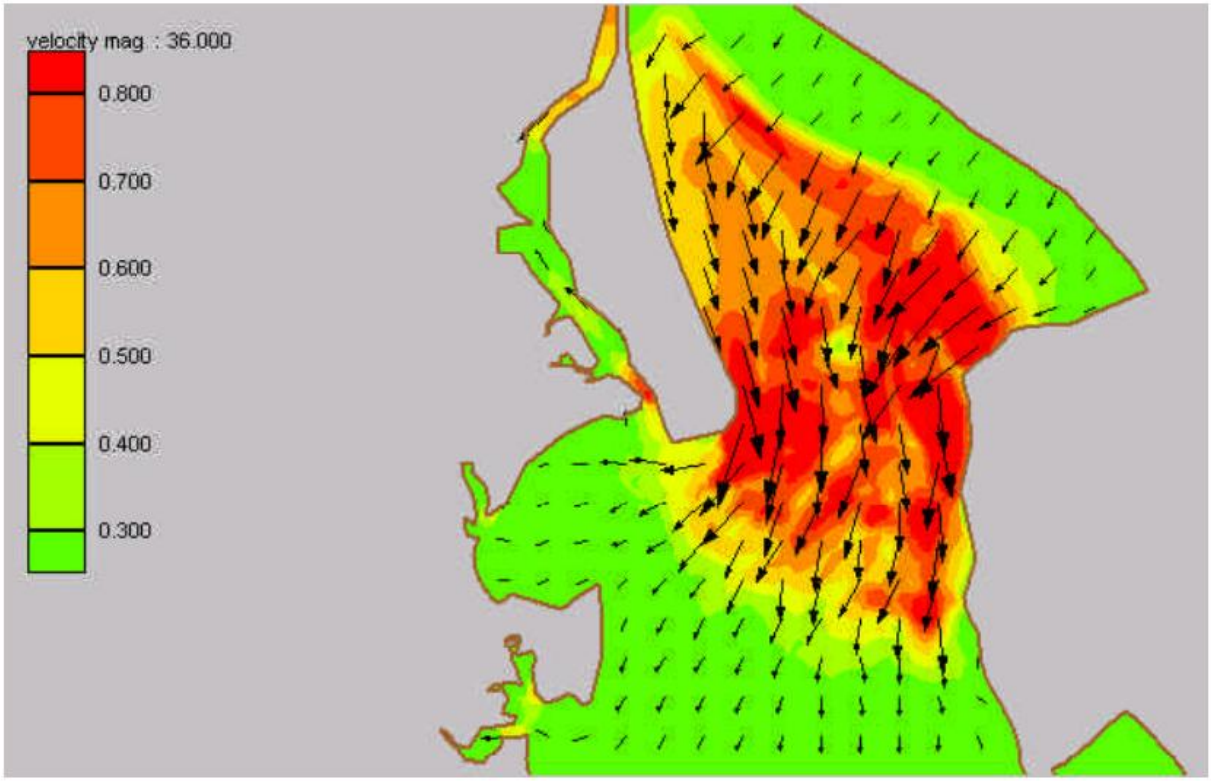


Figure 3.15 Peak Mean Spring Tide Current Speeds - Northern Delta

Figure 52: MBSES presentation of tidal hydrodynamics – none shown for northern area [206]

3 POLICY FRAMEWORKS

3.1 Introduction

This chapter provides a high-level assessment of the extent to which existing policy frameworks are compatible with the shift from 'passive protection' to 'proactive enhanced coastal management' as recommended in Part 3 as well as this report. Detailed discussion regarding approvals or approval frameworks is not provided, as those matters should be addressed as part of any strategic planning and detailed design for actions that may arise from this Review.

The discussion below also considers available evidence regarding historical and existing management arrangements, including outcomes. It is not intended as a 'program review'; the analysis is specific to the project area. However, the project area is a small portion of more extensive protected areas, so the context is innevitably broader. Additionally, the discussion necessarily touches on global challenges, such as the effects of climate change on international migratory waterfowl.

Accordingly, our observations and recommendations are specfic to the project area and its circumstances, including the profound physical changes accompanying the breakthroughs, the locally complex coastal and estuarine dynamics, and the particular history of use and management as documented in this Review.

3.2 Ramsar

The Moreton Bay Ramsar area encompasses nearly the entirety of the project area, with the notable exception of the Deepwater Point Reserve (discussed further below), refer to Figure 53. The Ramsar status is a Matter of National Environmental Significance (**MNES**), so Commonwealth Government interests and the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) apply. Whilst other aspects of the *EPBC Act* potentially apply to our proposed solutions, a broader discussion of the EPBC Act is not included in this section, for the simple reason that we are providing advice to the Queensland Government about policy instruments that it controls. The Queensland Government does, for Ramsar sites within its jurisdiction, take the lead for planning and management, but there is effectively a nested three-layer jurisdictional framework for actions that occur in this area.

The Ramsar status is relevant to this Review, notably because we suggest that this area should be managed in accordance with Ramsar principles, that those values should be central to a forward plan. Our proposed solution provides an opportunity to improve management – to embrace "wise use" through enhanced proactive management, rather than relying on passive protection. Accordingly, this policy aspect is presented as an introduction to this chapter.

Overall, the Ramsar obligations are relatively simple and principled, with contracting parties agreeing to plan and manage declared areas for "wise use" and conservation of wetlands that are international significance. The *EPBC Act* provides a more prescriptive regulatory framework to promote consistency and the Commonwealth publishes various materials to further guide Australia's approach to fulfilling obligations. State and Territory governments in turn have frameworks in place, but their jurisdiction does not extend to full control; consultation with the Commonwealth is required if there is a potential impact on MNES.

We note that the provisions call for a management plan to be prepared and we did not identify one in our research. DETSI confirmed that the management of the Moreton Bay Ramsar site is mainly undertaken through protected area management, with the most relevant documents/plans guiding management for the area being the Moreton Bay Marine Park zoning plan, management plans for the Bribie Island National Park and Recreation Area as well as Fish Habitat Area policy. An additional overlapping layer of management planning would be of questionable benefit, however the lack of a single coordinated plan, even if it was only a high-level discussion of how the various instruments are intended to integrate, provides an observable gap.

As discussed below, there are potential opportunities to evaluate Queensland's approach to planning and management and, perhaps, identify improvements. Initiatives that may arise with respect to the project area could serve as a pilot for those investigations and possibly trial alternatives that may provide instructive insights for subsequent changes in other locations or on a broader scale.

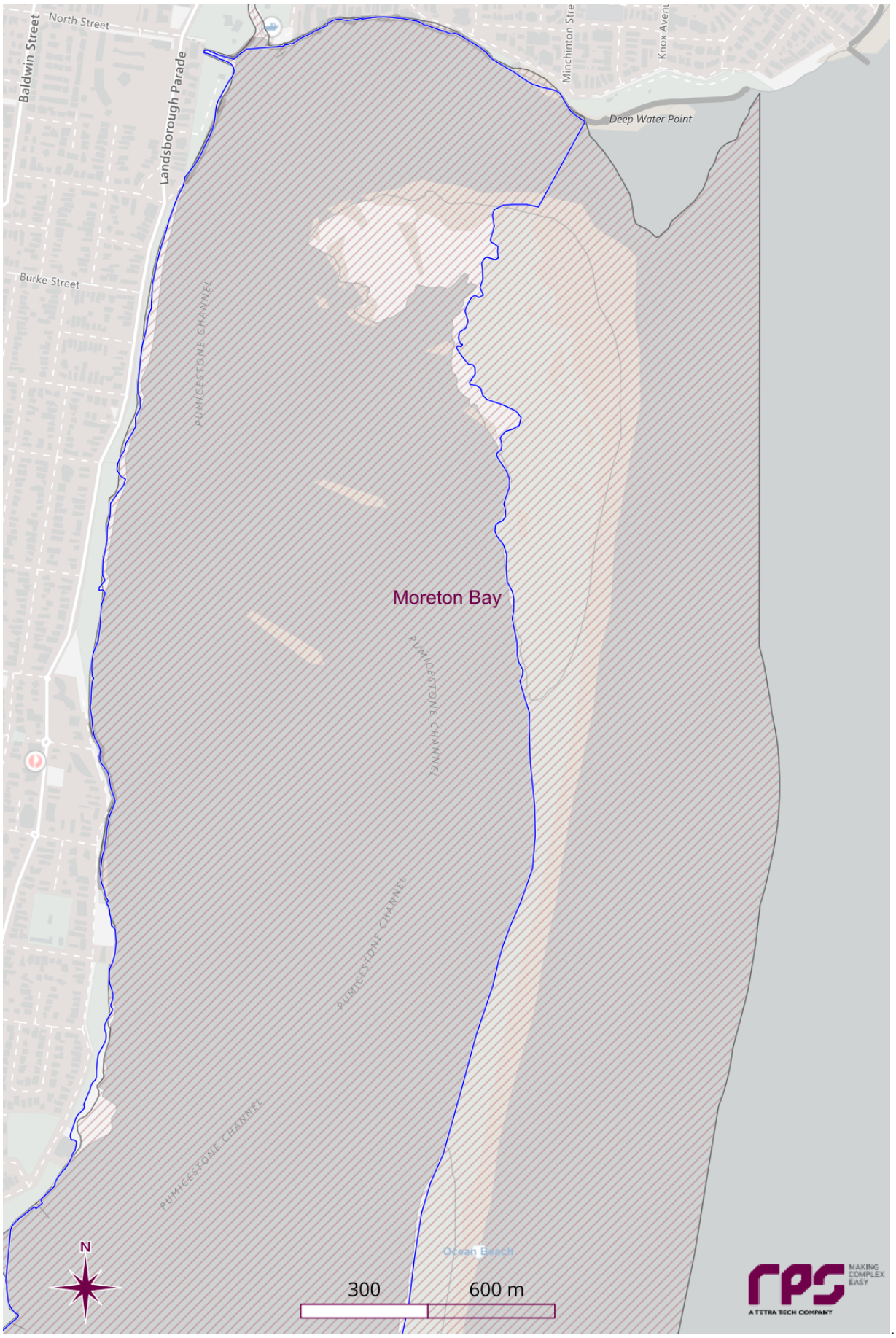


Figure 53: Moreton Bay Ramsar site boundary (red hatch) in the vicinity of the project area

3.2.1 Convention

The *Convention on Wetlands of International Importance especially as Waterfowl Habitat* (the original name, now more commonly referred to as Convention on Wetlands of International Importance or the Convention on Wetlands, or simply "Ramsar", after the city in Iran where the convention originated in 1971). The current text reflects revisions in 1982 and 1987 and is dated/issued in 1994 by the United Nations Educational, Scientific and Cultural Organization (**UNESCO**).

It is a relatively brief 6-page document. Basic premises include that wetlands are important, including for waterfowl that migrate across international borders, and signatory countries ('Party'/'Parties') should identify and nominate suitable sites, with selection of sites for "the list" based on their international significance in terms of ecology, botany, zoology, limnology or hydrology, with international significance to waterfowl prioritised.

For listed sites, the Parties agree to undertake planning towards conservation, and as far as possible the wise use of wetlands in their territory. It provides that each Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference, and that information on such changes shall be passed without delay to the responsible organization or government, who will in turn provide advice to the International Union for Conservation of Nature and Natural Resources (IUCN – acting as the 'bureau').

3.2.2 Declaration

Australia was the first nation to become a Contracting Party to the Convention. Queensland has five Ramsar sites, with Moreton Bay and Bowling Green Bay nominated in 1993 (22/10/1993). The nomination letter advises Australia is pleased to nominate additional sites; these two sites are first Queensland Ramsar sites, but presumably not Australia's.

The Moreton Bay Ramsar site is relatively large (~1,206 km^2) but, but in terms of area it sits in the middle of the five Queensland Ramsar sites (the largest, Shoalwater and Corio Bays Area, is ~2,020 km^2 and Bowling Green Bay is the smallest at ~367 km^2). Four of the sites are coastal (Currawinya Lakes is inland and on the QLD/NSW border).

The Great Sandy Strait Ramsar area (~837 km^2) lies between Fraser (K'Gari) Island and the mainland and includes a double-ended barrier estuary. Fraser Island is a declared World Heritage area and is the largest sand island in the world. Moreton Island, North and South Stradbroke Island (formerly connected as a single island prior to the breach at Jumpinpin c.1900) and, to an extent, Bribie Island, share a common longshore drift system and collectively represent an internationally significant system. A notable distinction between these two Ramsar areas is that the Moreton Bay site is comparatively discontinuous, with the southern section being the largest, followed by the northern section, and several isolated areas in the middle, refer to Figure 54.

3.2.3 Ramsar Information Sheets

Ramsar Information Sheets (**RIS**) we identified are dated 1995 (9 pages) [099], 1999 (13 pages) [105] and 2023 (45 pages, plus additional information, dated 2018, 89 pages) [178]. DETSI advised that the 2023 RIS is the appropriate reference in relation to the Ramsar site and ecological character. However, we do include a discussion of previous versions (outdated, superseded) as we consider it appropriate to the context of this Review and the solutions we are proposing.

Regarding Conservation measures taken, the 1995 RIS includes:

- Pumicestone NP 1462 (Bribie Island) - declared 20 August 1988 (area 1930 ha)
- Bribie Island EP 2699 - declared 4 November 1989 (area 1330 ha) joint trustees - Caloundra City Council / Caboolture Shire Council

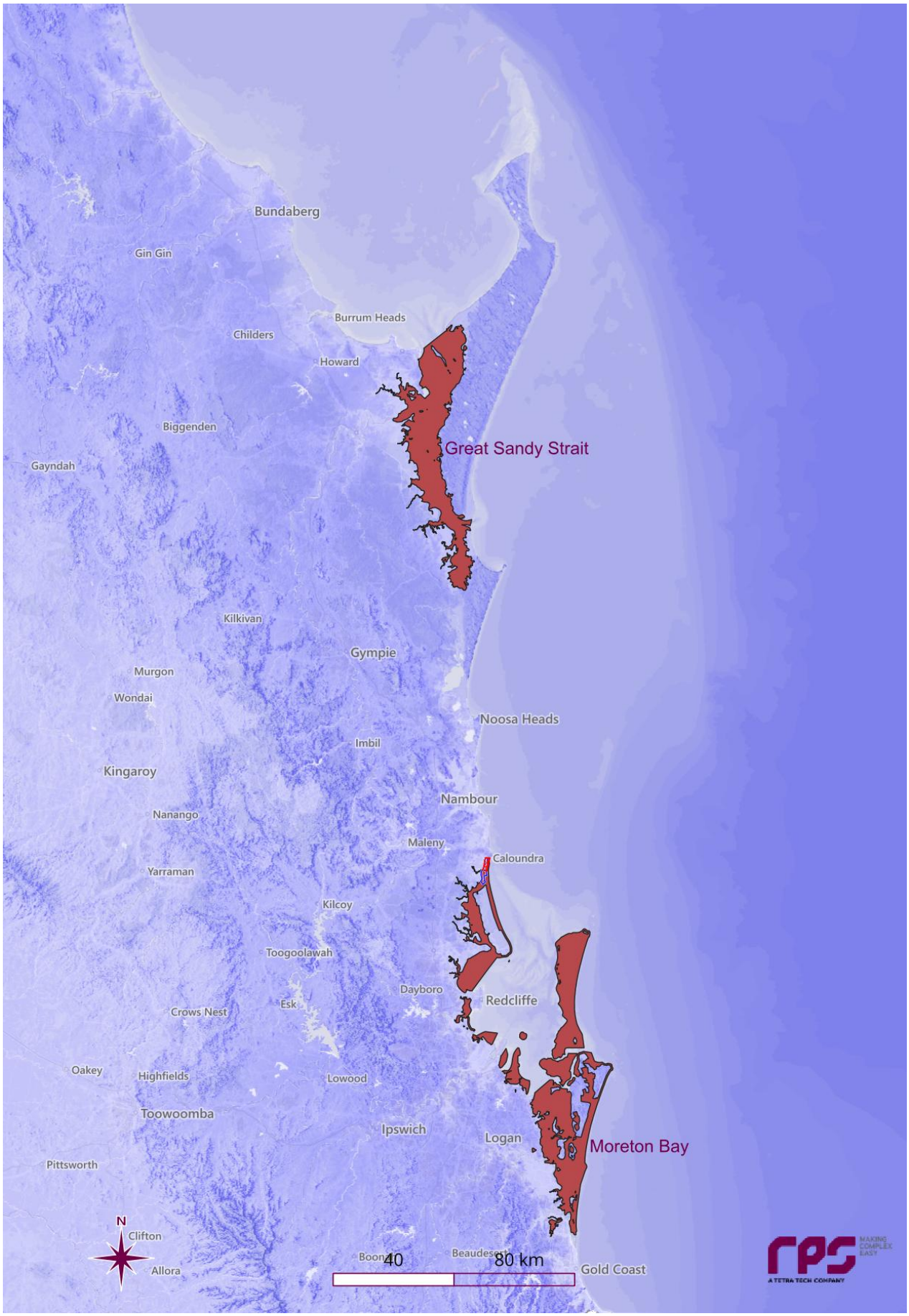


Figure 54: Moreton Bay and Great Sandy Strait Ramsar sites

The 1999 RIS includes Bribie Island NP (but not the two referenced above) and the 2023 RIS includes Bribie Island NP, Pumicestone National Park and Bribie Island State Forest, and declared Fish Habitat Area (Pumicestone Channel (FHA-011)), as well as non-statutory designations for Moreton Bay & Pumicestone Passage as an Important Bird Area. Mentions of Pumicestone Passage include:

- Image analysis of all intertidal areas in Moreton Bay, including Pumicestone Passage estimated that a total of 23,000 ha of tidal flats are exposed at low water datum characterised by marked differences in substrate type and species of waders present (Thompson 1990b). (1995 RIS)
- The sewage affected sites in Bramble Bay are entirely devoid of seagrass, as are a few sites in Pumicestone Passage and Southern Moreton (Thompson 1991). Driscoll (1991), found that the substrate and conditions in Pumicestone Passage were not uniform throughout and that different locations had variations in the numbers of wader species present. (*ibid*)
- Pumicestone Passage's tidal flats and estuarine wetland assemblages support intertidal flats, shoals and seagrass, and are critical to dugongs (Lanyon et al. 2005). (2023 RIS)
- Water mouse (Xeromys myoides)
  - ICUN red list and EPBC – Vulnerable
  - Wetland dependent. High density population in Pumicestone Passage and Southern Moreton Bay incl. North and South Stradbroke Island. *(Western foreshores)*
  - Total population estimated to 10,000 mature individuals and Moreton Bay population estimated to support more than 1% of the population. (*ibid*)
- The southern part of Pumicestone Passage contains a complex mosaic of mangroves, seagrass, unvegetated sand and mud flats and deeper waters in close proximity to each other. This combination and diversity of habitats may represent important nursery habitat for many prawn and fish species of commercial significance (Laegdsgaard and Johnson 1995; Tibbetts and Connolly 1998 in Tibbetts 1998; Sheaves 2009). (*ibid*)
- The water quality monitoring under the previous Ecosystem Health Monitoring Program (EHMP 2007a; 2007b), noted that water quality within the Pumicestone Passage was degraded in places, with generally poorer quality water (higher nutrients and turbidity) in the northern and central reaches compared with the southern reaches. Several small creeks discharge into the Passage, which are known to contain high levels of nitrogen, sediments and tannins, and are considered to be of 'fair' quality (ibid). Pesticides have also been detected in the Pumicestone passage catchment (Kookana et al. 1998). (*ibid*)

The 2023 RIS appears to be based on a template/form and includes the question: "Has the ecological character of the Ramsar Site (including applicable Criteria) changed since the previous RIS?", to which the included answer is "No". An optional text box to provide further information has the response "Not applicable".

A review of the adequacy of reporting to the Ramsar Convention on change in the ecological character of wetlands [214] concludes that, with the exception of qualitative national-scale reporting in triennial Contracting Party National Reports, there is inadequate implementation and compliance with most of these mechanisms, notably concerning required reporting under Article 3.2 of the Convention and the updating of the Information Sheet on Ramsar Wetlands (RIS).

Table S1 in related supplementary data indicates that with respect to the Article 3.2 reporting, for the Moreton Bay site, third party reports were submitted in 2002-05 and 2005-08, and that subsequently (2015-2018) third party reports as well as confirmation from the contracting party was recorded. These statistics are reflective of overall trends, as per the author's conclusion above.

As noted above, the wording regarding change is potentially focused on anthropogenic disturbances, such as development. The Bribie Island breakthroughs are potentially a disruptive environmental change, and are attributable to natural causes, however, as documented above, we would suggest that there are also contributing anthropogenic factors. Regardless, the project area is arguably a small part of the overall site, so are these changes "significant"?

The RIS response includes textual description of potential threats from surrounding catchments, as well as management responses. An included table (5.2) for "Ecological character threats and responses (Management)" lists 32 factors, across 10 themes. Many of the boxes are ticked ('yes') for the applicability of those factors, both within the site, and in the surrounding area. In all cases, "unknown impact" is the

response provided regarding Actual threat and Potential threat, and with respect to changes (within and surrounding) the universal response provided is “No change”. Accompanying explanatory text is as follows: *“A comprehensive site specific assessment and ranking of impacts has not been undertaken. The term "unknown" (above) should be interpreted as "not formally assessed".”*

Additional information regarding significance provided in the 2023 RIS includes:

- The Site supports habitats that are important at critical stages in the life cycles of numerous wetland-dependent species, including at least 28 migratory shorebirds. Each summer, more than 33,000 migratory shorebirds spend the non-breeding season (approx. Nov-Mar), and part of their northward and southward migratory journeys in Moreton Bay. A subset of the non-breeding population (typically sub-adult birds not yet ready to reproduce) remain in Moreton Bay year-round before making their first northward migration to the breed. This includes the nationally critically endangered eastern curlew. While in Moreton Bay, shorebirds feed twice daily on benthic invertebrates in exposed intertidal habitats. At high tide, when intertidal foraging areas are submerged, shorebirds congregate in high densities (‘roosts’) in supratidal habitats in or along the periphery of the Site, including claypans, sandy and rocky foreshores, and mangroves (coastal and islands) (Zharikov and Milton 2009).

The above excerpt is not specific to Pumicestone Passage, however, excerpts above note the existence of intertidal areas in the Passage and their importance to waders. The RIS includes a substantial amount of information and the summary above is admittedly curtailed about the documented diversity and other important factors. As sand is a significant focus for this review, it is relevant here to include discussion regarding the 1991 report for the Queensland Department of Environment and Heritage entitled *Survey of Waterbird, Seabird, and Wader Feeding Areas and Roosts in Pumicestone Passage, Spring 1990* [215]. Note that the publication is close to the date of the Ramsar declaration. The report includes the following advice:

- Much of the fringing environment to Pumicestone Passage is belts of mangroves, claypan and saltmarsh which sometimes back onto Melaleuca: swamps. The general landform is very similar to that of the Great Sandy Strait except on a smaller scale. The pattern of bird useage is also reminiscent of what occurs- in the Great Sandy Strait with roosting, and to a lesser extent feeding activities, being more pronounced along the western side of the waterway.
- Another possible determinant of wader densities is the timing and range of tides which in Pumicestone Passage shows an intriguing pattern. The tidal range in the northern section of the Passage is on average half what it is in Tripcony Bight and farther south (about 1 m vs 2 m). The poor exposure of intertidal areas and low intensity of feeding over much of the northern section was most apparent.
- With the exception of the Golden Beach Roost area, sites to the north of Tripcony Bight generally have a low density of feeding and there is very little activity through the Skids area where there is little exposure at low tide. There are moderate levels of feeding activity close to Roys and a range of species occur here (site 2). There is comparatively less exposure of mudflat north of Egg Island towards Golden Beach where the tidal range is less than elsewhere.
- Golden Beach. Roosting occurs over a wide area of sandbar and mudflat out from Golden Beach and to a lesser extent on beachfront and sand dune on the northern tip of Bribie Island. If the tide is very high the alternatives are fewer but the site on Bribie Island invariably remains above water as does a small sandbar with scattered vegetation at the northern end of high ground in the centre of the channel. Most of the Bar-tailed Godwits that roost at Golden Beach feed in Tripcony Bight where the high tide occurs 3 hours later. Therefore, when birds finally come in to roost there is usually ample area of exposed bank and if birds are disturbed by people they are often able to settle in another position.
- [Daily movements of birds] 1) There is comparatively less feeding area in the northern Section of the Passage and many birds using the Golden Beach roost area simply spread out locally as the tide recedes. The main movement is of Bar-tailed Godwits between the Golden Beach roost and the central region of tge Passage (as far as Tripcony Bight). Movement of large numbers of other wader species in the northern section was not observed.
- [Management issues] d) There are three areas where larger numbers of people in future may discourage feeding or roosting by birds. The first is the northern tip of Bribie where medium sized flocks roost over high tide. The second is on the sand bars in the centre of the channel out from Golden Beach where many thousands of birds roost and hundreds feed. Fisherman and other people visit these bars, albeit in low numbers.

High tide roost sites, sufficiently separated from disturbances, were a key ecological asset identified in northern Pumicestone Passage, around the time various protected areas, including the Ramsar site, were declared. More comprehensive consideration of ecological character, including biodiversity, is warranted for future planning. Regardless, this study supports the notion of 'reversing' some of the evolutionary changes discussed above, of transforming some elevated and vegetated areas to sandbanks. Select figures from the report are provided below, refer to Figure 55 through Figure 59.

Technical review of Part 4 included advice that more recent shorebird monitoring data is available and should be discussed. We agree, in part because we consider this to be an important consideration to both the declaration of protected areas, and as a characteristic of the area that should be central to forward management planning.

We note that this is a Review, with the solutions provided being conceptual, and that environmental considerations, whilst primary to management considerations, are an extension of our brief under the ToR. So, there is no intent to be comprehensive or exhaustive, but we recognise that the environmental values of the Passage are also central to community concerns, and we recommend that they should be a central focus for forward management.

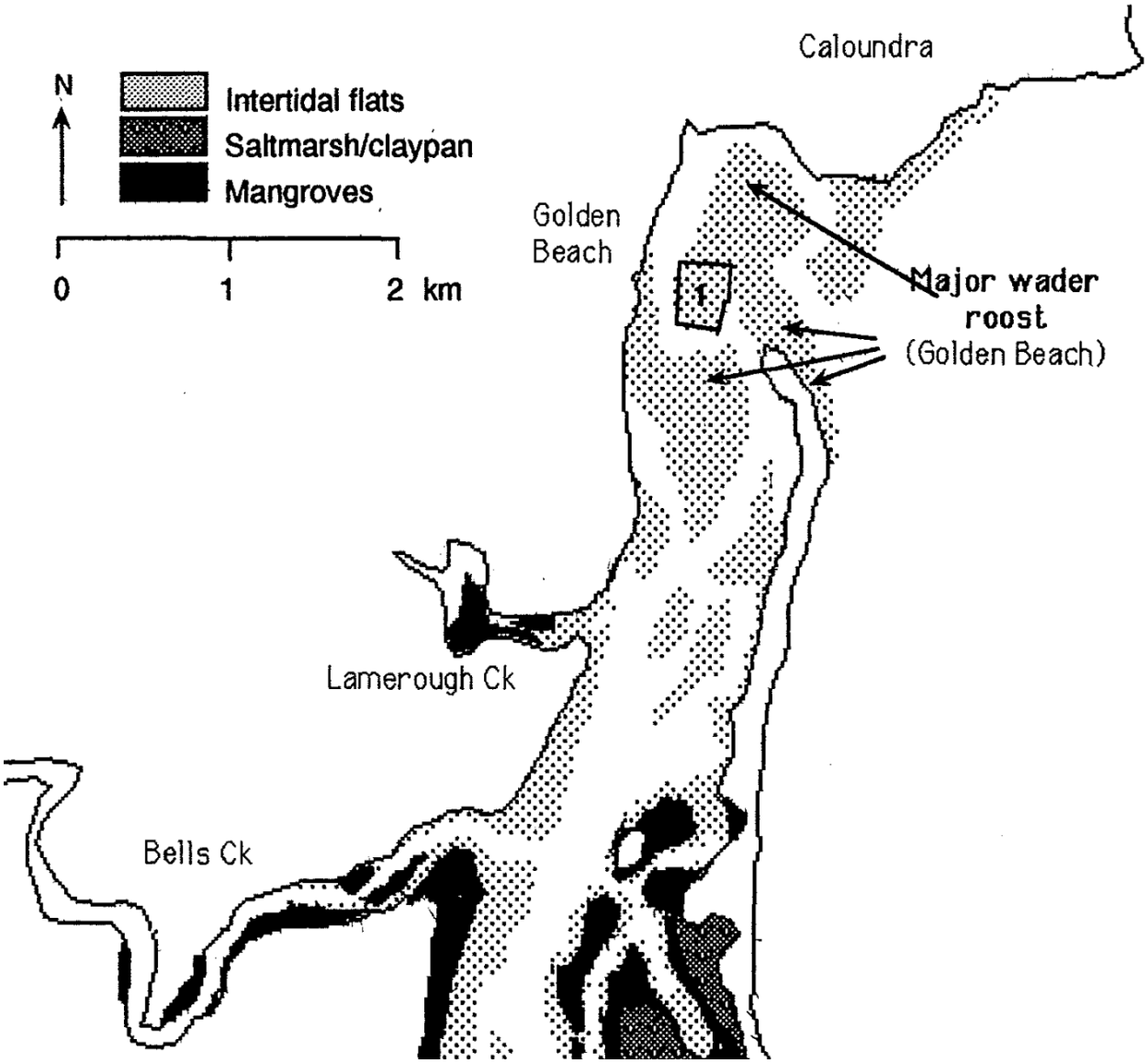


Figure 55: **"Figure 2a. Northern section of Pumicestone Passage (see Figure 1) showing the only intertidal sampling location used in this section (no. 1 & part of 2). The bird density was intermediate of between 4 & 8 waders per hectare." [215] (*partial screenshot of full figure*)**

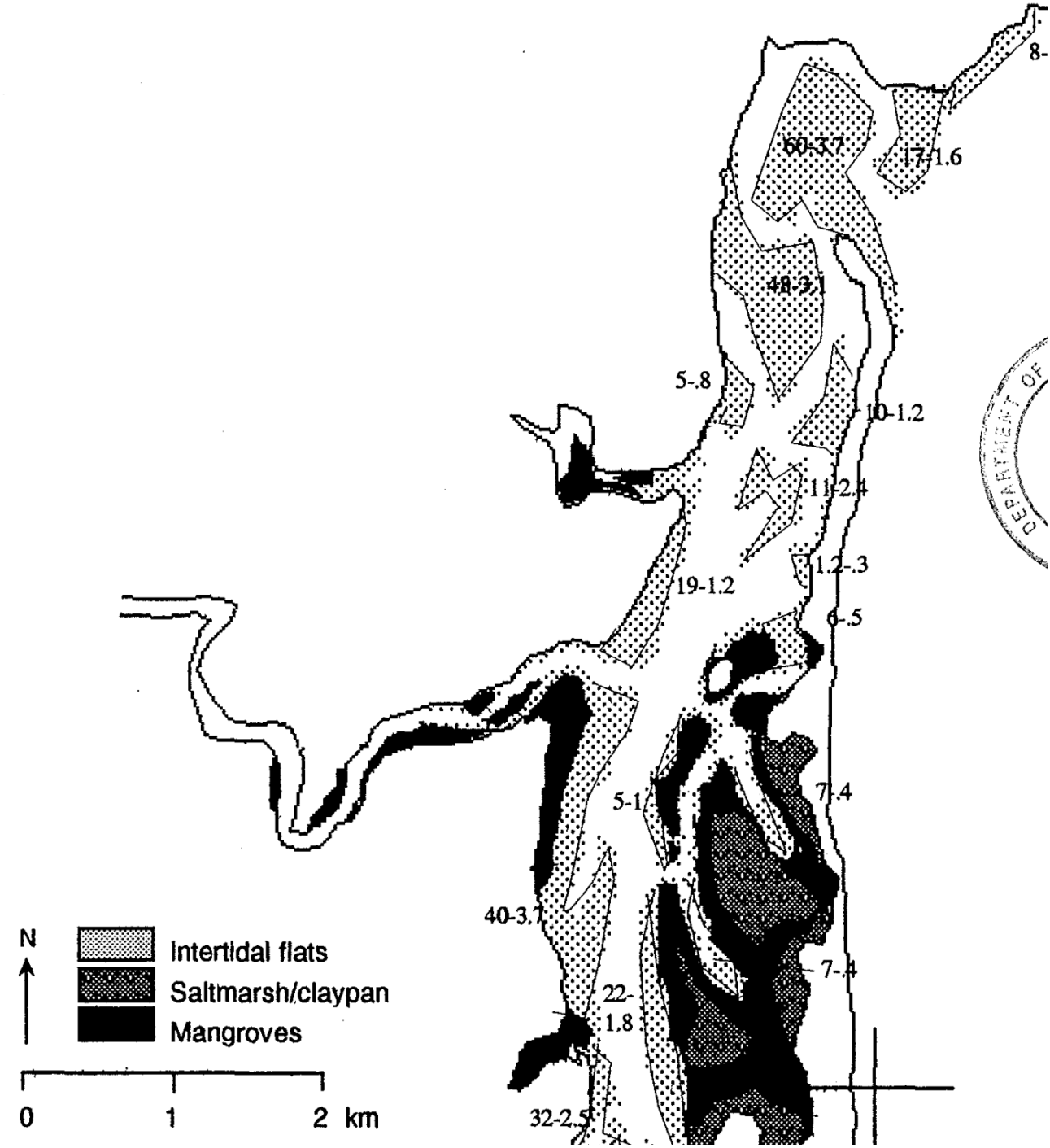


Figure 56: **"Appendix A (page 1) Maps showing intertidal areas and distances along low tide shorelines (northern section - refer to Figures 1 & 2)… Noted is the number of hectares for each bounded area followed by the shoreline length in km (after dash)" [215] (*partial screenshot of full figure*)**

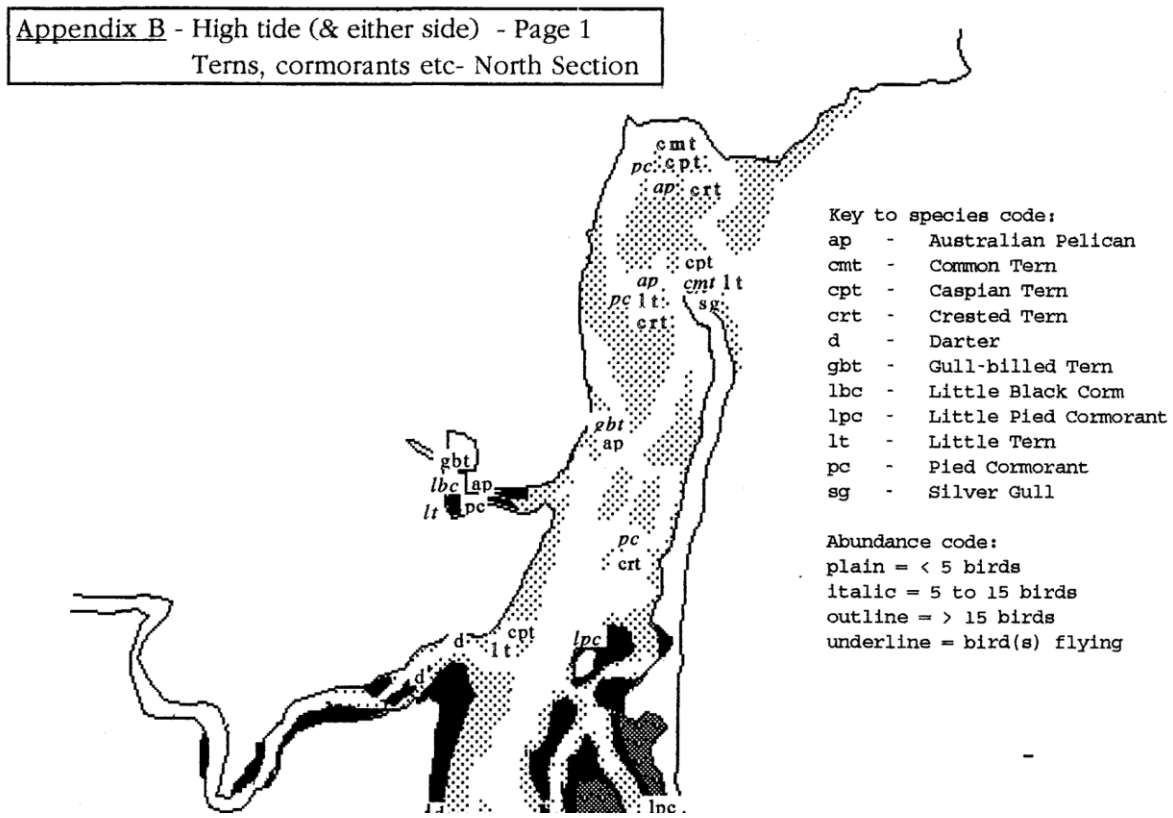


Figure 57: High tide (& either side) – Terns, cormorants, etc [215] (*full caption above*)

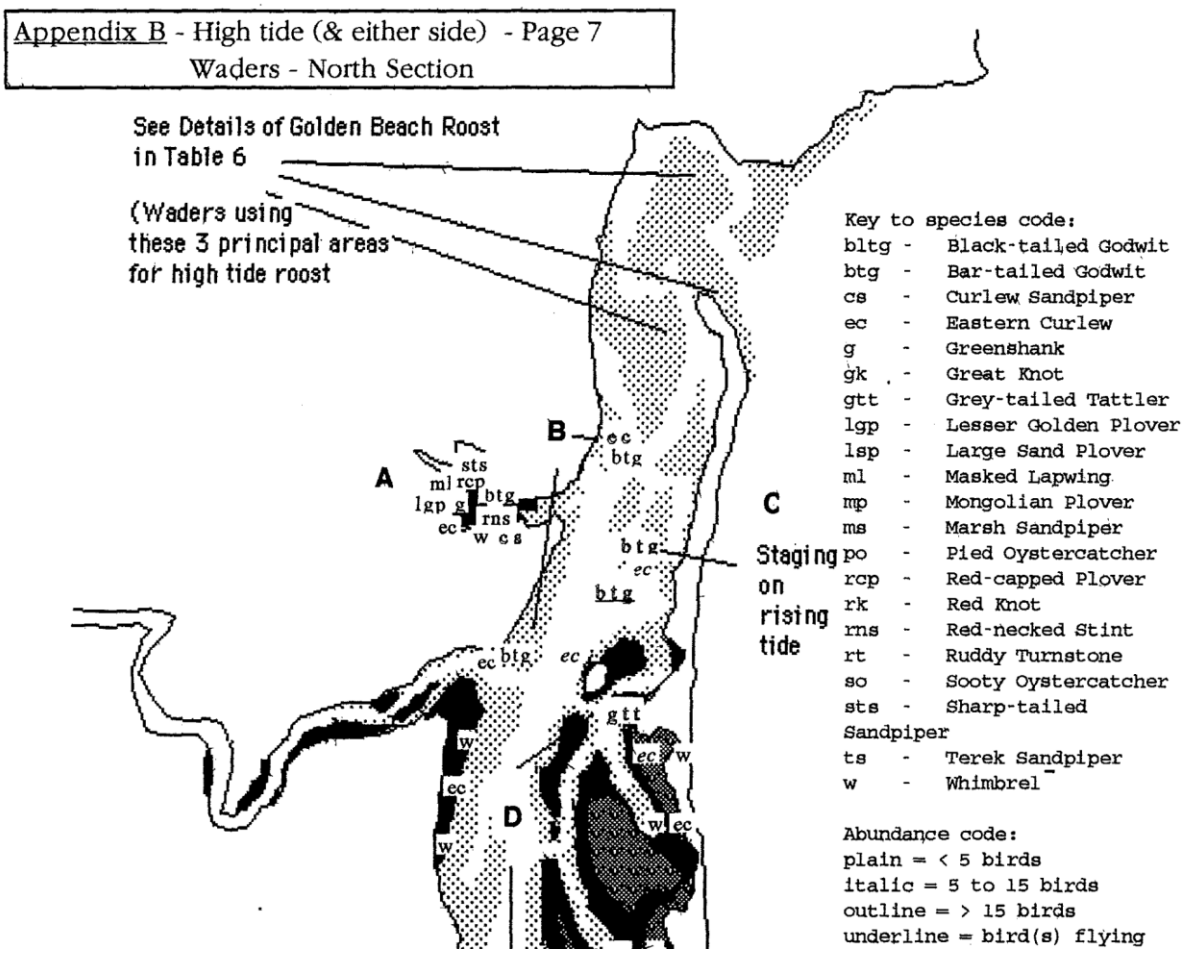


Figure 58: High tide (& either side) – Waders [215] (*full caption above*)

Table 6. Counts of waders at the main high tide roosts in Pumicestone Passage. Details of several other roosts with fewer birds are given in Section *. Counts in italic are those made by Thompson (1990) for December 1989.

Species		Dux Ck	Toorbul		Donnybrook		Golden Beach	
Haematopus longirostris	Pied Oystercatcher	6	+				18	
Himantopus himantopus	Black-winged Stilt							
	Large Sand Plover and Mongolian Plover			*61*		*28*	100	*35*
Charadrius ruficapillus	Red-capped Plover					*2*	+	
Pluvialis dominica	Lesser Golden Plover					*15*	13	*7*
Pluvialis squatarola	Grey Plover							
Vanellus miles	Masked Lapwing	5						
Arenaria interpres	Ruddy Turnstone		+					
Calidris acuminata	Sharp-tailed Sandpiper	40		*2*		*15*		
Calidris alba	Sanderling							
Calidris canutus	Red Knot		+					*1*
Calidris ferruginea	Curlew Sandpiper		110	*4*		*48*	65	*6*
Calidris ruficollis	Red-necked Stint		+	*49*		*10*	15	*5*
Calidris tenuirostris	Great Knot	10	70	*127*	135	*81*	+	
Limosa lapponica	Bar-tailed Godwit	305	802	*1850*	1340	*1350*	1185	*800*
Limosa limosa	Black-tailed Godwit			*15*		*45*		
Numenius madagascariensis	Eastern Curlew	365	97	*1*	439	*28*	48	*45*
Numenius phaeopus	Whimbrel		200	*308*	+	*45*		
Tringa brevipes	Grey-tailed Tattler		36	*62*		*28*		
Tringa nebularia	Greenshank	11	16	*29*	15	*15*		
Tringa terek	Terek Sandpiper		22	*3*				

Figure 59: Counts of waders at main high tide roosts, including Golden Beach [215]

Admitting our review is cursory, we also admit to potential bias, in that we arrive at a similar observation as previously voiced regarding sand transport – it's complex, arguably including more questions than answers. This complexity should be embraced as part of management planning. Simple answers to complex questions potentially avoid important factors. We take heart in the advice included in Part 2 – *a response to threats of serious environmental damage should not be postponed due to a lack of full scientific certainty*. In that context, we include and note the following more recent information regarding shorebirds and wetlands of international importance:

- Shorebird surveys and assessments available from SCC span the period of 2020-2025 (Reports and publications | Sunshine Coast Council.
- That SCC webpage also includes a report providing longitudinal advice *Changes in shorebird use of the Maroochy River estuary, Sunshine Coast, Queensland over 25 years* [216]. Whilst that report is outside the immediate project area, it offers insights we consider relevant:
  - Over the period 2011 to 2022 there was a significant decline in the total migratory shorebird count at low tide during both the summer… and winter.
  - Since 1997, abundance at roost sites at high tide through the summer period has declined significantly for [some species], increased significantly [for others], whereas there has been no trend for [others].
  - Assessing whether the dredging of sand close to the mouth of the estuary for beach replenishment has had an impact on migratory shorebird abundance at low tide is complicated by the significant declines that many species experienced prior to the dredging works.
  - To minimise potential impacts on migratory shorebirds and their habitat, dredging activities are temporally and spatially restricted. No dredging is allowed between October and April (the months when most migratory shorebirds are present) apart from six weeks in February and March. If dredging is conducted in February-March, sand extraction is restricted to the deeper sub-tidal and highly dynamic area[s]…, and a temporary shorebird refuge area is created on the Maroochy North Shore throughout the period of dredging.
- The 2024-25 survey and assessment [217] includes the following advice (for sites referenced below, refer to Figure 60):
  - While two sand banks, SBN1 and SBN2, remain the most important feeding areas, increasing numbers of shorebirds are using two new tidal flat areas that have formed since 2022, NTBI across the old entrance and SBN3 to the south of the new entrance.
  - Shorebirds *(sic)* numbers were generally similar to the averages over the previous four years.
  - Eight shorebird roost sites are currently recognised at Golden Beach and Caloundra.
  - The average numbers of shorebirds recorded roosting during summer (October-February) in 2024/25 were generally similar to the averages over the previous four years.
  - The formation of the new entrance to Pumicestone Passage has increased the availability of suitable alternative roost sites, with suitable roosting habitat now present on a broad sandy beach at SBN3.
  - While the area of roosting habitat on SBN2 has increased following the increased deposition of sand at this location, it is still inundated on high spring tides.
  - On the other hand, there is now increased accessibility by people to these roosting areas, which increases the risk and frequency of disturbance.
  - Whereas the CBAR, SBN1 and NTBI roost sites previously experienced low to moderate levels of disturbance, the risk of disturbance has now increased.
  - This has largely been due to the silting up of the old entrance channel that allows people to access the northern tip of Bribie Island from Caloundra on most tides. Similarly, the risk of disturbance to shorebirds feeding and roosting on SBN2 has increased.

Figure 60: Locations of tidal flat shorebird feeding habitat areas (as referenced above) (BAAM)

- Regarding the various RIS –
  - The 1995 RIS advises:
    - Based on recent estimates (Thompson, 1990b) the bay could be upgraded from the 20th to equal 11th most important site in Australia for waders (Lane 1987).
    - Image analysis of all intertidal areas in Moreton Bay, including Pumicestone Passage estimated that a total of 23,000 ha of tidal flats are exposed at low water datum characterised by marked differences in substrate type and species of waders present (Thompson, 1990b).
    - Intertidal and shallow waters support seven species of seagrass which occur over an area of 6522 ha. This provides food and habitat for turtles, dugong, commercially and recreationally important fish and invertebrate populations in the bay.
    - Driscoll (1991), found that the substrate and conditions in Pumicestone Passage were not uniform throughout and that different locations had variations in the numbers of wader species present.
    - One third of all waders counted were bar-tailed godwits but data from Thompson (1990c) suggests that the numbers of this species present in the Passage decrease in autumn.
    - Conversely the number of grey-tailed tattlers was found to be higher in autumn and this was reflected in data from the Great Sandy Strait further north (Driscoll 1990).
    - At least 43 species of shorebirds use intertidal habitats in the Bay, including 30 migratory species listed by JAMBA and CAMBA.
    - “More than 50 000 wintering and staging waders depend on Moreton Bay during the non-breeding season (Thompson, 1990b).
    - The Bay is particularly significant for the population of wintering Eastern curlews Numenius madagascariensis (3,000 to 5,000) and the Grey-tailed tattler Tringa brevipes (more than 10,000), both substantially more than 1% of the known Flyway population.
  - The 1999 RIS largely duplicates the above advice.
  - The current, 2023 RIS advises:
    - While in Moreton Bay, shorebirds feed twice daily on benthic invertebrates in exposed intertidal habitats. At high tide, when intertidal foraging areas are submerged, shorebirds congregate in high densities (‘roosts’) in supratidal habitats in or along the periphery of the Site, including claypans, sandy and rocky foreshores, and mangroves (coastal and islands) (Zharikov and Milton 2009).
    - Overall waterbird numbers of 66,340, 2013-2017 (QWSG 2017; Hansen et al. 2016)
    - Monthly counts of migratory and non-migratory shorebirds, as well as other waterbirds, at no fewer than 40 high tide roost sites, have been undertaken by the Queensland Wader Study Group (QWSG) since 1992 (further detail can be found in Wilson et al. 2011).
    - Estimated populations at the Site from 2013-2017:
      - Migratory shorebirds (28 species): 33,929
      - Non-migratory shorebirds (15 species): 3,758
      - Other waterbirds (59 species): 28,653

Regarding the above, we note long-term trend data – has the protected area improved, maintained, or lost ‘value’? – is inconclusive. As the Moreton Bay Ramsar site is large, and the project area is only a small part of the overall area, it would be difficult to make generalisations in the absence of spatial disaggregation of data. However, even at the larger scale, we find the reporting unclear about trends and note that the data is often dated and incomplete regarding long-term trends (for example, the 2023 RIS including data for 2013-2017).

The study by Penn Lloyd et. al., does provide insight regarding long-term declines internationally. This means that if long-term trend data was available, any changes could in part be to uncertain global factors, likely making the trend data questionable or inconclusive.

Suggestions received during technical review of Part 4 included advice to see the work by Professor Richard Fuller, University of Queensland. He has published extensively (as co-author in the case of all of the publications below). We did locate some research that is of interest, as discussed below. We also attempted to reach him to have a discussion but were unsuccessful.

An emerging coastal wetland management dilemma between mangrove expansion and shorebird conservation [218] reports on the potential conflict between mangrove and shorebird conservation because mangrove afforestation and restoration may occur at the expense of bare tidal flats, which form the main foraging habitats for threatened shorebirds and support other coastal organisms. The authors quantified the changes in 22 important shorebird areas in mainland China between 2000-2015. They found a decline in the extent of tidal flats across all 22 sites, and for sites with mangroves (14) an expansion of that habitat. For 8 of the sites, they concluded that the mangrove expansion had impacted shorebird habitat. They developed and present a decision tree, to improve management decision making regarding potential trade-offs.

Predicting resilience of migratory birds to environmental change [219] provides insights derived from modelling and empirical tracking data. The authors identified adaptation strategies to habitat loss and climate change, both observed and predicted. A key finding was that body size (as well as other factors) influenced the relative degree of adaptation required. Notable for this project perhaps is that the Bar-tailed Godwit, the largest species included in their assessment (present at the project site – see above) requires substantial adaptation, including an increase in migration duration (159%). Strategically, this species historically employed a 'jump' strategy, being a relatively long flight, followed by a long stay at a single stopover. Observed trends and model predictions suggest the required adaptation strategy is towards a 'skip' strategy, with more stopover locations, for shorter times, to feed and compensate for deteriorating habitat conditions.

High-resolution global maps of tidal flat ecosystems from 1984 to 2019 [220] notes that a lack of data regarding the extent of tidal flats has frustrated assessment of their global distribution and change. They developed globally consistent mapping of tidal tidal flats, defined as sand, rock or mud flats that undergo regular tidal inundation, using satellite imagery. The article is largely concerned with the methodology, rather than reporting on historical changes. The data is available for download, and on an online viewer, which has been retired but can still be accessed (Ocean+ Habitats | Australia).

Protected areas have a mixed impact on waterbirds, but management helps [221] notes that protection is a focus for international policy, with studies showing the effectiveness of the strategy for preventing habitat loss, but evidence lacking in terms of the effect on species' populations. The authors explore how 1,506 protected areas have affected the trajectories of 27,055 waterbird populations. Based on their robust methodology, the conclude that the relatively simpler study designs typically used for assessment incorrectly estimate effects for 37–50% of populations (both positive and negative errors). Their findings indicate that protected areas have a mixed impact on waterbirds, with areas specifically managed for waterbirds or their habitat more likely to benefit populations. The advocate for a focus on creating and supporting well-managed protected and conserved areas that measurably benefit populations.

These articles provide a more global perspective regarding both information gaps (e.g. historical changes in tidal flat extents globally), refinements to understanding regarding ecosystem 'trade-offs' (e.g. mangroves vs shorebird habitat), predicted impacts of climate change on migratory birds, and nuances regarding protected area benefits.

Overall, we conclude that it is uncertain whether the values that were intended to be protected in the project area have improved, declined or remained more or less the same, due to both a lack of adequate data, as well as uncertainty arising from global trends. The information above also supports opportunities in general to examine and revise protected area management.

3.3 Planning Act

The *Planning Act 2016* and associated frameworks provide a coordinating mechanism for approvals, allowing the provisions of other acts to be incorporated into a single assessment and approval action for a project. It does other things as well, such as setting foundations for land use planning by local government and identifying triggers for referrals to agencies or parties that may have a jurisdictional interest in an application (much of this is greatly facilitated by mapping that can be publicly accessed). There are no obvious conflicts arising from the *Planning Act* or associated frameworks with respect to a shift in management approach for the project area.

There are various codes under the State Development Assessment Provisions (**SDAP**) that apply and may present issues, but those potential issues arise from other acts such as the Coastal Act, and alteration or reinterpretation of those other provisions may resolve any conflicts, or codes may be amended.

3.4 Coastal Protection and Management Act

The main objects of the *Coastal Protection and Management Act 1995* (Coastal Act) are to:

a. provide for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity; and

b. have regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone; and

c. ensure decisions about land use and development safeguard life and property from the threat of coastal hazards; and

d. encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

Those objects are well aligned to the suggested shift in management of the project area. The current Coastal Management Plan ("Coastal Plan" in the Act) is dated 2013, with the Act providing a 10-year life, which can be extended by regulation to not more than 12-years. Accordingly, it appears that the plan is past or near expiry. The management principles are also generally consistent with a revised approach; indeed, they embrace a number of actions that do not appear to have occurred in the project area, such as maintaining dune vegetation.

The review does give rise to some potential investigations regarding coastal management more generally. One is that the State appears to have made a unilateral decision to allow the dune barrier protection to erode, which shifted the burden of response to SCC. It is unclear whether the State took any action to provide SCC with extraordinary support (compared to other QLD coastal local governments) in recognition of the effect of their policy decision. Arguably, such a concession may have been merited under the circumstances.

The second observation is that the information cited regarding coastal processes is largely dated – reports from 25-50 years ago, or more. Many of those early reports were done by government, including BPA investigations, collection of aerial photographs, and fieldwork, including through a network of volunteers. The reports include frequent advice regarding the need to collect further information. Those knowledge gaps do not appear to have been resolved, at least not for this part of the coast.

This suggests a role for government, even if it takes a different form than in the past. For example, an emphasis on alternative means of collecting and analysing data, such as leveraging existing remote sensing data such as satellite imagery, or commissioning the collection of data such as bathymetric LiDAR. Some of that has been done in relation to sea level rise, but it is not clear that the work extends to coastal process, or that there are not, at least, opportunities for improvement.

3.5 Protected Areas

3.5.1 National Park

As advised in Part 1, the Bribie Island National Park was declared by at least 1995. Governing legislation includes the:

- *Nature Conservation Act 1992* and subordinate legislation
  - *Nature Conservation (Protected Areas Management) Regulation 2024*
  - *Nature Conservation (Protected Areas) Regulation 1994*

With respect to the project area, Bribie Island National Park resides within Lot 105 of AP22462 (the park extends further southwards as well, including Egg Island, Lot 1 of AP22462). The outline of Lot 105 does not conform to any of the BPA historical coastline (0m AHD) outlines provided earlier, and it extends ~525m north of the 1992 BPA outline. In 1993, that northward extension was an intertidal sand spit. Presently it is vegetated and elevated, effectively training one side of the entrance, obstructing historical flow paths, and providing terrestrial rather than the intertidal habitat present at the time of protected area declarations.

A similar feature exists to the north, Lot 707 of CG3863, which is a Crown Reserve, presumably with SCC as trustee (purpose of the reserve not clear from research). This reserve is also misaligned with the 1992 BPA coastline, although it does approximate the spit that was there at that time, with the orientation shifted. The area is largely unvegetated sand, or water, in recent imagery, refer to Figure 61 and Table 7.

Whilst the above discussion is focused on the National Park, this area also includes a National Recreation Area under the *Recreation Areas Management Act 2006* (the two overlap, but not completely). The *Bribie Island National Park and Bribie Island Recreation Area Management Statement* (14 pages) is dated 2013 [222]. Various values within and surrounding the areas are discussed, as are stakeholders and legislative and policy frameworks. With respect to management issues and responses, Pest management and Fire management are discussed. There is no mention of coastal erosion or explicit actions to manage dune vegetation.

The Management Directions do include this key outcome: “The natural processes of beach foreshore accretion and erosion are managed in accordance with current coastal management principles and legislation.” Associated Actions and guidelines include: “A3. Continue to make available for public use the Northern Access Track and connecting roads to Gallagher Point and Poverty Creek Access Track and the Ocean Beach (south of the Northern Searchlight).”

Restricting vehicular access north of the searchlight is a strategy to address some potential impacts to dunes and associated vegetation, but the sorts of measures included in the BPA scheme discussed earlier, such as controlling pedestrians (for example by access tracks, boardwalks or dune fencing) or undertaking revegetation works as necessary, are not evident.

This key objective is also included: “Shorebird habitat (roosting, breeding and feeding sites) is identified, conserved and threats mitigated in line with international treaties.” Actions accordingly may have been undertaken, and it is not clear the northern island sand spit would have been a preferred roosting site when connected to the island, however, when separated by a channel it likely was. As such, the vegetation and islandisation of that area is seemingly at odds with this objective.

It is not certain whether this management statement is subject to a 10-yr sunset clause, like the Coastal Management Plan; regardless, that seems like a reasonable time period for review. Other related management statements and plans that were identified during the review include:

- Great Sandy Region Management Plan (1994, revised 2005) (128 pages) [223]
- Moreton Island National Park, Cape Moreton Conservation Park & Moreton Island Recreation Area Management Plan (2007) (41 pages) [224]
- Southern Moreton Bay Islands National Park Management Statement 2013 (2013) (12 pages) [225]

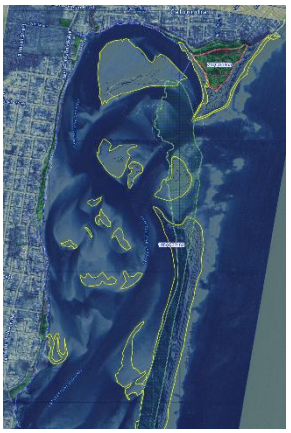
As discussed earlier, coastal erosion processes are currently limited to northern Bribie Island, approximately north of the searchlight. It may be appropriate to consider a management plan for this area, if the needs and/or stakeholders are substantially different from areas of the park to the south.

Figure 61: Bribie Island National Park/105AP22462 (green), 1992 BPA coastline (blue) and 707CG3863 (red)

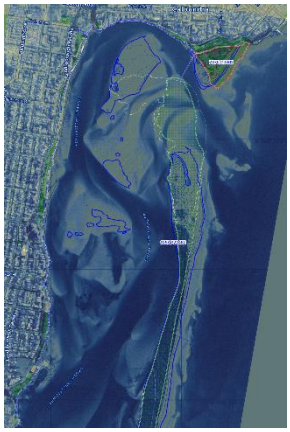
Table 7: Tenure (see text) with historical coastlines (insets)

1940

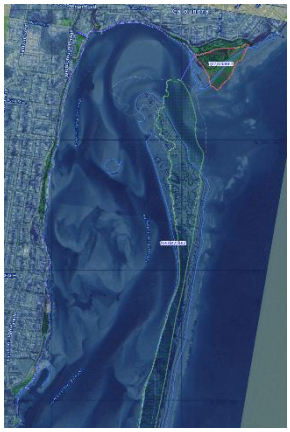
1961



1971

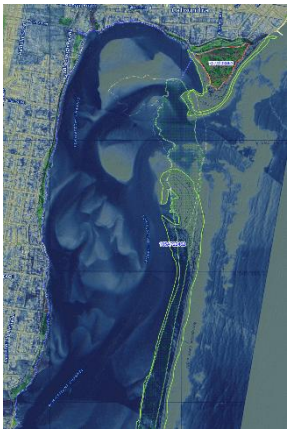


1992



1982

1979



1972

However, it is not evident that protected status as a National Park has been beneficial to managing coastal erosion, or sufficiently proactive to at least constitute proactive management in accordance with BPA guidance under the scheme. It would be instructive to learn if QPWS&P undertakes proactive dune erosion control in other estate areas. Management of trails, erosion, etc. is undertaken by rangers, so whilst there may be resourcing issues, the concept is not fundamentally foreign. QPWS&P historical management of this area may be a reflection of State policy to allow this area to fully retreat.

We note that the management intent of National Parks is protection and maintenance of their natural condition. However, as some of the observed changes are likely to have included anthropogenic contributions, such as park visitors walking across dunes or otherwise damaging the integrity of natural erosion defences, it seems reasonable to expect management would include consideration of those impacts and management measures to appropriately mitigate potential adverse effects.

The structural elements suggested in Part 3 are likely to be incompatible with the declared Bribie Island National Park and Recreation Area. Therefore, alternate land tenure arrangements may be a necessary consideration for the northern section of the Island to support not only any future Part 3 construction and development, but also ongoing management of this land and the associated coastal protection infrastructure.

Advice provide by DETSI is that consideration should be given to resolving this matter through revoking part of the National Park and Recreation Area and dedicating the land to another tenure compatible with future ongoing works and use of the area as approved by government for long term coastal protection. Advice from the Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development is that a relevant purpose in Schedule 1 of the *Land Act 1994* may be “conservation, scenic and land management purposes” (which includes as examples: beach protection, and coastal management).

As a final note, we provide a figure from the 1974 Land Use Study, which suggests a different footprint from current cadastral arrangements, including a reserve for the northerly spit that extends nearly to the Island. Recall that advice from this study informed decisions to create various protected areas, refer to Figure 62.

The historical imagery and other related reports that have been discussed suggest that provision should be made for an entrance delta with a width of ~1,000 – 1,250m. That width includes potential allowance for sand spits to the north and the south (off Deepwater Point and off Bribie Island), each intruding ~250m, leaving an area of ~750m for the channel to migrate.

Migration of the channel is potentially critical to supporting natural littoral drift processes. An extended ebb delta that includes Kings Beach, which is allowed to shift in accordance with varying weather, is consistent with historical observations. The ebb delta should extend westwards to a substantial flood delta, to mitigate impacts to the mainland foreshore. Historical advice is that shifts in the deltas were accompanied by differential shoreline issues. An extended flood delta will also attenuate tide heights.

As discussed further below, a general premise for iterative works would be to start shallow, around MSL, and dredge broad, rather than deep, to allow natural processes to create and shift channels. This is discussed further below, however, as the National Park boundary, along with the Reserve off Deepwater Point are potentially involved in this concept, it is introduced here. The boundaries for these areas do not necessarily need to be adjusted; rather, it is potentially simply a matter of adjusting how the reserves are managed.

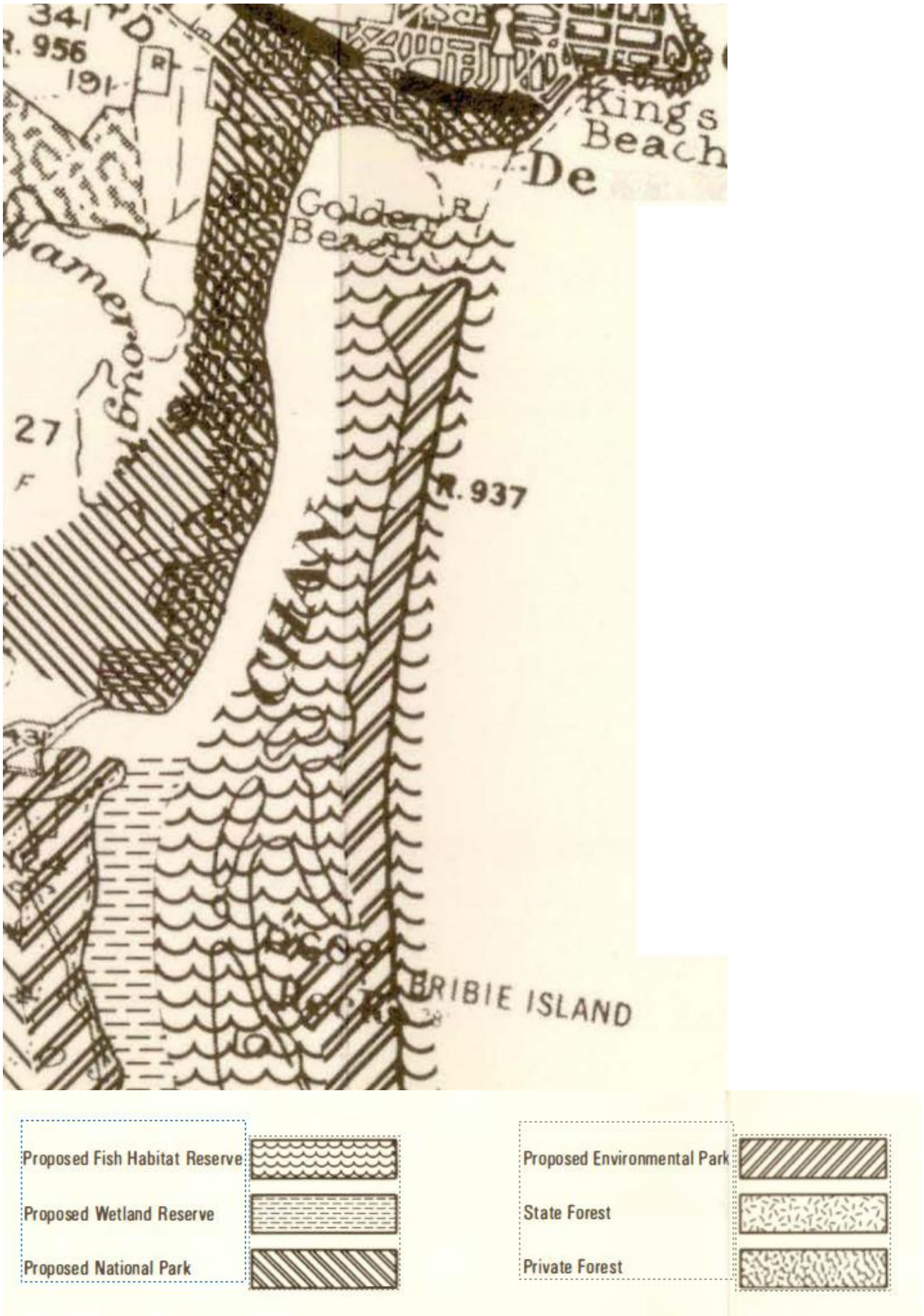


Figure 62: Detail from Pumicestone Passage Water Quality and Land Use study (Vol.4, Fig.5) [060]

3.5.2 Marine Park

As discussed in Part 1, the Pumicestone Passage Marine Park was declared in 1986 with a zoning plan provided under the *Marine Parks Act 1982* [072]. The Pumicestone Passage Marine Park was repealed and the area incorporated into Moreton Bay Marine Park in 1997. The *Marine Parks Act 1982* was repealed in 2006; the current Act is the *Marine Park Act 2004*. The accompanying Explanatory Notes discuss the reasons for replacing the former Act, which include uncertainties regarding reclamation activities within a Marine Park and revocation of reclaimed areas. Also discussed are zoning plans and management plans, the latter being by exception, for example areas of high demand, to assist with management decisions. The relationship between Conservation Parks and National Parks is also discussed, with provision for transferring parts of a terrestrial park to a Marine Park, where the latter provides equivalent or 'better' protections for waters, with a note that the alignment of Marine Park zones (e.g. National, Conservation) to these terrestrial parks facilitates transition. The ability to amend zoning plans is also discussed, with public notification required, unless the changes are minor. The current location specific management arrangements for the Moreton Bay Marine Park, such as zoning, designated areas and entry and use provisions are detailed in the Marine Parks (Moreton Bay) Zoning Plan 2019.

In the project area, there is a small nearshore area of General Use Zone (least restrictive) in the northern part of the Passage, however, the majority of the foreshore areas, as well as the coastal foreshore of Bribie Island are Habitat Protection Zone; this area also includes a designated mooring area. The centre of the Passage is Conservation Park zone, the most restrictive of these three zones. The most restrictive zone, Marine National Park zone, applies to a large part of the north banks, refer to Figure 63.

Advice during review is that works envisioned in Part 3 could potentially be permitted in the Habitat Protection zone, but only following the designation of a 'works area' over the footprint of the area of the proposed works. The Marine Parks (Moreton Bay) Zoning Plan 2019 allows for the establishment of a works area in the marine park for the purpose of 'carrying out necessary major works for the public benefit'. Works areas can be designated only in General Use and Habitat Protection zones and their establishment requires legislative amendment to the zoning plan following Ministerial consideration of a range of matters detailed in the zoning plan. Major works are incompatible with the intent of the Conservation Park Zone.

If legislative amendments were made to change the zoning (Conservation Park zone to either Habitat Protection or General Use zone) including designation of a works area, a Marine Park Permit authorising the works would be required. Unlike an approval, this permit is focused on the operational activity, the manner in which, for example dredging, is carried out, including measures to minimise or mitigate adverse effects.

Overall, the existence of a Marine Park in the project area is not, in and of itself, a barrier to a policy shift, and it could align or assist with some of the potential objectives. As a general comment, mapping for the Marine Park zoning excludes an area corresponding with part of Bribie Island and the footprint shown on mapping for that exclusion differs from the cadastral lot and National Park boundary (compare Figure 61 and Figure 63). Technically, the declared area definitions include provisions to allow for boundary shifts based changes to HAT; regardless, the mapping footprints are noteworthy in the context of discussion provided in Part 4 regarding historical mapping, etc. The mapping suggests that the Marine Park, declared in 1982, may have been based on a narrow, north/south aligned island, similar to the early maps discussed above.

One of the documents identified through research is the 1992 *Management planning for national, environmental and marine parks of Bribie Island and Pumicestone Passage: management framework, constraints and issues* (74 pages) [226]. This document is superseded by plans discussed above; however, it merits discussion here for several reasons.

The first is that, as the title suggests, it integrates consideration of the various protected areas and other provisions, including fisheries habitat and the BPA BECD scheme. As the project area has a number of overlapping jurisdictions, arising from different acts with differing objectives, an integrated approach to management planning would be beneficial, including incorporation of matters such as Fish Habitat Areas.

The second is that it was produced concurrent with the creation of the protected areas and it contains a substantial amount of historic information regarding the area and relevant values, including documenting the knowledge base. For example, the importance of intertidal areas as roosting areas is documented, including use of many of the same illustrations provided above. Using this document to inform forward planning would not be inappropriate, perhaps integrating it with more recent planning, for example that undertaken for the Great Sandy Strait, as referenced above.

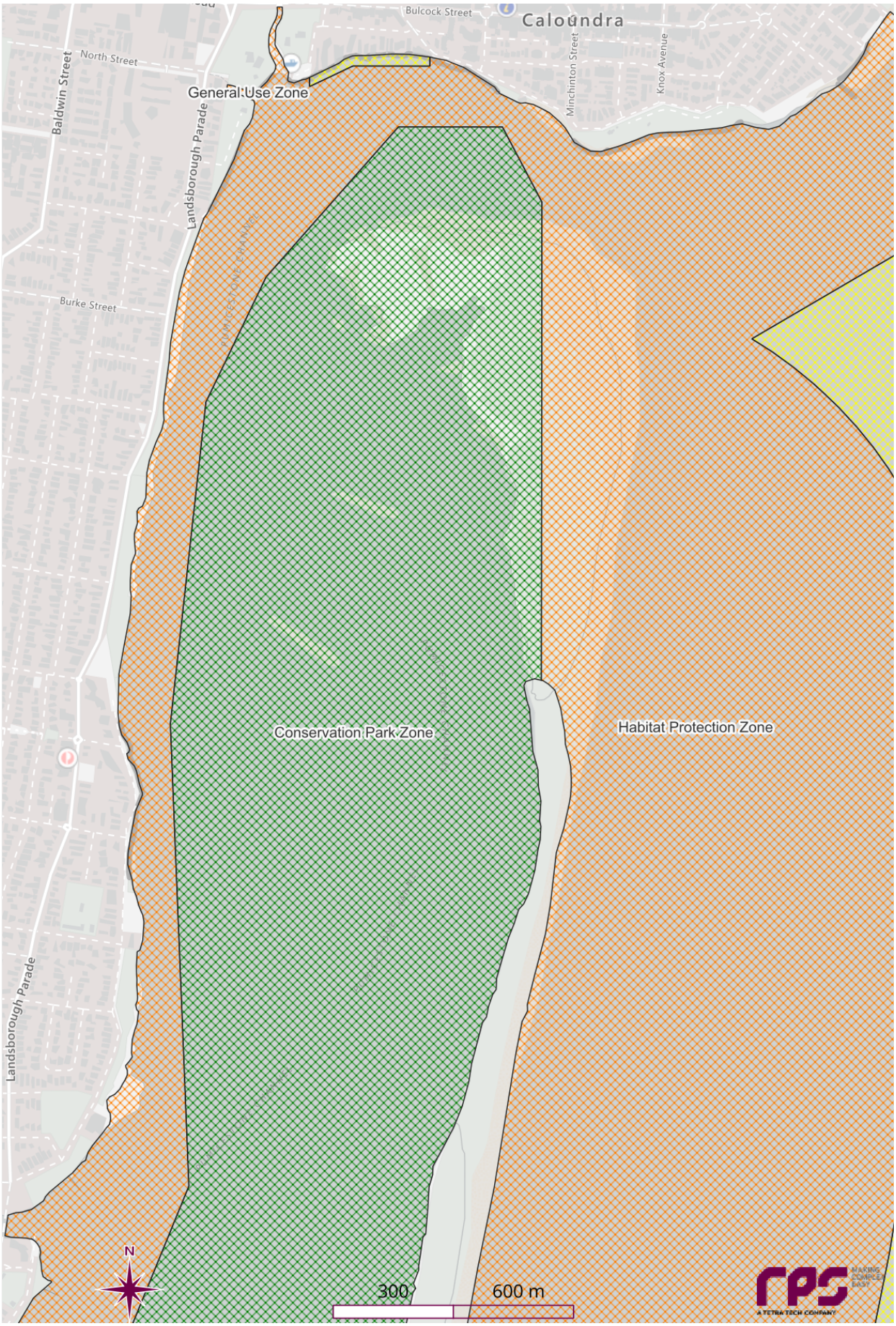


Figure 63: Marine Park zoning in the project area

An interesting note is that the figures and maps in the report show differing footprints for the Island, possibly just due to how the source material depicted the land contour. In addition, vegetation mapping indicates a change in communities in the vicinity of the breakthroughs, possibly originating from the narrow width, although this could also be an earlier indicator of sea water intrusion affecting shallow perched aquifers, refer to Figure 64. Additional figures of potential interest are also included below, noting that the document includes many more, refer to Figure 65 and Figure 66.

Regarding Management Issues and Constraints, it is worth including the following excerpt regarding erosion in its entirety as it documents knowledge, as well as gaps, and policy, regarding both coastal erosion of the Island, and erosion of the Passage foreshore of the Island.

5.1.6 Erosion

Erosion problems are evident in the dune systems on the eastern beach, particularly at informal crossing points and unofficial camping areas, along the western shore of Bribie Island, along Golden Beach and the mangrove islands in the Passage. Particularly vulnerable areas include the northern spit, the central "skids" area, Mission Point and the south-western shore of Bribie Island in the vicinity of. Bongaree and Bellara. With the exception of the "skids", these are all "high-use" areas.

The dune system is dynamic and is eroding as a result of a shortage of sand and occasional heavy wind and wave action during storms. This natural erosion is being exacerbated by uncontrolled pedestrian and, in some cases, vehicle traffic on the dunes. Access points need to be controlled both on the eastern beach and on the western side of the spit. There are two possible vehicle access points near the second and third lagoons on the eastern beach which should be closed. Although permits issued by the Caboolture Shire Council for 4WD use on the beach specifically prohibit dune crossing they do occur at these points. Around 40 "squatter huts" are located in the dune system along the eastern beach in areas vulnerable to erosion. Some of these huts are quite elaborate whilst others consist only of a few poles with sheeting nailed over the top. These huts need to be removed and areas allowed to revegetate. Several of these sites would be suitable for limited camping.

The causes of erosion in the Passage are unclear. The eroding north-western spit appears to be-predominantly caused by natural channel erosion. However, increasing boat traffic and visitor access to key destination points are contributing factors in bank erosion at this site and at Mission Point. The Department of Environment and Heritage is assessing the historical rates of erosion along the northern spit of Bribie Island using available aerial photography.

Limited erosion management has been done. Vehicle access through the dune systems has been prohibited and signs have been erected on the spit advising that camping is prohibited. The eastern beach within the Caboolture Shire Council is patrolled five days a week and illegal campers are fined. Irregular patrolling of the eastern beach and spit area within Caloundra City also occurs predominantly during school and public holidays. The Bribie Island • Environmental Association (BIEPA) has carried out erosion control work at Welsby Lagoon. This consisted of Casuarina planting and some fencing.

At the end of 1991, the Caloundra City Council undertook beach replenishment along Golden Beach. A permit was issued to allow sand to be dredged from the Marine Park and pumped onto areas of Golden Beach. The Caboolture Shire Council is also seeking approval for a beach nourishment project along the south-western end of Bribie Island where erosion has resulted in undermining of the seawall in the vicinity of Bongaree. Consideration will need to be given to the potential effects of such a project on adjacent seagrass beds.

Finally, as an appropriate segue to the next section, the following excerpts are provided:

- Tagging studies carried out by DPI (Fisheries) have shown that the Bream stocks of Pumicestone Passage are crucial to the entire south-east Queensland Bream fishery (Pollock, 1984).
- Recreational fishing is very popular within the Passage and from the eastern beach. Patterns of use revealed from regular patrols of the Passage in January 1990 clearly shows that recreational fishing is the major boating activity occurring in the Passage; it occurs throughout the Passage, but is greatest in the north (from Bells Creek to the Caloundra Bar)
- Recreational fishing from the shore is also popular, particularly from Bulcock Beach to the Bar, along the western shore of the spit, along the south-western shore of Bribie Island and along the eastern beach. No data are available on the level of shore-based fishing.
- There is potential for conflicts between recreational fishing and other, more high-profile recreational activities (water-skiing, jetskiing). Similarly, loss of habitat and alteration of the visual character of the

Passage will have adverse impacts on recreational fishing. Many recreational anglers have expressed concern over declining catches in the Passage and variously blame commercial fishers and increasing sedimentation. Recreational anglers within the Passage are targetting Bream, Whiting and Flathead with Tailor being fished for from the eastern beach of Bribie Island. A creel census undertaken in November 1981 during the annual peak of the Summer Whiting fishery found that this fish accounted for 97.4% of the catch and that 45% of the fish retained by anglers were smaller than the mimimum legal length (Morton, 1982). A further analysis of fishing club records from 1959 to 1981 found that the weight of Summer Whiting had decreased but that the number caught/angler/trip and fishing effort had increased (Morton, 1982). Further study is needed into all the fish species being targeted to determine if fish stocks in the Passage are declining.

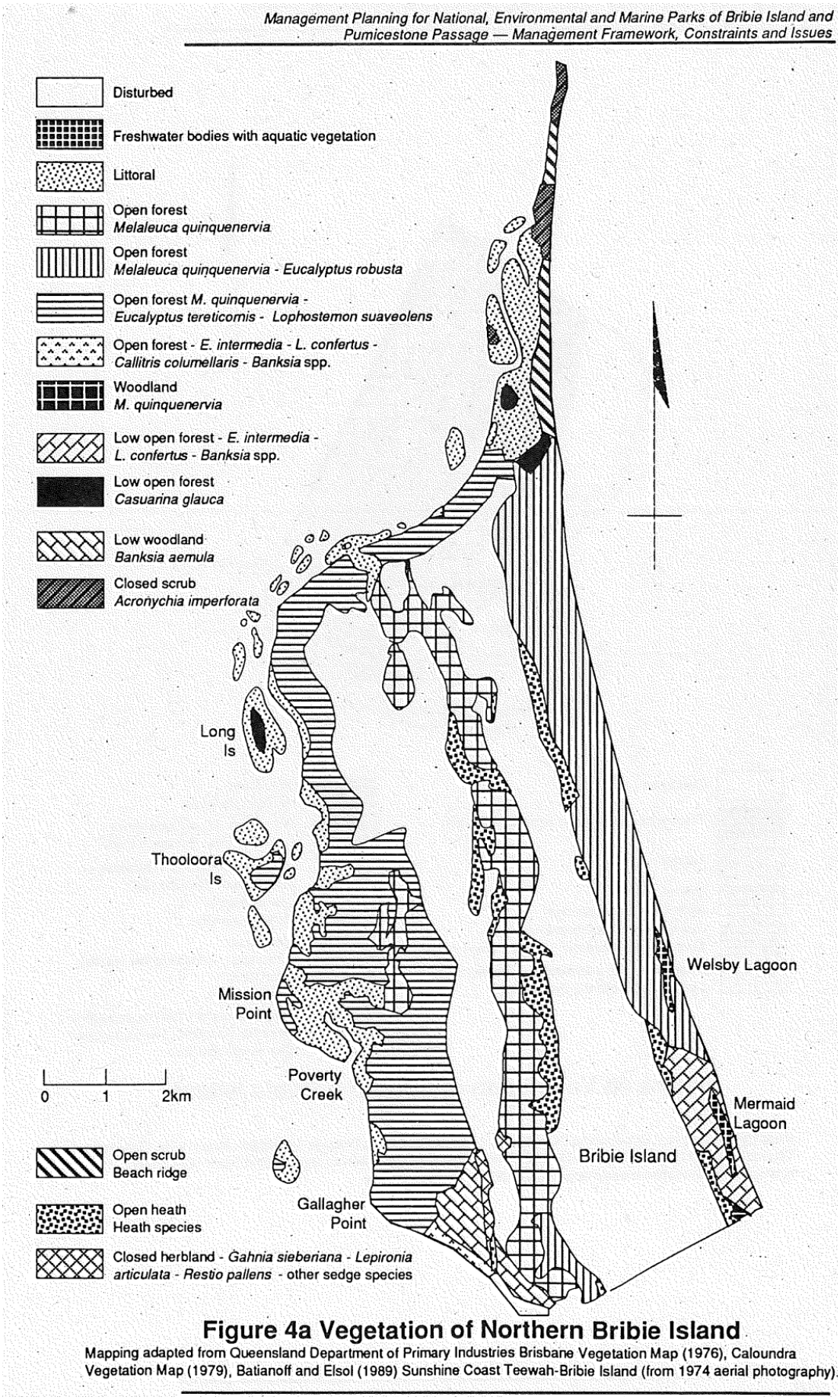


Figure 64: Vegetation mapping (historical, as captioned) indicating variation in vicinity of breakthroughs

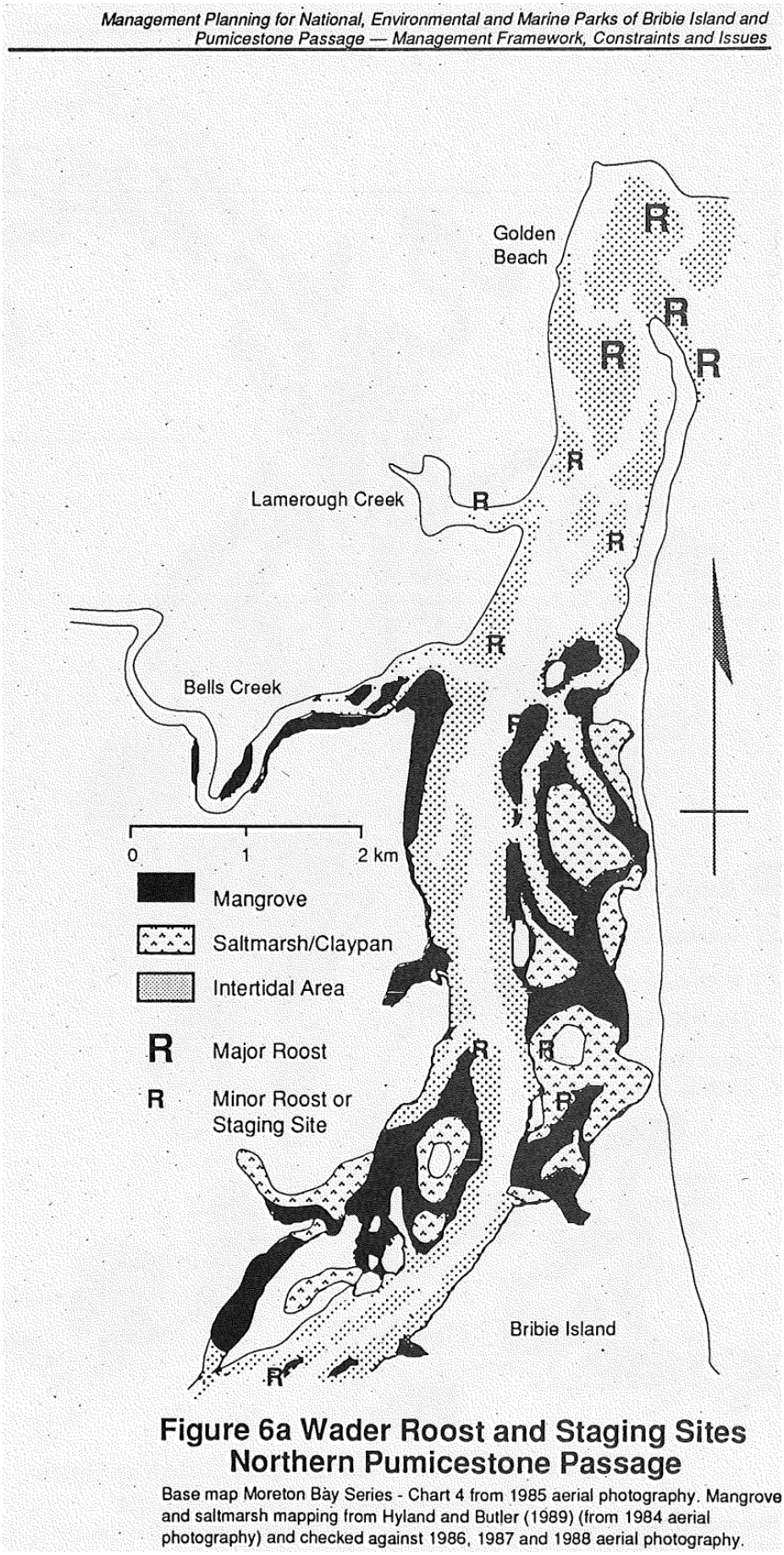


Figure 65: Wader roost and staffing sites, including habitat mapping

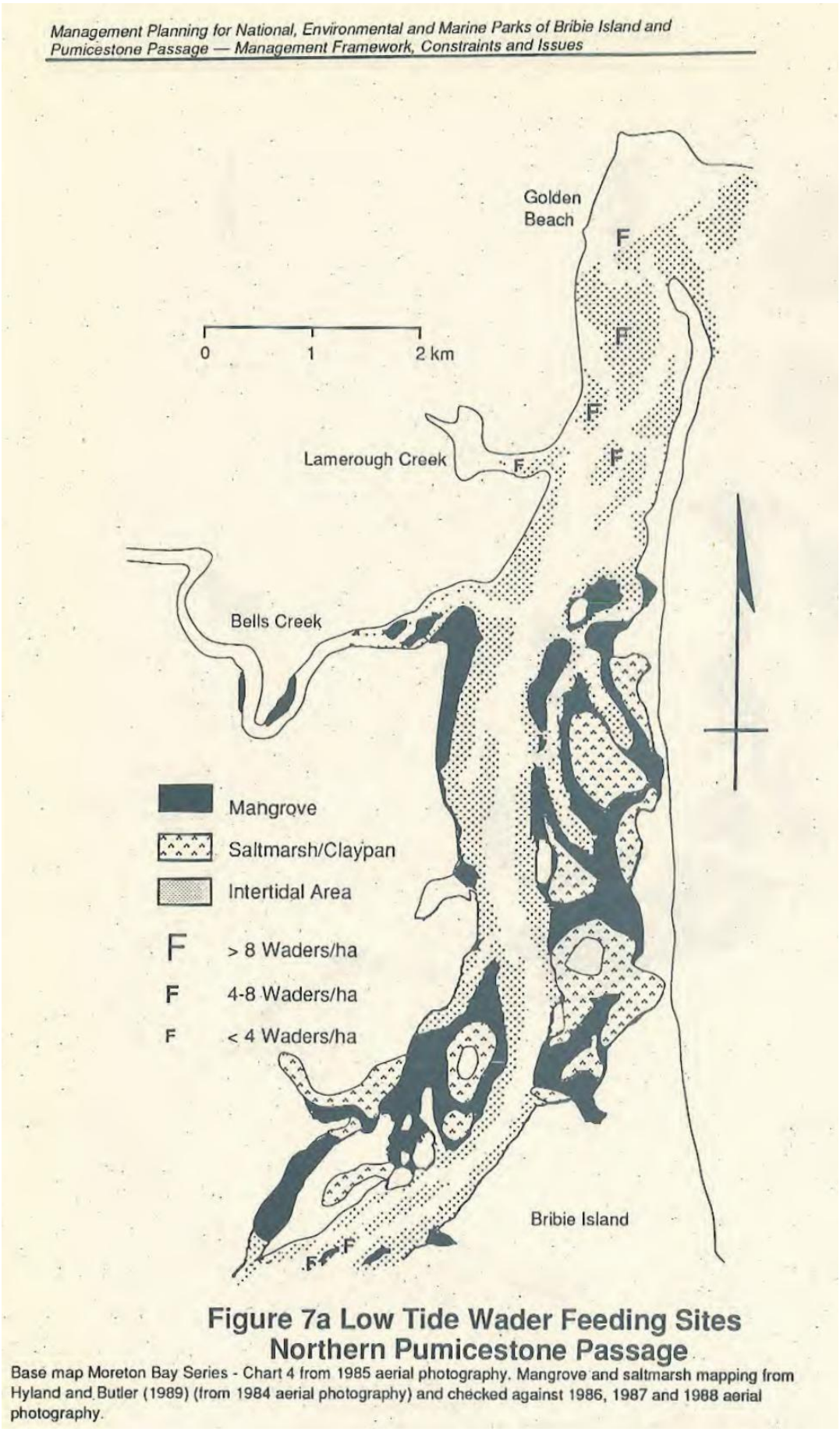


Figure 66: Low tide wader feeding sites

3.6 Fisheries Act

Part 1 advises of early legislation to manage a booming industry, including the *Oyster Act of 1863* (banning the burning of live oysters for lime) and the Queensland *Fisheries Act of 1887* (to preserve/protect breeding and feeding grounds). Both of these acts post-date the separation of Queensland from NSW (1859), however the earliest acts on the Queensland Legislation website appear to be the *Fish and Oyster Act of 1914*, which was amended many times until the *Fisheries Act of 1957* was passed.

The current Act is the *Fisheries Act 1994*, so contemporaneous with the declaration of protected areas. The Explanatory notes advise that a management plan may be made, for fishery or a fish habitat area (**FHA**), with an intent that these be flexible, so as to accommodate potentially overlapping plans, such as with the project area, where FHA overlaps with Marine Park and a Ramsar area.

The current Act refers to Codes of Practice that may be made for a FHA. *The Fisheries (General) Regulation 2019* mentions the 'Fish Habitat Area code of practice—The lawful use of physical, pesticide and biological controls in a declared Fish Habitat Area'. The use of such controls is prohibited, unless it is in accordance with the code of practice.

A key objective of the Act is to protect fish habitat, with the declaration of a FHA a key means to establish protections for specific areas. The Pumicestone Channel FHA–011 (revision 1) excludes the shoreline in the northern Passage (south of Bells Creek it does extend to and encompass parts of the shoreline). The boundary is somewhat similar to the Marine Park Conservation zone in that respect, however, the two do not fully align, and the FHA does not exclude the Island, refer to Figure 67. Rather, the definition for the FHA provides that:

- "The declared fish habitat area excludes the national park land that is not tidal land within the outer boundary shown on the fish habitat area plan for the area."

Accordingly, the breakthroughs, in transforming land (National Park) to tidal land (and waters) effectively converted those areas to FHA. Various policies, including Fisheries Habitat Management Operational Policies (**FHMOP**) as well as guidelines (**FHG**) exist, including:

- FHMOP 001: Management and protection of marine plants and other tidal fish habitats (2007, 66 pages) [227]
- FHMOP 004: Dredging, extraction and spoil disposal activities (1998, 85 pages) [228]
- FHMOP 010: Tidal fish habitats, erosion control and beach replenishment (2007, 43 pages) [229]
- Management of declared fish habitat areas (FHA) (2015, 89 pages) [230]
- FHG 002: Restoration of fish habitats: Marine areas (1998, 50 pages) [231]

Provisions include:

- All beach replenishment and artificial beach creation outside the scope of…(FHMOP 010) is not supported. (FHMOP-001)
- Fisheries Group is likely to give supportive comments for beach replenishment activities where there are obvious community benefits and the works are conducted in such a way that impacts on the marine environment are minimised. (FHMOP 004) Dredging, extraction or the use of other techniques such as sand pushing to obtain material for beach replenishment is not permitted in any declared FHA. (FHMOP-010)
- Depositing material for beach replenishment is not permitted in management A areas. (*ibid*)
- DPI&F's entire policy position on works and activities in declared FHAs is outlined in the Fish Habitat Management Operational Policy—Management of declared Fish Habitat Areas (FHMOP 002). (*ibid*)
- This policy position links with the State Coastal Management Plan's policies 2.1.9 Dredging, 2.2.2 Erosion prone areas and 2.8.2 Coastal wetlands in terms of fish habitat management. (*ibid*)
- Replenishment material is to be sourced outside of declared FHAs—a buffer zone of at least 100m is required between the extraction site and the boundary of the FHA. (*ibid*)
- Replenishment material is to be sourced and placed away from locations where there are marine plants, fishing grounds or key habitats of commercial and recreational fisheries importance. (*ibid*)

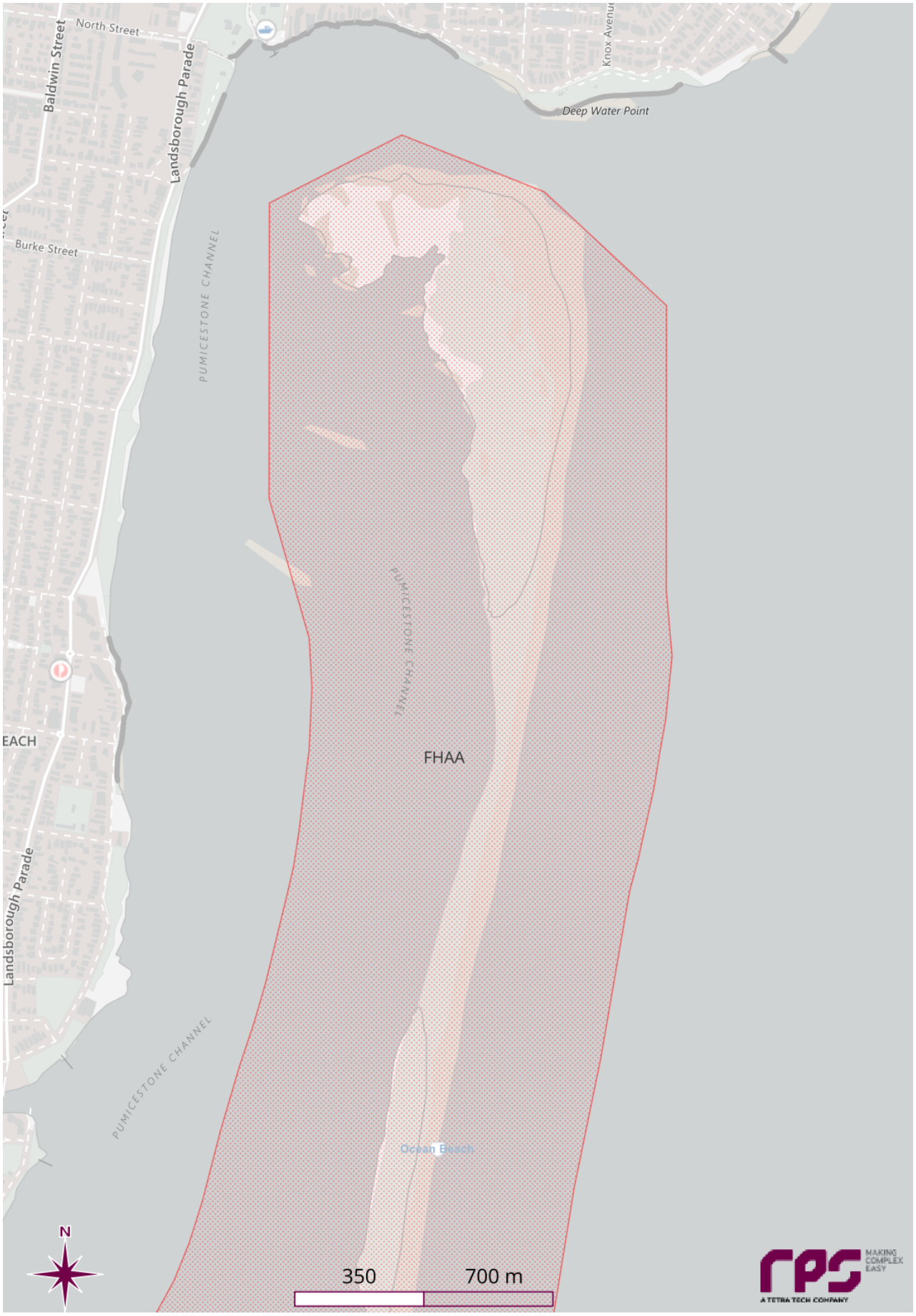


Figure 67: Fisheries Habitat Area in project vicinity

- Filling of tidal land for the creation of a dune or beach of a level above the HAT as part of a beach replenishment program may be supported only where it:
  - is an integral part of the erosion control design; and
  - will minimise replenishment frequency or impact of ongoing replenishment on tidal fish habitats; or
  - will remove the need for other erosion control works (e.g. the construction of groynes. (*ibid*)
- Depositing material for beach replenishment for the purpose of erosion control – Section 60 of the Fisheries (General) Regulation specifies that this prescribed development purpose is only for management B areas and only for the purpose of erosion control. (Management of Declared FHA)

We suggest several observations from the above extracts. One is that there are policy provisions to allow for nourishment, erosion control, etc, as well as rehabilitation. The second is that replenishment is not allowed in FHA type A areas (**FHA-A**), which is the type that applies in the northern Passage and the area of the breakthrough, and that material for replenishment must be sourced from outside the FHA.

This policy position is derived from an interpretation of the regulation, where s.60(j)(ii) stipulates that "depositing material for beach replenishment in the area for the purpose of erosion control" is a prescribed development purpose for a FHA-B area. The policy is consistent with the principles of statutory interpretation, notably that the explicit allowance in a FHA-B area means that it is not allowed in the more restrictive FHA-A area, even though there is no express prohibition in the regulation.

Crown law or other legal advice may provide further or different insight, but it is likely that a change to the regulation, or a change to the FHA boundary or type, would be required to reinstate the Island. More importantly perhaps, progressing works such as are envisioned in Part 3 would have to use a source of sand outside the FHA. Even if the part of the Passage that is FHA had not shoaled significantly as a result of the breakthroughs, the discussion above suggests that progressive shoaling is part of the issues that need to be addressed if the intent is to reinstate the Passage to a former (or similar) state, notably, transforming 'land' into intertidal area.

Evidence of conflict with these provisions, and adaptation required by climate change is suggested in the *Marine Parks and Other Legislation Amendment Regulation 2024*. The Explanatory Notes advise the regulation was progressed to support the implementation of measures to better address coastal management issues identified during the review of the Marine Parks (Great Sandy) Zoning Plan 2017.

The regulation includes amendments to the *Fisheries (General) Regulation 2019* to declared FHAs that overlap the Great Sandy Marine Park, including to facilitate the ability for local councils to better manage emerging issues in response to climate change e.g. through coastal protection /beach nourishment works.

The Explanatory Notes further advise that "changing the management level of parts of various FHAs allows for improved outcomes especially in relation to managing climate change impacts and the delivery of public infrastructure" and "will provide broad community benefit by supporting necessary coastal development works by local councils, for example, works necessary to protect eroding foreshore areas, enhance coastal community assets and facilitate public and private access to Great Sandy Marine Park and the FHAs."

Amendment is possible, but arduous and a long process. Climate change adaptation will potentially demand greater agility.

3.6.1 Oyster leases

Oyster leases in the Passage are well documented, however, there are some information gaps that should be investigated further as part of implementation. The records include "Oyster Camp" reserves on the Island (visible on some of the maps presented earlier) and the clear presence of leases near the western foreshore, to the north of the Power Boat Club. The evidence of leases along the inner Island foreshore is less certain. The DHM History includes a substantial amount of information regarding fisheries records in general, including the following advice:

- Cultivation by the 'stick' and 'tray' methods had increased in favour among the lessees and good results were obtained for a period. However, by 1932 the stick method had been practically abandoned. (p.473)

There is evidence that the stick method was used in Pumicestone Passage, refer to Figure 68. The sticks shown in that photo have likely rotted and are not currently evident, however, at low tide 'rock groyne' structures are visible, refer to Figure 69 through Figure 73. As reported by John Groves [232] these were constructed in the channel to take advantage of current flow, which benefited oyster cultivation. The

methodology suggested is the placement of rocks on the bottom, in rows, potentially including progressively adding more rocks to increase height, following subsidence or accretion, with the leases quite likely acting like groynes.

The leases are reportedly long abandoned, with disease a potential contributing factor. Suggestions have been made, as discussed above, that the leases promoted meander of the main channel, away from its original alignment along the western foreshore (where the leases were located to take advantage of the current) towards the Island, resulting in the erosion of the inner foreshore, as documented above. The earliest aerial photo (~1940) does not indicate a western channel; however, the leases appear to have been established much earlier, perhaps prior to 1900.

Removal of the leases based on the simple principle that they are anthropogenic in nature and rehabilitation should have occurred on abandonment, has merit. The nature of the works, as well as the substrate (were they placed on sand, or a harder surface like coffee rock?) is uncertain. It may be possible to simply 'scrape' them off with mechanical equipment. There have also been suggestions that they could be crushed and the remains left i*n-situ*. Further investigations will be required, and perhaps trials, with a need to consider water quality as disturbance may promote leaching. At present, the area is well scoured, providing an ideal opportunity to investigate and conduct tests, including perhaps piloting alternative removal techniques.

If they have been acting as groynes, and removal could be done so as to promote a more western channel, then interventions raise concerns about potential shoreline erosion. Detailed planning will need to take this into account. Foreshore nourishment should be considered, widening the foreshore to provide an erosion buffer (anecdotally, there was a wider sandy beach historically in this area). Other mitigations such as groyne placement or extension, as well as possible extension of infrastructure such as stormwater culverts may be required. Mangroves should also be considered as a foreshore protection element, with existing western foreshore groynes already demonstrating an apparent ability to facilitate colonisation.

Stick Cultivation of Oysters.
Experimental work in oyster stick culture by Department of Harbours and Marine officers on Oyster Bank No. 181, Bribie Passage, May 1949. This method of 'vertical' stick culture is no longer used, the sticks instead being laid horizontally on racks above the mud. *Department of Forestry.*

Figure 68: Oyster sticks in 'Bribie Passage' 1949 [203] (image and caption as provided, p.474)

Figure 69: Oyster banks labelled (1980s) and visible in foreground (PPCMB)

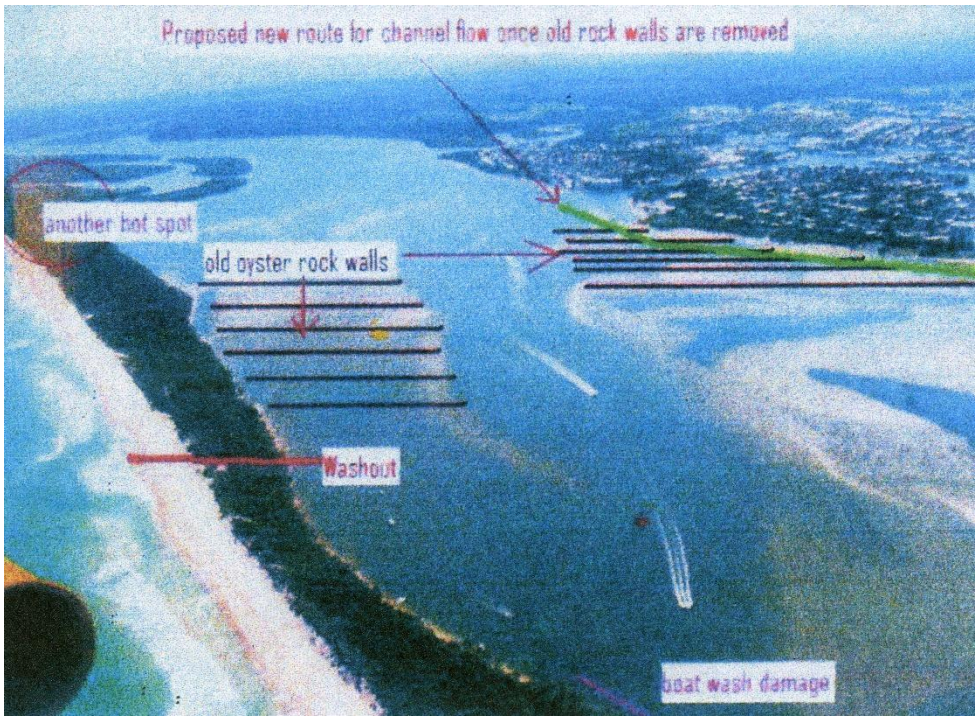


Figure 70: Oyster leases suggested along eastern foreshore (PPCMB)

Figure 71: Oyster leases, low tide, 2025 – Overview (Bluey's Photography)

Figure 72: Oyster leases, low tide, 2025 – Closer view (Bluey's Photography)

Figure 73: Oyster leases, low tide, 2025 – Detail (Bluey's Photography)

The conceptual view of a realigned channel shown below is an attempt to incorporate several matters discussed above:

- Erosion of the inner foreshore of the Island
- Providing a clear and direct tidal flowpath, which is outside the FHA, allowing maintenance dredging as required to address shoaling; to manage periodic flood delta growth/migration
- Creating a sandbar to:
    - further train that primary tidal channel
    - provide roosting area
    - act as a potential secondary line of defence (should a breakthrough occur in the future)
- Provision of a secondary channel near the entrance, reminiscent of historical flow paths
    - *Note that the restoration of intertidal entrance extents by 'levelling' elevated land as discussed earlier, would promote the natural formation and migration of secondary channels, so this could simply be an interim strategy*

The alignment of the sandbar to the FHA boundary is simply an arbitrary convenience to support the thought exercise. However, spatially it arguably 'fits':

- The distance from the shoreline to the FHA varies between ~200m (north) to ~500m
- The channel width shown is 40m and the sandbank with is 60m

Even in the narrower sections, this envelope should accommodate reasonable batter slopes, if the channel invert is of moderate depth. From the perspective of matters addressed above, the general suggestion would be that any dredging that is undertaken to address long-term accretion in the Passage, seek to maximise intertidal areas. So, shallow dredging, around MSL, across a broad area, rather than focusing on channels.

Earlier studies discussed in Part 1 recommended that dredged navigation channels have maximum width of 30m and depth of 1.5m, versus modelling that used a depth of 2m. Based on an agile and iterative approach, consideration should be given to initially adopting an increased width and decreased depth (e.g. 60m x 1m). The rationale is to allow for natural response – to see where the channel invert "wants to be", including potentially allowing it to meander over time, within acceptable boundaries.

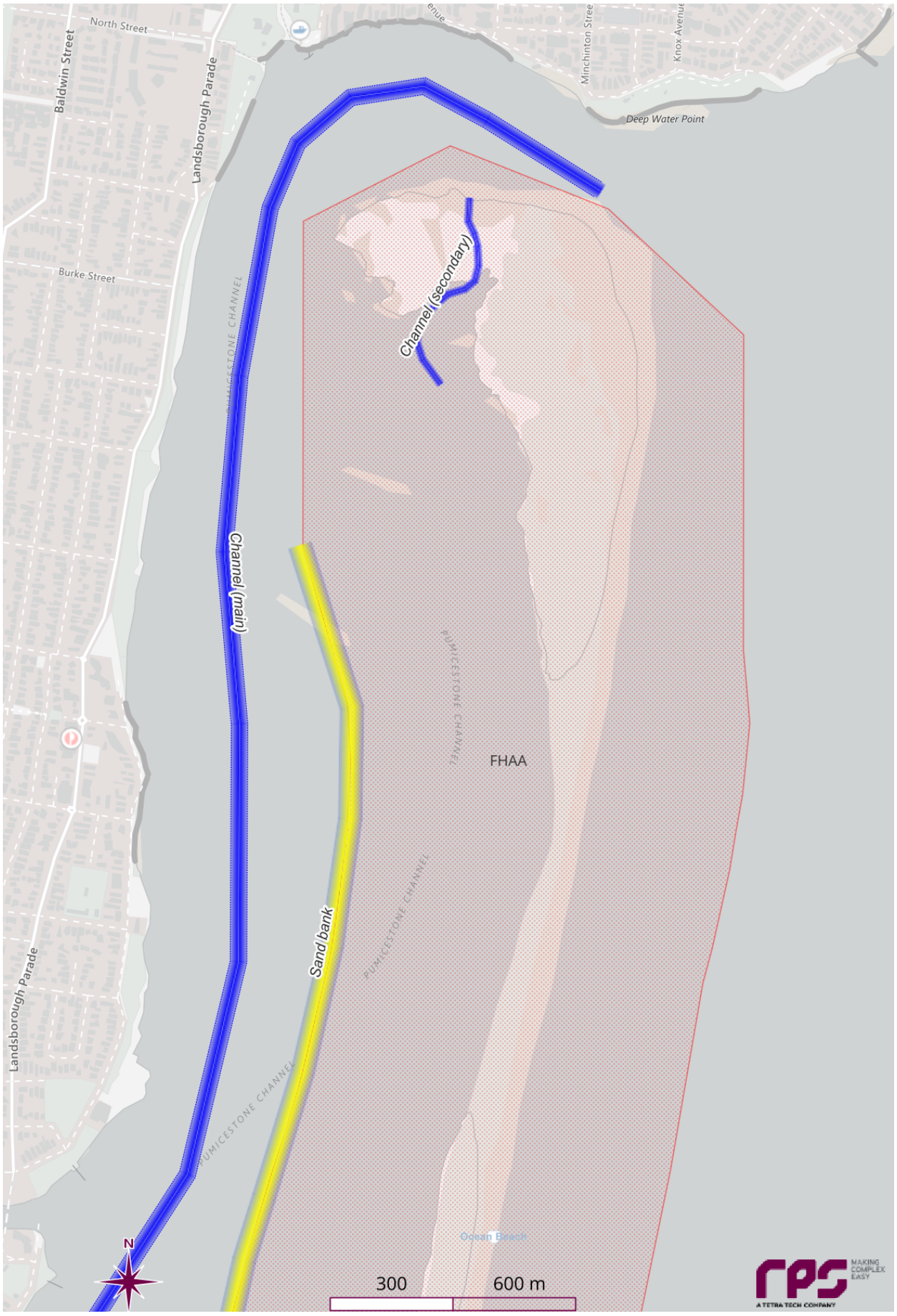


Figure 74: Conceptual realignment of main channel, including provision for sand bank along FHA

The sandbar and the foreshore provide boundaries. Nourishment as necessary to create extended batter slopes can be included to introduce a suggested new morphology (channel between the foreshore and the sandbar, rather than adjacent to either). Shallow batter slopes to maximise a range of intertidal exposure times also has the potential to promote seagrass colonisation, with turbidity often a limiting factor.

3.7 Sunshine Coast Planning Scheme

Advice is that the SCC Planning Scheme does apply to Bribie Island. Tidal works can be prescribed, with local government as the lead, rather than the State. Conceptually, there are no fundamental impediments presented by the Planning Scheme; however amendments may be suggested by more detailed planning. Discussion is included here simply to note the importance of SCC to implementation, including recognising local planning instruments.

3.8 Environmental Protection Act

The *Environmental Protection Act 1994* does not provide any obvious impediments to a revised policy approach. Dredging is an Environmentally Relevant Activity (**ERA** 16) requiring an Environmental Authority (**EA**). It is a concurrence ERA, which means that application (or referral) and assessment is coordinated through the State Assessment and Referral Agency (**SARA**) under the *Planning Act* (note, this has not always been the case).

An EA, similar to a Marine Park Permit, is focused on the operational aspects of the ERA. Dredging in the Passage should predominantly involve the disturbance of 'clean sand' with minimal fines content, so water quality issues should be relatively manageable, and the material should be acceptable for nourishment.

3.9 Aboriginal and Cultural Heritage

"The Kabi Kabi Traditional Owners have demonstrated a continuous connection to their land, culture and history on the Sunshine Coast, following a Federal Court of Australia native title consent determination on 17 June 2024." [DNRMMRRD]. Part A of the determination provides for "non-exclusive access". Whilst the interests of the Kabi Kabi people and other Traditional Owners and custodians have been long recognised and integrated in various forms in planning, etc., this determination provides and additional recognition of their connection to this country, which includes the project area.

As the determination is recent, despite extensive negotiations that took place prior to the decision, it can be expected that there will be a learning curve for all involved going forward. This will need to be integrated in any forward planning that arises. Regardless, the Kabi Kabi people have the potential to contribute knowledge and lore that will potentially benefit outcomes, including for example insights from ethno-botanists to assist with revegetation plans. The Kabi Kabi people should be recognised as a key stakeholder going forward.

4 ADMINISTRATIVE ARRANGEMENTS

4.1 Introduction

This section is forward looking. Discussion in Part 1 and within this report documents historical arrangements, as well as to an extent current arrangements. The intent of this section, as with s.3, is to work from an assumption that a policy change is intended, and that this will involve progressing plans that reflect, to some extent, the recommendations we provide throughout the various reports arising from the Review. This includes the suggestion in Part 3 to manage this area as an enhanced coastal dune barrier island. It also includes a presumed intent to manage this area as a community asset that has recognised values. Affording appropriate protection to those values and hopefully restoring and/or enhancing those values through proactive management is desirable.

If so, how could alternative management arrangements contribute? This discussion is offered at a relatively high, conceptual level, with the recognition that significantly more consideration could, and perhaps should, be given to this topic. As independent reviewers, we recognise that any changes will necessarily involve significant discussions internal to the State government, and most likely inter-governmental, as well as potentially consultation. Accordingly, the discussion is limited to consideration of the "waterways authority model" and an alternative "partnered" approach.

4.2 Waterways Authority model

The Gold Coast Waterways Authority (**GCWA**) provides a model that can be explored as a possible arrangement for managing an enhanced northern Pumicestone Passage / northern Bribie Island. A number of the purposes of the *Gold Coast Waterways Authority Act 2012* are potentially relevant:

- deliver the best possible management of the waterways
- plan and facilitate sustainable long-term development
- improve and maintain navigational access
- develop and improve public marine facilities
- promote and manage sustainable use of the waterways for recreation, tourism and marine industries

A land management element is explicitly included in terms of a role in The Spit Masterplan (this was added following progression of the plan by government – elements of the plan do not reside with GCWA). GCWA is also trustee for several Crown Reserves, including the northern tip of The Spit (Doug Jennings Park), Wave Break Island, and the southern tip of South Stradbroke Island.

These trusteeships arose from the creation of the Seaway by the first GCWA, with the Doug Jennings Park reserve including "Port and Harbour Purposes", and the purpose of the Wave Break Island reserve being "Coastal Protection" (the Island was 'built' by elevating and vegetating sand bars that were present – a flood delta – in order to protect the western foreshore from waves that would now be able to progress through the stabilised entrance). The tip of South Stradbroke Island was the Nerang River entrance at the time of construction and dredging and bypassing was used to close that entrance and extend the island to the northern training wall of the Seaway. This reserve is jointly held by GCWA and Gold Coast City Council for the purpose of "Scientific Research and Management".

On that basis, a "SCWA" could conceivably be created, with some part of northern Bribie Island transferred from a National Park estate to a reserve for coastal protection, or similar purposes, and the new entity as trustee. However, that does not fully address additional considerations with the GCWA Act specifying that it does not affect operation of the *Fisheries Act 1994* or the *Marine Parks Act 2012*, as well as other Acts. The GCWA publication 'Who's Who in the Blue' suggests additional conflict with the concept of integrated management, illustrating the myriad of overlapping jurisdictions affecting the waterways, refer to Figure 75. It is worth noting that only the northern portion of the Gold Coast waterways lies within the Moreton Bay Marine Park, whereas the entirety of the waterways in the project area is included in the park.

The original 1980 GCWA originated under DHM legislation, essentialy being something between a small boat harbour and a port (prior to GCWA, there was a small boat harbour, with a limited footprint). Whilst current arrangements differ, GCWA still resides within the transport portfolio and reflects, to an extent, a focus on navigational aspects – waterways transport infrastructure. Similar provisions formed the basis of the *Transport Infrastructure (Sunshine Coast Waterways) Management Plan 2000*, repealed 14/12/2012.

Our beautiful waterways are a valued community asset. The Gold Coast Waterways Authority sustainably manages and maintains access to our waterways so they can be enjoyed now, and into the future. However, we don't do this on our own – we work in partnership with other agencies and organisations to achieve this. So we've developed this handy guide to explain each agency's area of responsibility and to help you identify who you may need to talk to about different waterways issues.

LEGEND
- ✔ Lead agency that should be contacted in the first instance
- ✔ Support agency that may assist the lead agency (if required)
- ✖ Agency with no role or responsibility

Enquiry or Issue	Agency													
	GCWA	QPS	QBFP	MSQ	AMSA	City of Gold Coast	DES	Seqwater	WHSQ	VMR & Coast Guard	DAF	HLW	AA	CASA
SPEED														
Speeding vessels	✖	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Setting marine speed limits	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Exemptions from marine speed limits	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Installing & maintaining speed signs	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Go-slow areas in Marine Parks	✖	✔	✔	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖
ENFORCEMENT														
Vessel wash & freestyling offences	✖	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Other boating safety offences	✖	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Alcohol and drug offences	✖	✔	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
POLLUTION														
Vessel-sourced oil pollution	✔	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖
Vessel-sourced sewage pollution	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖
Vessel-sourced garbage pollution	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖
Land-sourced waterways rubbish	✖	✖	✖	✖	✖	✔	✔	✖	✖	✖	✖	✔	✖	✖
Land-sourced pollution	✖	✖	✖	✖	✖	✔	✔	✖	✖	✖	✖	✔	✖	✖
ON-WATER REGULATION														
Buoy moorings	✔	✖	✔	✔	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖
Anchoring	✔	✔	✔	✔	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖
Recreational vessels	✖	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Commercial vessels	✖	✔	✔	✔	✔	✖	✔	✖	✖	✖	✖	✖	✖	✖
Noise complaints	✖	✖	✖	✖	✖	✔	✔	✖	✖	✖	✖	✖	✖	✖
ENVIRONMENT														
Environment protection & management	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖	✔	✔	✖	✖
Marine flora and fauna protection	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖	✔	✔	✖	✖
Environment education	✖	✖	✔	✖	✖	✔	✔	✖	✖	✖	✔	✔	✖	✖
Fish Habitat Areas	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖
Aquaculture	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖
Noxious fish management	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖
DREDGING														
Dredging navigation channels	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Dredging canal systems	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
Dredging approvals	✖	✖	✖	✖	✖	✔	✔	✖	✖	✖	✖	✖	✖	✖
Dredging in Tallebudgera & Currumbin Creeks	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖

gcwa.qld.gov.au Version 2.1 October 2022

Figure 75: 'Who's Who in the Blue' – continues below (GCWA)

LEGEND
- ✔ Lead agency that should be contacted in the first instance
- ✔ Support agency that may assist the lead agency (if required)
- ✖ Agency with no role or responsibility

Enquiry or Issue	Agency													
	GCWA	QPS	QBFP	MSQ	AMSA	City of Gold Coast	DES	Seqwater	WHSQ	VMR & Coast Guard	DAF	HLW	AA	CASA
INCIDENT REPORTING														
Marine incidents & accidents	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖
On-water criminal activities	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Unseaworthy vessels	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖
Abandoned vessels	✔	✖	✖	✔	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖
Diving accidents	✖	✔	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖
Unlicensed vessel masters	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖
Vessels in bathing reserves	✖	✔	✔	✔	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
WATERWAYS MANAGEMENT														
Aids to Navigation	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Stormwater management	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✔	✖	✖
Water quality monitoring	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✔	✖	✖
Surf Management Plan	✔	✖	✖	✔	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
Water supply management	✖	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖
Public boat ramps, pontoons, jetties, car parks	✔	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
SAFETY & SECURITY														
Boating safety education	✔	✔	✔	✔	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖
Marine search & rescue	✖	✔	✖	✖	✔	✖	✖	✖	✖	✔	✖	✖	✖	✖
Marine radio watch	✖	✖	✖	✔	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖
Water supply security	✖	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖
Biosecurity	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✔	✖	✖	✖
Notices to Mariners & marine pilotage	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Lifeguard services & beach management	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
RECREATION & EVENTS														
Commercial & recreational fishing	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖
Water skiing prohibitions	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Aquatic event authorities/permits	✔	✖	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖
Event permits Doug Jennings Park	✔	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Boating activities on dams	✖	✔	✔	✔	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖
Buoy mooring areas in Marine Parks	✔	✖	✖	✖	✖	✖	✔	✖	✖	✖	✔	✔	✖	✖
DEVELOPMENT														
Public boat ramps, pontoons & jetties	✔	✖	✖	✖	✖	✔	✖	✖	✖	✖	✖	✖	✖	✖
Tidal works assessment	✔	✖	✖	✔	✖	✔	✔	✖	✖	✖	✔	✖	✖	✖
AVIATION														
Helicopter noise	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✔	✖
Helicopter safety	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✔

Gold Coast Waterways Authority (GCWA)
Phone: 07 5539 7350
Website: www.gcwa.qld.gov.au

Queensland Police Service
Phone: Emergency 000 or Policelink 13 14 44
Website: https://www.police.qld.gov.au/

Queensland Boating & Fisheries Patrol (QBFP)
Phone: 13 25 23 or 07 5635 6900
Website: https://www.daf.qld.gov.au/

Department of Agriculture and Fisheries (DAF)
Phone: 13 25 23
Website: https://www.daf.qld.gov.au/

Department of Environment and Science (DES) – Moreton Bay Marine Park
Phone: 13 74 68
Website: https://www.des.qld.gov.au/

Maritime Safety Queensland (MSQ)
Phone: 07 5585 1810
Website: https://www.msq.qld.gov.au/

Australian Maritime Safety Authority (AMSA)
Phone: 1800 627 484
Website: https://www.amsa.gov.au/

Australian Volunteer Coast Guard Association Southport
Phone: 07 5531 1421
Website: https://coastguard.com.au/

Volunteer Marine Rescue Southport
Phone: 07 5591 1300
Website: http://vmrsouthport.com.au/

Airservices Australia For aircraft noise complaints
Phone: 1800 802 584
Website:www.airservicesaustralia.com/community/environment/aircraft-noise/about-making-a-complaint/

City of Gold Coast
Phone: 1300 465 326 or 07 5582 8211
Website: www.goldcoast.qld.gov.au

Healthy Land and Water (HLW)
Phone: 07 3177 9100
Website: https://hlw.org.au

Workplace Health and Safety Queensland (WHSQ)
Phone: 1300 362 128
Website: https://www.worksafe.qld.gov.au/

Seqwater
Phone: 1300 737 928 Website: http://www.seqwater.com.au/

Civil Aviation Safety Authority (CASA)
For aircraft safety concerns
Phone: 131 757
Website: https://www.casa.gov.au/

4.3 Partnership model

The intent here is to contrast a formally constituted Waterways Authority with a collaborative or partnered approach that creates arrangements to coordinate existing powers. This approach could potentially be implemented more rapidly and at a lower cost, assuming that it can be done without protracted negotiations; that mutually beneficial outcomes can be identified and agreed upon.

4.3.1 Moreton Bay and Catchment proceedings

The 1998 Moreton Bay and Catchment Proceedings [104] were discussed in Part 1. Chapter 9 is entitled "Management Options" and includes two essays. The first discusses values and management responses to pressures. The second, by Daryl Low Choy provides a model for development of a new management system. He reviews historical planning, including some overlap with investigations discussed in Part 1. He proposes elements that should be adopted for future planning (emphasis as provided in original text):

1. It should embrace a regional setting which allows the inclusion of all elements and issues of **regional significance**;
2. The scope of the study should be **comprehensive** and multidisciplinary and it should embrace the biophysical and socio-cultural elements of the marine and the terrestrial environments of the Bay;
3. Planning considerations need to be based on **scientific knowledge**;
4. The underlying planning philosophy should embrace the **environmental planning principles** of diversity, sustainable development, environmental carrying capacity, equity and the precautionary principle;
5. The planning study area should approximate a **natural area**, and be delineated on the basis of an ecosystems or biophysical approach, without regard to the existing legislative and administrative arrangements;
6. It should be a **democratic and participatory** process that facilitates the maximum involvement of all stakeholders;
7. Future planning should promote a cooperative approach that involves the community at all levels of government in **partnership** arrangements;
8. It must be capable of resolving conflicts, but more importantly **managing potential conflicts** before they arise;
9. 9. It should be an open and **transparent** planning process that achieves and retains the confidence of all participants;
10. 10. It should be capable of producing a viable range of **alternative options**.

He provides additional discussion regarding these elements, including the need to consider overlapping jurisdictions, includes a preliminary analysis of stakeholders, and advises a two-pronged approach:

"A Management Plan, not another Strategy, is required, although a comprehensive Strategy embracing both marine and terrestrial components of the Bay, will be a necessary requirement in the first instance. Hence the two phase process is recommended, which will allow a composite strategy to be assembled with a minimum of delay and repetition."

4.3.2 Gold Coast Waterways Steering Committee

This section provides a "case study" of an initiative that preceded the 're-formation' of the current GCWA; an alternative approach to integrating overlapping state and local government jurisdictions. It also includes discussion of a strategic approvals framework, that began at the same time, but was realised subsequent to the formation of GCWA, with the approvals jointly held by the State (GCWA) and Gold Coast City Council.

This initiative included a Heads of Agreement (**HoA**), signed by the Minister (Transport) and the Mayor, to enter into a Memorandum of Understanding (**MoU**). The MoU was successfully negotiated and signed by the Director Generals for three State agencies, the CEO for Council, and the head of the peak industry body Marine Queensland. The top-down approach was intended to provide political support as a catalyst, but transfer implementation to the administrative level.

The HoA is a relatively short (4 pages) document that established principles, including formation of a joint steering committee, and cost sharing. It established time frames, with ~3-months to complete the MoU and an additional 3-months to form the steering committee. The MoU is longer, but still relatively short (26 pages overall, with the main body being 15 pages). A funding agreement was also executed. The MoU provides detailed Terms of Reference for three Working Groups to be established under the Steering Committee:

- Dredging
- Destinations, Access and Management
- Marine Industry Planning and Major Development Projects

The Gold Coast Waterways Steering Committee and the three Working Groups operated for ~3-years, up until the formation of the GCWA. During that time ~$12.5M of jointly funded works were delivered, as well as a range of plans and other outputs through the Working Groups. This model did not include a community component, other than Marine Queensland as representative of an industry sector, but the general framework could be easily adapted. The basic premise is a representative steering committee, which operates by coordinating existing powers and contributing joint funding, and is advised by working groups to provide opportunities for coordination at an 'officer' level.

The strategic approval framework that was subsequently negotiated includes dredging for navigational access, and management of foreshores, including nourishment. Similar to the MoU, the intent was to integrate jurisdictional responsibilities to promote integrated and holistic management. Elements include:

- A Sand Management Plan (**SMP**), which provided a strategic overview of historical management (notably dredging for navigational access) and suggested future needs to meet user demand
- An Environmental Management Framework (**EMF**), which identified required approvals and provided a matrix to define a common set of criteria that satisfied all of the approvals (seven in this case)
- A traffic-light system that identified channels, or segments as either:
    - Green –areas with good management knowledge; projects can be progressed subject to conditions;
    - Yellow – areas with a history of management, but data gaps, for example dredge spoil may be unsuitable for nourishment and previous projects used ad-hoc approaches; projects can be progressed subject to compliance assessment of a project-specific plan;
    - Red – no history or demonstrated need for works; so technically no approval, however, the 20-yr approval allowed for revising these designations, so a Yellow area could become Green, and a Red could become Yellow or even Green.
- Establishment of an Agency Steering Committee (**ASC**) to ensure ongoing proactive collaboration; and a
- Scientific Advisory Committee (**SAC**) – to progress knowledge and thereby mitigate regulatory risk and deliver other potential efficiencies

This initiative is discussed here as a fundamental driver was to improve relationships – to promote a partnered approach. The ASC is an obvious example of this intent, but the SAC was as well, with representation from local universities. It also promoted efficiencies, within exiting regulatory restrictions. The SMP included identification of knowledge gaps, and the traffic-light approach allowed for an approval to be issued with less detailed support than would normally be required. The EMF allowed for a single document to be prepared that addressed all required approvals, rather that separate submissions.

Aside from efficiencies, this approach also meant that all agencies were receiving the same set of information – a point of truth – rather than only the segments required by their respective legislation. Meeting collectively through the ASC to openly discuss projects in advance, rather than at the time of lodgement, or pre-lodgement requests, contributed efficiencies and promoted partnering.

As discussed above, some legislative changes may be required, however, alternative approaches may also be available to address some impediments. A potentially significant benefit of a 'softer' partnered approach is that it is likely to be more accommodating to change, better able to integrate with the recommended agile approach. As such, it provides a potential transitional arrangement – a pilot approach – which if successful could preclude the need to adopt more formal arrangements, such as creation of a 'SCWA', or at least provide time and likely valuable learnings to inform and improve any subsequent arrangements.

Copies of the HoA and MoU are provided for reference in Appendix E.

5 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Part 1 – Desktop Review – suggested that the long-term erosion and breakthroughs had the characteristics of a 'wicked problem', including lots of reports, but relatively little historical action, absent a consistent policy to not intervene with natural coastal processes.

Part 2 – Recommended Immediate Options – assessed the effects of the breakthroughs, high-level options – including "do nothing", and recommended actions to mitigate the most immediate concerns, notably, those arising from the second and more recent breakthrough (as well as the washover).

Part 3 – Long Term Recommendations – considered the option of establishing a new entrance within the location of the first breakthrough and presented a conceptual plan for reinstating the Island and the former Caloundra Bar, using 'soft' engineering approaches to enhance access and coastal protection.

Part 4 – Final Report – discusses sand movement – coastal, estuarine, and the human contributions; examines how key policy frameworks may have contributed to historical events and may be incompatible with a proposed shift such as is presented in Part 3; and presents a recommended management approach.

Community consultation, largely targeted at Part 3 recommendations, indicates majority support the path forward that we have suggested (~65%). Our objective during the short period of time available for this Review was to assemble and present available evidence, as well as our recommendations based on that body of knowledge, including consideration of both subjective and objective aspects of that history.

The reports were released during the Review process, to invite the community to follow the journey. Community concerns influenced the report sequencing – start with a 'point of truth' (Part 1), followed by those things that could/should be done soon (Part 2). The State Government allocated funding for Part 2 recommendations, a Works Regulation was passed, contractor(s) appointed and works are underway.

Following a more traditional approach, Part 4 would have preceded and informed Part 3. However, knowing that we were trying to chart a difficult course – towards consensus – we thought it made sense to present a vision of how things could be first, and then finish up with this report, which we knew would include more detail, including uncertainties, and provide both supporting rationale and obstacles, impediments.

The approach we put forward involves trade-offs. We prioritised pragmatism; the shift from decades of policies of non-intervention based on legislative protections, to proactive management, is challenging. If that can be achieved, further transformation – iterative evolution – is possible.

Reinstating the Island and the former bar is the lowest-risk intervention. It offers the potential to return tidal flows and coastal processes to an approximation of historical conditions, reset Golden Beach's climate change adaptation settings to pre-breakthrough conditions, and restore navigational access. We suggest that through proactive management, these aspects and other recognised attributes of the area such as environmental values, can be enhanced – made 'better' than they were, over time, through iterative, agile, adaptive, collaborative, consultative and holistic management of the integrated system.

Whilst enhancement – including a safer/more navigable bar – is possible (not guaranteed) with more proactive management, our proposal does not eliminate the navigational hazards and constraints of a bar crossing. Also, it will not (is not intended to) eliminate the need for ongoing climate change adaptation measures for the low-lying communities of Golden Beach and the surrounding Passage foreshore areas. It offers the potential to delay the urgency for those actions, but adaptation will still be necessary.

5.2 Conclusions

Queensland is a recognised world leader in coastal management, as evidenced by commissioning of the 1965 Delft Report [233] and the progressive implementation of the recommendations that report provided. The Gold Coast Sand Bypass system is an example of that world class innovation. The proactive coastal management approach of the Gold Coast also arose from those origins, as well as the ongoing commitment and leadership of the Gold Coast City Council. The origins of the BPA also stem from those recommendations and current coastal management policy is derived from the work the BPA undertook.

That Delft report recommended a program of statewide investigations and the evidence we've presented suggests those were commenced, and that attention would turn to Caloundra following the priority needs of the Gold Coast. The Gold Coast, unlike Caloundra and discussion in Part 3 about parts of the NSW coast, justifies and can support significant coastal management expenditure based on the substantial waterfront development, tourism industry that includes beaches as a prominent feature, and thriving maritime industry and recreational boating.

There have been proposals to provide a trained entrance at Caloundra, and they have included development opportunities. The community proposal we presented in Part 1, from ~1965, is one such example. A report we located after Part 1 provides further options and answers some questions arising from our earlier investigations. The 1987 DHM report *Options for the Stabilisation of the Caloundra Bar* [234] advises:

- The bar itself is a major obstacle to safe navigation and the inherent technical and financial difficulties in dealing with the bar problem was a key consideration in the choice of Mooloolaba as the Department's Pilot Station in the late 1960's.
- The position of the entrance has fluctuated over a wide area over the last 45 years or so. In 1940, the entrance was directly opposite the southern end of Kings Beach. Subsequently, the entrance moved southwards accompanied by the growth of a spit formation extending southwards from Kings Beach. As the entrance then moved northwards, the spit retreated as evidenced by a comparison of the 1961 and 1974 air photos.
- The size of this spit has varied markedly throughout the air photo history of the area from 1940 to the present. Whenever the spit formation reaches an appreciable size, it seems to attract various development proposals because of its key location. However, history has shown that the spit should be regarded as an unstable and temporary sand deposition area in the local littoral system.
- Coastal Management Control District No. 1 extending from the southern boundary of the Landsborough Shire up to Currimundi was declared on November 14, 1968. The District includes the Caloundra spit area and the seaward frontage of Bribie Island to a width of 400 metres measured inland from mean high water springs.
- A Scheme of Works for the District was considered by the Beach Protection Authority in June 1973 and the Scheme forwarded to the Landsborough Shire Council for comment. The Scheme included the possible construction of a groyne on the spit area adjacent to Caloundra bar as shown on Plan SC1141 attached as Appendix II. This groyne would limit the northerly migration of the entrance and stabilize a useable beach to its north.
- The Landsborough Shire Council advised in 1974 that, due to lack of funds, it was unable to undertake the beach protection works recommended in the proposed Scheme. The Scheme has not been advertised and has not been approved by Governor in Council.
- At the request of the Council, the erosion at Caloundra spit was considered by Authority engineers in late 1980. It was concluded that the original scheme of works was still the most appropriate means of combating erosion along the spit and Kings Beach and would cost about $2 million on 1980 prices.
- The 1987 equivalent cost is probably about $4 million (average 10% annual increase).
- Such a scheme would effectively stabilize the Caloundra spit against further northward channel migration but is not designed to render any marked improvement to the navigability of the Caloundra Bar.

This excerpt confirms and clarifies several matters we have discussed. One, Mooloolaba was selected over Caloundra due to the recognised challenges (technical and financial) presented by the bar. Second, the BPA Scheme of Works, presented in detail in this report, was never approved. The alternate groyne design/location presented in that scheme was intended to stabilise/train the northern half of the entrance and provide an extended Kings Beach foreshore, with further confirmation provided in 1980 that this remained the 'best option' to combat erosion but would not markedly improve navigability of the bar.

The DHM report also advises that:

- It is also noteworthy that the draft zoning plan for the Pumicestone Passage Marine Park specifically prevented stabilization of the Caloundra Bar. However, this provision was subsequently deleted in major modifications to the draft zoning plan.

The DHM report presents four options for “stabilising” the bar:

1. **Existing Entrance** - A single training wall at the northern side of the existing entrance and a small area for development behind the beach and erosion prone area between the training wall and Kings Beach.
2. **Realignment of Existing Entrance** - A single training wall in the middle of the existing entrance and some dredging to re-establish the entrance using the existing southern channels. Provides a larger area of development behind the beach and erosion prone area between the training wall and Kings Beach.
3. **New Entrance** - A new entrance located at the eroding area at the northern end of Bribie Island. A 300m long training wall on the northern side of the entrance to prevent the new entrance moving north. A further training wall on the southern side may be required to prevent the entrance moving south. The existing entrance would be closed and there would be a large area in the Passage between Caloundra and the new entrance that could be utilised for development.
4. **Close Existing Entrance** - Provides for closure of the existing entrance such that the only entrance to the Pumicestone Passage would be at the southern end of Bribie Island.

Further advice provided is that all options include:

- An increased length of stable beach south of Kings Beach.
- An area of reclaimed land in Pumicestone Passage suitable for development.
- Stabilization of the location of the Caloundra Bar
- A surfing beach wider than Kings Beach.
- An erosion prone area which extends 140 m landward from the seaward vegetation line. This width is indicative only and is based on that used for similar beaches in the area, with the exact shoreline shape and final erosion prone area width subject to detailed assessment.
- Channel dredging necessary to re-establish existing navigational access within Pumicestone Passage.

All of the options specifically exclude both a trained entrance for all-weather navigational access and increased depth of water for navigation across the bar. The features, costs, advantages and disadvantages of each option are presented, with Option 1 being the lowest cost ($4.7M) and Option 3 the most expensive ($10.9M – based on only one training wall, with, as noted above, a second southern one possibly required).

This report is dated 17 June 1987, 1-yr after the approval of the Pumicestone Passage Marine Park zoning plan, well after the Fisheries Habitat area declaration, and about a decade before the declaration of the current National Park on the Island (however, as discussed in s.3.2.1, early declarations occurred in 1988).

Whilst it may seem odd to present this detail as part of the conclusion for this Review, we do so to reinforce the fact that there have been numerous attempts to resolve navigational access and promote development opportunities of various sorts. The way forward that we have suggested does not resolve the matter of the bar crossing (but may offer the opportunity to manage it better). It also does not include development.

If we had put forward any of the options from the 1987 report, it is doubtful this would have resulted in majority support (particularly Option 4). Option 1 has merit, particularly if it is combined with the BPA scheme proposal for an alternative groyne. We don’t rule that approach out; it should be considered in forward planning, including because it at least partially addresses community comments from the Round 2 consultation that pointed out the benefits of access to Northern Bribie Island afforded by the current closure of the former bar, as well as due to the DHM advice above about extending surfing benefits.

Nor are we opposed to forward planning including development aspects. The alternative groyne provides an extended Kings Beach foreshore, moderate development. The current access to northern Bribie Island could be provided by adventurous options such as a cableway from Caloundra Headland, perhaps integrated with reinstatement of the navigational light and a LiDAR sensor to provide near real-time bar bathymetry. As discussed earlier, access includes concerns such as human interference with shorebirds, as well as consideration of the need for surf lifesaving. Those issues can be managed, including through options such as stabilised pedestrian access across the dunes for boats using the Passage, an anchorage/landing area, and/or even low-impact development such as interpretive educational displays, a coastal science field research facility, and/or a Kabi Kabi cultural centre.

We have put forward a solution that includes reasonable consideration of available information and fully documented that information so that it can continue to inform forward planning. We have attempted to bring the community along on the journey to catalyse a consensus for change – an agreement that the journey towards improvement should commence. The direction we suggest is enhanced, proactive, coastal management.

Our forward direction is based on going backwards. The rationale is both simple and complex. Simplistically:

- This area is subject to various protections
- Which were preceded by extensive and consultative investigations
- That provide a lot of data regarding conditions and values at that time

Complexities include uncertainty regarding whether those protections have improved, or even maintained values, or have optimally managed issues. This arises from both a lack of reporting/data (at least that we could identify), as well as indications of global trends of declining values, arising most likely from multiple factors, including habitat degradation generally, but also the advancing and uncertain evolution of climate change. Gaps in information about sand transport dynamics in this area are a further complexity. It is clear that the erosion was not solely due to natural processes – human actions have contributed.

The proactive management approach we propose includes doing things that have been prohibited (and indeed, are currently prohibited). Climate adaptation is a well embedded concept, but less so in the context of protected areas, where non-intervention, at least in terms of natural processes, is an embedded principle. Responses, and proactive management more generally, do occur. Controlled burns are now an accepted management practice in protected areas, but only after decades of fire suppression and a realisation that this promoted larger and more impactful wildfires (this is still a transitional and not universal concept). This transition is also arguably 'going backwards', including practitioner engagement with indigenous lore.

Included in our suggested approach is 'levelling' land – the east/west trending extension of northern Bribie Island, including parts of the National Park. Those areas were intertidal in 1967, part of the entrance dynamics, and recognised Fish Habitat Area. Their transformation most likely includes natural processes (e.g. possibly tidal sand deposition and vegetative colonisation) but also includes human actions and choices (e.g. possibly planting of vegetation by community members and allowing the northern spit of the National Park to become supra-tidal, rather than managing it to ensure it remained as part of a dynamic entrance).

These are complex policy choices. Is the transformation of Fish Habitat Area to National Park an improvement or otherwise? Perhaps, if it is solely the result of natural processes, the value judgement shouldn't apply – the transformation is simply 'as it should be'. However, that is not the case; people contributed to those changes. As presented in Part 1, we suggest that environmental values are subjective. That means that we have to choose. Doing nothing is a choice; arguably, a choice to abdicate responsibility.

That need not be the case. A thoughtful and concerned evaluation could result in a reasoned decision that the best course of action is to do nothing, and that may be the context for historical decisions. However, in the present circumstance, we have made a case that as a society we contributed to the outcomes, that the post-breakthrough conditions include possible benefits but also substantial community concerns arising from those changes, and that it is possible to do something.

Even so, should anything be done? From our perspective, one of the strongest arguments for doing something is that the breakthroughs provide an opportunity to learn about – to experiment with – proactive management of a natural coastal area for climate change adaptation. To continue Queensland's tradition of innovative coastal management.

Adaptation measures for developed foreshores are progressing in Queensland and worldwide, as well as for low-lying remote islands, with Australia contributing to some of those international efforts. For protected areas, including international protections such as Ramsar sites, proactive interventions are likely to be uncommon. The project area is a small part of the overall Moreton Bay Ramsar site that has been impacted by breakthroughs. The breakthrough events provide a relatively unique opportunity, a reason to intervene, to proactively manage part of a protected area. Initiatives piloted here could identify opportunities to improve management in other parts of the Moreton Bay Ramsar site, as well as proactive adaptations that could be applied elsewhere as the uncertainty of climate change continues to unfold, including the potential for knowledge transfer beyond Australia.

This Review is focused on a particular area and the community that cares deeply about that area. However, the issues, including sand transport dynamics and the connectedness of this area to larger protected areas, such as the Moreton Bay Marine Park and Ramsar site, mean that decisions about what should/could be done in this area necessarily involve an extended framework ('boundaries').

The essential issue, our objective, is to catalyse community consensus to explore change, including a suggested direction. If we can/have accomplished that, then the State Government may choose to support our recommendations. Primary amongst those recommendations is to establish appropriate management arrangements to progress the work that we have begun.

We fully expect that our recommended solutions will transform if/as they are progressed by others. We've started the process of engaging the community but believe that forward management requires further and ongoing development of that partnership, as well as refinement of risks, options analysis, investigations and detailed design. That collaboration and other work undertaken will undoubtedly lead to change. The overall approach we've advocated is agile and iterative, so inherently geared for change, and thereby appropriate for responding, adapting, to climate change, as well as evolving community consensus.

5.3 Recommendations

1. Retain and continuously improve understanding of this complex system

We are not satisfied that the historical sand extraction approved under the Moreton Bay Sand Extraction Strategy adequately assessed the potential effects on littoral processes, with evidence indicating there was no consideration of the project vicinity. Future decisions regarding extraction, including dredging for the Channel Enhancement Project, should as fully as possible consider these dynamics, including in the case of the North West Channel, provide data and analysis of morphological changes subsequent to previous approved capital dredging, including accounting for maintenance dredging, and how the observed changes relate to changes predicted by studies that supported those approvals.

The State Government should also investigate whether there is a need to resume the proactive investigations regarding coastal matters that were part of the reason for creating the BPA pursuant to the Delft report recommendations.

Expanded discussion

Part 1 and this report provide a lot of relevant information, including 'lost' knowledge that we re-discovered. Many of those records are dated, others are still missing, and efforts to fully progress that early knowledge base are not apparent, including recommended further investigations to refine understanding of the complex sand transport dynamics in the project vicinity. Forward management of this area should be informed and should seek to refine and share that knowledge base.

The State Government should also investigate whether there is a need to resume the proactive investigations regarding coastal matters, including 'citizen science' such as the BPA COPE program[6], that were part of the reason for creating the BPA pursuant to the 1965 Delft report recommendations. Times have changed, the State has progressed modelling for Sea Level Rise to enable local government planning, Commonwealth Government initiatives such as Digital Earth Australia, and citizen science through platforms like CoastSnap, arguably address this need. But there may be gaps and opportunities.

We are not satisfied that the historical sand extraction approved under the Moreton Bay Sand Extraction Strategy adequately assessed the potential effects on littoral processes, with evidence indicating there was no consideration of the project vicinity. The reports note that the approved extraction volume is a very small part of the total sand reserves present within the banks. However, the approved annual extraction rates are significantly more than the known annual supply from the south. The associated modelling excludes most of the northern banks, including the project area. Sand transport dynamics in the project vicinity are complex, with the historical investigations dated, the observations preliminary, and further investigations recommended.

These early and preliminary investigations have been relied on to presume that there is no connection between those offshore sand reserves and the project area. Is the Moreton Bay Delta simply a complete sand sink, with little or no northward export, including towards Fraser Island? The BPA scheme for the project area suggests a belief that Caloundra Headland intercepts sand transport and redirects it southwards towards Kings Beach, the entrance/Passage and then potentially southward along Bribie Island. Where does that sand come from?

Alterations, such as historical extraction of sand reserves, have the potential to affect sand transport processes; those effects may be subtle with transitions spanning decades. That makes them difficult to detect, particularly without active intentional monitoring and, even with data, complex to interpret, to disaggregate from natural 'disruptions' such as increasingly varied storms that alter historical trends.

Future decisions regarding extraction, including dredging for the Channel Enhancement Project, should as fully as possible consider these dynamics, including in the case of the North West Channel, provide data and analysis of morphological changes after previous approved capital dredging, including accounting for maintenance dredging, and how the observed changes relate to changes predicted by studies that supported those approvals. If the channel has progressively scoured, that information should be documented and discussed.

[6] Coastal Observation Programme Engineering (COPE) commenced in 1971 and provided field data on waves, currents and beach conditions from daily measurements collected by volunteer observers.

2. Proactively manage, not just passively protect, the Passage and the Island

This drastic shift is recommended as the recent breakthroughs have dramatically altered the physical environment and certainty regarding the extent to which those alterations are beneficial or otherwise won't be determined in the near term. As a pilot initiative, this project has the potential to contribute learnings well beyond the obvious boundaries. This area deserves a single, coordinated, consultative and comprehensive management plan; other areas may as well.

Expanded Discussion

Comprehensive consultative planning was progressed in the 1970s and 1980s, which led to the declaration of protected areas. Whilst those various protections included management planning, for example marine park zones, management of the physical environment has been passive, or prohibited.

Part 3 provides a vision of enhanced coastal management, as well as elements related to the Passage; Part 4 includes additional recommendations regarding the Passage. The approach we recommend requires changes to protected areas, including legislative changes.

This drastic shift is recommended as the recent breakthroughs have dramatically altered the physical environment and certainty regarding the extent to which those alterations are beneficial or otherwise won't be determined in the near term. But there is certainty that human activity contributed to these outcomes, providing a reasonable basis for embarking on a course towards improvement, and an opportunity to learn and transfer knowledge for the future.

This course, if commenced, may suggest changes on a larger scale. Responding to an uncertain future benefits from agility. Protected area provisions are predominantly difficult to change. Disaster funded road repairs have required the installation of hard engineered batter slope protections in national parks; a clash of interests/policy objectives. There may be larger themes and synergies. As a pilot initiative, this project has the potential to contribute learnings well beyond the obvious boundaries. This area deserves a single, coordinated, consultative and comprehensive management plan; other areas may as well.

3. Establish appropriate management arrangements

Current arrangements could be coordinated to support a shift towards proactive management. A partnered approach is recommended as it is consistent with an agile and iterative strategy that prioritises near-term action. Chapter 5 provides high-level detail regarding establishment of a Steering Committee and the initial business that body should consider progressing to move towards the future we suggest, including progressing a strategy, management plan, and works program, through community consultation, as well as investigation, design, and, if desired, options assessment.

Expanded Discussion

Current arrangements could be coordinated to support a shift towards proactive management. A partnered approach is recommended as it is consistent with an agile and iterative strategy that prioritises near-term action. The basic elements we put forward for consideration are (ideally in <6-months):

- Progress a simple Heads of Agreement to establish shared principles and commitment
- Progress a more detailed Memorandum of Understanding to establish a Steering Committee (**SC**)
- Suggested key/core SC membership includes a single representative each from:
  - The Queensland Government
  - Sunshine Coast Council
  - The Kabi Kabi People's Aboriginal Corporation
  - The Community
  - The Commonwealth Government
- Develop Terms of Reference for:
  - A Community Reference Group to support their SC representative
  - Other subcommittees and/or working groups that the SC may nominate from time to time
- Provide a secretariat to support the SC operation and progress SC business
- SC business, including subcommittees/working groups, should be transparent and outward facing
- Include a 'sunset clause' – a 10-yr review/renew/suspend term is suggested
- Task the SC with initially producing –
  - A Strategy / Strategic Plan
  - A Management Plan
  - A Works Program

These documents should be intended to secure Commonwealth support that implementation is 'Not a Controlled Action if conducted in a particular manner'. Early engagement should be undertaken towards this end.

We suggest that the Ramsar designation is not an impediment; rather, the framework of "wise use" underpins our recommendations and should be a basis for forward management.

Securing Commonwealth agreement provides support for a Queensland Government Act that exempts the Works Program from State approvals. Existing restrictions and prohibitions should be reviewed and revised, but that process should not be rushed, and the ability to undertake further works should not have to be deferred until those matters are resolved.

The SC should submit these documents to Government for approval (e.g. Minister, annually).

Overall, a pilot approach – incremental, iterative, and agile, is recommended, to support early action, reduce risk in the face of uncertainty, and provide data to inform revised plans.

Plans, learnings, etc. should be proactively communicated and opportunities to enhance community engagement – ideally in a dialogue – should be explored and promoted. Digital platforms, such as a dashboard, as well as interactive strategies such as web-map platforms to promote continuous feedback opportunities as well a community dialogue (e.g. 'thumbs up' voting), should be considered to provide a strong focus on engagement and responsiveness.

The Strategy should include a long-term vision (e.g. 50-100 years) but focus on the initial 10-yr time-frame, be short and sharp, broadly inclusive, and provide stakeholders with clarity around measurable objectives and how and when progress will be reported.

The Management Plan should include appropriate detail regarding the ‘place’, ‘people’, and ‘practices’ to monitor, manage and respond to issues and opportunities. As a ‘start-up’ and agile initiative, management should be principled, rather than prescriptive, to facilitate iterative improvement. The 1992 DEH Management Framework may be a useful information source [226].

4. A forward Works Program should consider Part 3 and Part 4 recommendations

The reports from this Review provide a conceptual framework for moving forward. The approach has reasonable community support, but continuous advice and opportunities for feedback is recommended, and planning should be sufficiently agile to allow for changes in response to views put forward.

Whilst planning is required, our approach and the community sentiment, calls for early action – this can (and should) be progressive, integrate learnings from monitoring the urgent works, including storm season response, and continuously repeat the cycle of Plan → Do → Review in a transparent and consultative manner. Overall, the priority should be to "do something"; start...

Notionally, based on historical entrance configurations, Part 4 supports and expands Part 3, adding –

- An overall north/south dimension of ~1,250 metres is suggested for the entrance, including stabilised sand spits to the north (Deepwater Point) and south (Bribie Island) each ~250m wide.
- Based on the 1967 survey (discussed in this report) an area of ~750m should be available for the entrance to naturally migrate.
- This is a suggested starting place, which can be refined based on further design investigations, observation of natural response, iterative management, and improved understanding, with tolerance and accommodation for natural variations such as weather.
- Dredging/levelling should initially be 'conservative', with 0m AHD, as a rough equivalent of Mean Sea Level, a nominal suggested target – allowing opportunity for tidal flows, etc., to influence the initial configuration.
- If a dredged channel is included, suggest a similar conservative approach – say -1m LAT maximum depth, or potentially shallower, but perhaps wider.
- In general, take a pilot approach, start conservative, and iteratively refine.

Expanded Discussion

The reports from this Review provide a conceptual framework for moving forward. The approach has reasonable community support, but continuous advice and opportunities for feedback is recommended, and planning should be sufficiently agile to allow for changes in response to views put forward.

Whilst planning is required, our approach and the community sentiment, calls for early action – this can (and should) be progressive, integrate learnings from monitoring the urgent works, including storm season response, and continuously repeat the cycle of Plan → Do → Review in a transparent and consultative manner.

Regarding potential timing, we provide the following suggestions, in large part to address community concerns about 'when?' The discussion below is framed around a potential 1-3-yr program of works and is a supplement to Part 3 (complements) based on material discussed in this report:

- Breakthrough #1 should be closed prior to re-establishing the former entrance.
- The sequence of dredging/closure/re-opening needs to be planned, and further advice to the community (dialogue), particularly regarding navigational access – bar crossing safety – as well as how the entrance will be trained and managed, is required.
- This report includes some further advice, complementing that in Part 3, which may address some of the comments provided in the recent consultation response; in summary:
- We recommend 'training' both sides of the entrance, with stabilised sand spits, one extending from Deepwater Point, and the other forming the tip of Bribie Island.
    - Stabilisation may include buried (not exposed) rock as a line of last defence (A-line, or C-line, or sea-line).
    - Dune vegetation and soft materials such as geotextile groynes are appropriate, but the goal should be to have the entrance framed by sand that can respond to natural processes (within bounds).
    - Notionally, based on historical entrance configurations –
        - An overall north/south dimension of ~1,250 metres is suggested

- To the north, Deepwater point effectively provides a trained/rock entrance, so additional hard defence may not be required. However, a sand spit is desirable to avoid a hard northerly entrance over exposed offshore rocks, provide recreational amenity, and afford some protection to Bulcock Beach. The Cadastral reserve is a reasonable minimum approximation, being ~250-300m deep. This could be extended southwards and include an alternative Kings Beach groyne such as suggested by the BPA.
- Based on the 1967 survey (discussed in this report) an area of ~750m should be available for the entrance to naturally migrate.
- To the south, Bribie Island should end in a sand spit, not a vegetated and elevated island, nominally of a similar width as the northern spit (i.e. 250 + 750 + 250 = 1,250m).
- This is a suggested starting place, which can be refined based on further design investigations, observation of natural response, iterative management, and improved understanding, with tolerance and accommodation for natural variations such as weather.
- Narrowing the entrance, for example by extending soft groynes, will potentially promote natural development of a deeper channel.
- Dredging/levelling should initially be 'conservative', with 0m AHD, as a rough equivalent of Mean Sea Level, a nominal suggested target – allowing opportunity for tidal flows, etc., to influence the initial configuration.
- If a dredged channel is included, suggest a similar conservative approach – say -1m LAT maximum depth, or potentially shallower, but perhaps wider.
- In general, take a pilot approach, start conservative, and iteratively refine.

○ Historically, including notably the 1967 survey (the only bank-to-bank navigational survey we found) the entrance included a large delta of intertidal sand banks, with multiple flow paths.

○ Restoring that configuration requires removing vegetation and reducing the height of the east/west oriented part of Bribie Island (as well as some of the north/south tip, to achieve the suggested entrance dimensions and configuration provided above).

○ Achieving this will provide more opportunities for flushing the northern Passage area prior to reopening the old bar entrance and, once it is opened, provide intertidal habitat, including shorebird roosts and opportunities for seagrass colonisation, and assist with attenuation of tidal flows, wave energy and vessel wash.

○ The flood delta – intertidal areas inside the entrance – attenuates tide levels, so it is important and should be managed accordingly. Dredging should be intentional, for multiple purposes.

○ Optionally, this work could be progressed prior to closing breakthrough #1 and opening the entrance at the former bar.

○ A strategy discussed in this report would be to use that sand, along with other material dredged from within the Passage, to form a sandbar running north/south, notionally along the western boundary of the Fish Habitat Area, providing shorebird roost areas, intertidal habitat and other potential benefits, including foreshore protection and management of vessel wash.

○ The aim should be to concentrate tidal flows between this sandbar and the mainland foreshore. This would potentially require alteration of the abandoned oyster banks, but the realignment could be progressive, including possibly minimal intervention initially.

○ On balance, removal of the oyster banks is recommended, but this requires more detailed assessment of foreshore considerations, including the possible need to extend storm drain outlets and/or groynes. Any such works required should be included in the plan, with funding support provided as appropriate to any negotiated agreement between the State and Council.

– In summary, the closure of Breakthrough #1 and reopening of the former entrance could potentially be deferred to year 2 of a works program, based on the relative need for consultation and planning, as well as monitoring of the performance of urgent works, including the extent to which they improve the issues that arose from the second breakthrough.

– Tide levels will not return to previous heights until Breakthrough #1 is closed, however, the urgent works and other works discussed above, including the sandbar, have the potential to mitigate some

of the foreshore impacts, such as wave run-up, as well as potentially manage erosion and accretion processes more favourably. Accordingly, a short (1-yr) deferral may be acceptable.

- The other works suggested above could be progressed during year 1 of the works program, assuring the community of progress, providing some benefits (restoring navigational access within the Passage being a paramount community concern) and provide opportunities to pilot and refine.
- Overall, it should be possible to substantially progress the recommended works within 3-years, assuming negotiations to establish arrangements, including producing plans and securing approvals, can be done within 6-months or less. Some elements, such as an offshore reef, may (if included in plans) take longer as they extend beyond restoring previously known conditions.

As discussed above, progressing the strategy, management plan, and works program, should include community consultation, as well as investigation, design, and, if desired, options assessment. Other ideas may surface and can be tested. Overall, we suggest that the priority should be to “do something”; start…

Triage for those things that are achievable, including agreement (consensus) that those things should/can be done, even if only at a partial scope to achieve consensus; move forward in an agreed direction.

Do those things in accordance with a plan that includes evaluation, for example monitoring currents and/or tides and collecting bathymetry before/after. Include a hypothesis – what you think/expect will happen, and how you are going to evaluate success (or otherwise).

Use ‘mistakes’ as learning opportunities. Plan for the possibility that you will make mistakes and for them to be ‘small’ – an acceptable margin of error. This may be another reason for pursuing a partial scope – taking the first step – and then progressing from there.

Share the plan, including risks, mitigation strategies and expected outcomes. Post-works, provide an open assessment of outcomes and explicitly integrate those learnings into the next steps of a revised program.

5. The Channel Enhancement Project should be, cautiously, viewed as an opportunity

Tidal flows – in and out of Moreton Bay – rather than waves, or disturbances from ships, are probably the dominant influence on sand transport – erosion and accretion – along on the northern Bribie Island foreshore. The North West Channel is both a natural and enhanced (dredged) pathway for tidal flows. An enhanced channel (deeper/wider), such as has been created through historical dredging and is proposed as part of the Channel Enhancement Project, promotes improved conveyance, at least volumetrically, if not in terms of velocities.

The coastal dynamics in this area are complex and understanding is incomplete. An enhanced channel may be the most logical and 'safest' alternative if there is a demonstrated desire to competitively align the port to meet projected international demand. We suggest it is an opportunity, as one of the best ways to improve the potential long-term sustainability of the proposed enhancement of Bribie Island would be to provide a substantial volume of sand for nearshore nourishment.

The Initial Advice Statement for the Channel Enhancement Project indicates that the expected dredging volumes will exceed anticipated demand and requests the ability to sell excess sand overseas. We recommend that priority consideration be given to using that sand for nearshore nourishment of Bribie Island. This will help to mitigate potential impacts, at least in the short term (which may be decades, or even centuries).

Nearshore sand nourishment may result in increased maintenance dredging requirements. We suggest that this would be an acceptable cost, that should be borne as part of the project, and that sand should be returned, perpetually, to the foreshore/nearshore zone. This approach will also allow for monitoring, improved understanding the dynamics of this system, and continual refinement of proactive management.

Expanded Discussion

The North West Channel is significant to coastal processes. It was naturally present, including apparent awareness by Captain Flinders, prior to 1800, as a (potentially preferred) navigational access route. The historical alternatives, including the South Passage and the North East Channel, are relatively more dynamic, therefore less reliable, with less certain but likely higher maintenance requirements, and potentially greater uncertainties and risks regarding interference with sand transport processes if dredging is undertaken to establish them as preferred/alternative routes.

Changing the approach to the North West Channel – having ships use a different path, would require dredging across the North Banks, which also involves uncertain disruption of sand transport processes, as well as possibly the wave attenuation they provide for the foreshore. Altering the offshore banks, including importantly Hamilton Patches, should on principle be avoided.

Tidal flows – in and out of Moreton Bay – rather than waves, or disturbances for ships, are probably the dominant influence sand transport – erosion and accretion – along on the northern Bribie Island foreshore (as discussed above and summarised below, there are uncertain complexities in the area of the breakthroughs). The North West Channel is both a natural and enhanced (dredged) pathway for tidal flows. An enhanced channel (deeper/wider), such as has been created through historical dredging and is proposed as part of the Channel Enhancement Project, promotes improved conveyance, at least volumetrically, if not in terms of velocities.

Vessel movement related impacts, wake and propeller wash, potentially contribute, but are less impactful than waves based on modelling, and conceptually tidal influences exceed wave impacts. A relative lack of sand is certainly a possible factor, but if that is the case, there are several potential contributors and as many or more questions than answers. Wave energy (swell and/or wind) is also accompanied by uncertainties – the North Banks dissipate wave energy, however, they get narrower and narrower towards the north. Waves from the southeast (predominant swell direction) may even 'wrap' around the pointy end of the North Banks and Hamilton Patches and take on a more shore-perpendicular orientation. The dynamic in this area are complex and understanding is incomplete.

An enhanced channel may be the most logical and 'safest' alternative if there is a demonstrated desire to competitively align the port to meet projected international demand. We suggest it is an opportunity, as one of the best ways to improve the potential long-term sustainability of the proposed enhancement of Bribie Island would be to provide a substantial volume of sand for nearshore nourishment.

The Channel Enhancement Project will be progressed through substantial studies and scrutiny. If approved, the movement of sand is likely to be based on well considered assessment, including addressing some of the current information gaps regarding coastal processes in this location.

Enhancement works arising from this Review, including enhanced proactive management, will also inform that understanding.

The Initial Advice Statement for the Channel Enhancement Project indicates that the expected dredging volumes will exceed anticipated demand and request the ability to sell excess sand overseas. We recommend that priority consideration be given to using that sand for nearshore nourishment of Bribie Island. This will help to mitigate potential impacts, at least in the short term (which may be decades, or even centuries).

Nearshore sand nourishment may result in increased maintenance dredging requirements. We suggest that this would be an acceptable cost, that should be borne as part of the project, and that sand should be returned, perpetually, to the foreshore/nearshore zone. This approach will also allow for monitoring, improved understanding the dynamics of this system, and continual refinement of proactive management.

Appendix A – Terms of Reference

Bribie Island Erosion and Breakthrough Review

Terms of reference – April 2025

Background

Ongoing erosion, has severely narrowed the width of the northern tip of Bribie Island, creating several weak points. In 2022, large waves cut a new channel through the weakest part of the northern tip of Bribie Island opposite Nelson Street, Golden Beach. This channel rapidly widened and became a new opening to the ocean. Soon after, the original Caloundra Bar closed over. This body of water has constrained the Caloundra Coast Guard, preventing access to the southern passage and open ocean.

Further severe weather caused by Tropical Cyclone Alfred in 2025 has further widened the 2022 breakthrough and caused more damage, including extensive erosion to the foredune at Lions Park. This event also created a second breakthrough south of Lions Park. These events have heightened residents' and businesses' concerns about future risk and impacts, given the Northern tip of Bribie Island has traditionally shielded Caloundra from effects of severe weather.

The Queensland Government committed to conducting an expert, independent review to investigate ongoing erosion, previous break through events and the impacts these have had on Bribie Island. Immediate and long-term recommendations will be developed and consultation with the Local Government, community organisations and local community will occur to assure that their concerns have been heard and are being actioned.

Scope

Issues and areas expected to be included in the review include, but are not limited to:

- Developing urgent recommendations to stabilise the situation for consideration by Government
- Undertaking a desktop review of previous reports and studies relating to the cause and impacts of the long-term erosion of the island and the breakthroughs in 2022 and 2025
- Identifying causes for the ongoing erosion of the island and subsequent wash overs and breakthroughs
- Identifying impacts of the breakthroughs on the natural protection of Caloundra including residents, business, recreational boating, and the Coast Guard.
- Assessing the impact of dredging and shipping channel operations in Moreton Bay that affect Bribie Island including on sand migration.
- Considering natural and anthropogenic changes contributing to island erosion across mainland catchment areas and Moreton Bay that affect Bribie Island.
- Developing long term recommendations to reduce risk of further damage, including to mainland foreshore, infrastructure, and waterways, preserve Bribie Island and maintain navigation through Pumicestone Passage
- Undertaking consultation with Local Government, Federal Government and the local community on short- and longer-term solutions.
- Any other relevant matters the independent reviewer considers appropriate to the review

Report

The output from the review is the final report. The report will include review of existing analysis, outcomes of consultation and short- and long-term recommendations. The review report will be compiled for submission to the Deputy Premier, Minister for State Development, Infrastructure and Planning and Minister for Industrial Relations. A critical element of the scope is that recommendations for immediate action can be made prior to the completion of the final report. Following approval, the final summary report may be published.

Public engagement

Community consultation will ensure transparency and that community views are representative of the local population. This will include a project webpage for written submissions and locally led community forums.

Appendix B – Authors and Contributors

Authors

An audience deserves to know something about the author. This review is the product of a team ('we') represented by two companies, RPS and ICM. RPS was founded in 1970 by a passionate team of academics in Oxfordshire, United Kingdom, and has been operating in the Australia Asia Pacific region since 2003. RPS is part of Tetra Tech Inc, which was founded in 1966 to provide engineering services for waterways, harbours, and coastal areas in the United States. Tetra Tech operations are global and include ~30k employees, however, this review is largely the independent voice of one RPS employee, Brian McRae.

Brian's relevant experience to contribute to this review includes three decades managing coastal and environmental matters in California (Los Angeles, including initiatives related to the L.A. River and the Santa Monica Bay), New South Wales (Sydney's Northern Beaches) and Queensland (including managing the Gold Coast Seaway, Sand bypass system, and navigational channel network), as well as involvement throughout his career in disaster management. His perspective includes training as a naturalist, biologist, environmental planner, and public sector manager. He attributes key achievements in his career to a passion for improving 'systems', including the complex dynamics between ecosystems, governance, economy and, importantly, relationships.

RPS supported Brian with his contributions to this review in a number of ways. Notable support was provided by Brad Williams, Practice Leader - Place (Sunshine Coast), who contributed insight regarding local community dynamics and context. He brings more than 28 years' experience as an urban planner and development consultant, and a deep appreciation of the Sunshine Coast community and environs. His key experience and abilities stem from his direction of large master planned communities, complex urban development projects, emerging regional communities and the drafting of statutory planning instruments.

ICM originated on the Gold Coast and earned global recognition for leading approaches to coastal resilience that rely on nature-based engineering solutions. As a Gold Coast City Council engineer in the 1980s, ICM founder Angus Jackson contributed to the pioneering of this approach, which is founded on Queensland Government investigations in the 1970s ('Delft report') pursuant to coastal storm damages. The Gold Coast Seaway, the GC and Tweed sand bypass systems, and the management of the Gold Coast shoreline originate from this early initiative. ICM has a strong history of innovation in coastal and waterfront design and delivery of cost-effective solutions globally.

Aaron Salyer, Director and Coastal Engineer, partnered with Brian to direct this project, and led the efforts of the team from International Coastal Management (ICM). Aaron's focus is on leading efforts to protect and restore coastal ecosystems, and in particular enhancing community resilience to ocean hazards. Through innovative engineering, he aims to implement nature-based solutions that promote multifaceted benefits. His goal is to foster a profound shift in how society values and interacts with coastal environments, promoting sustainable development and marine conservation worldwide. Aaron is also an expert panellist for the United Nations Ocean Decade.

Contributors

The Department of State Development, Infrastructure and Planning provided invaluable assistance to facilitate the delivery of this review, including supporting RPS/ICM throughout to successfully apply an agile delivery methodology, including organising a Queensland Government Technical Working Group (**TWG**). A separate working group of Sunshine Coast Council officers with relevant subject matter expertise was formed and operated in parallel with the QG TWG. Both groups assisted with the identification of relevant sources, and through reviewing and commenting on draft outputs. Agencies represented include:

- Department of State Development Infrastructure and Planning
- Department of Premier and Cabinet
- Queensland Treasury
- Department of Environment, Tourism, Science and Innovation
- Department of Primary Industries
- Department of Resources, Mining, Manufacturing and Regional Development
- Department of Transport and Main Roads, Maritime Safety Queensland
- Queensland Reconstruction Authority
- Sunshine Coast Council

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Appendix D – Seaway Evolution Fact Sheet

Fact Sheet

Is the Broadwater silting up?

An overview of shifting sands in Gold Coast waterways

Periodically one hears that 'the Broadwater is silting up', often attributed to 'years of neglect', but someone else will typically respond that the Broadwater is a 'naturally shallow estuary'. Neither statement is entirely correct. The truth is more complex and includes uncertainties, but recent research provides some insight.

HISTORY OF THE SEAWAY

Construction of the Seaway altered the hydrodynamics (how water moves) and morphodynamics (shifting sand – shoaling and scour) of Gold Coast waterways. The tide range changed by ~0.5m as the entrance became more hydraulically efficient due to: stabilisation; sand bypassing to manage the bar; and dredging of the North and South channels. The system has been adjusting since the opening in 1986, but this is only one part of a long history of change. In recent history, the breach of Jumpinpin Bar around 1900 (creating North and South Stradbroke Islands) had similarly transformative effects.

Pre-Seaway photos support claims of long-term residents that 'you could walk across the Broadwater'. Construction of the Seaway changed the tidal prism, so low tide is now lower than it used to be and high tide is higher. This means that you can't just look at a photo and conclude that there is more or less sand than there used to be.

The "Seaway Evolution" in response to stabilisation of the entrance, as well as historically, is partially explained in a number of studies and projects. Recent work under the GCWA *Scientific Research and Management Program* provides both an authoritative review of this previous work along with original research that provides new insight into how the Broadwater has shoaled and scoured.

By design, the Seaway and coastal bar should provide about 6.0m of water (5.3m AHD, 6.0m LAT). Within about 18-months of opening, parts of the Seaway were over 12m deep, with a peak of nearly 20m in 2007. Yet the ocean bar, until recently, has frequently had shoals above 4.0m.

The 'conceptual model' of the Seaway has for some time attributed shoaling on the bar to 'leakage' past the Sand Bypass System. This thinking was challenged when GCWA digitised a 1983 (pre-Seaway) survey so that it could be compared to the only other bank-to-bank survey, a composite substantially based on 2005 data. In 2014 GCWA completed the first ever topo-bathy LiDAR survey, providing a third bank-to-bank dataset for Gold Coast waters.

Recent comprehensive work confirms preliminary findings – the net effect of the Seaway construction has been an export of sand from the Broadwater – scouring. The revised conceptual model attributes the growth of the delta to this export, rather than inefficiencies in the Sand Bypass System.

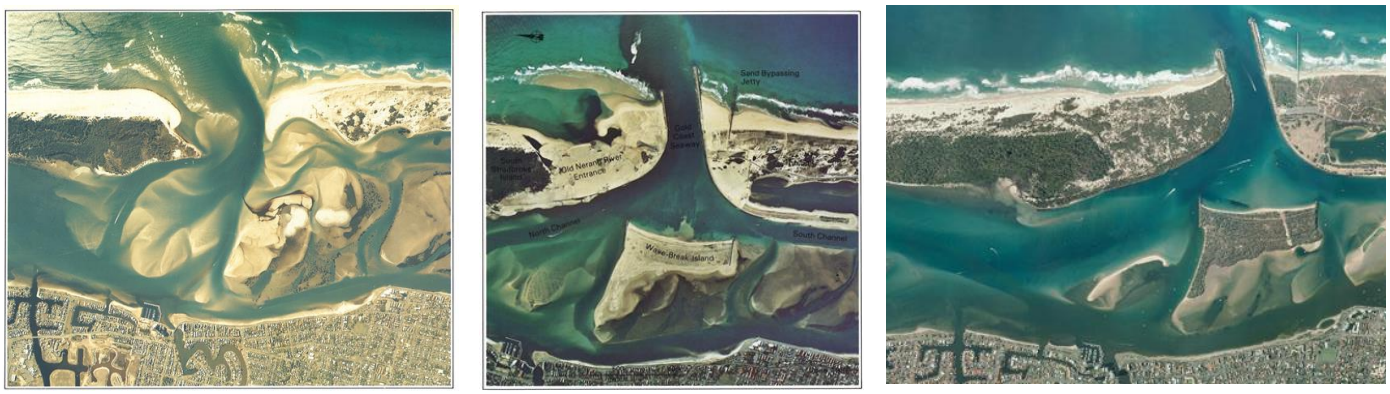


Figure 1 Three views of the Broadwater, 1984, 1986 and 2009 (left to right)

Queensland Government

Fact Sheet

Is the Broadwater silting up?

An overview of shifting sands in Gold Coast waterways

SAND MOVEMENT

The table below (Table 1) shows the net effects of the conceptual sand budgets provided in the images to the right (Figure 2). The overall trend is a shift, from a flood-tide dominated system (net sand movement from the ocean onto an internal delta) to an ebb-tide dominated system (with export building an ocean delta).

While the data is limited, a reasonable interpretation of historical accounts would suggest that the breach of Jumpinpin had similar, but opposite, effects. Before the breach, the Nerang River entrance would have been the only tidal outlet. The breach provided an alternative outlet, weakening flows through the Nerang. After the breach the net sand movement shifted from an export (onto the bar) to an import, leading to shoaling of the Broadwater and Nerang River. The Seaway construction has had the reverse effect.

The data below also shows a stabilisation trend, with less export recently, suggesting the system may be approaching, but hasn't yet reached a new equilibrium.

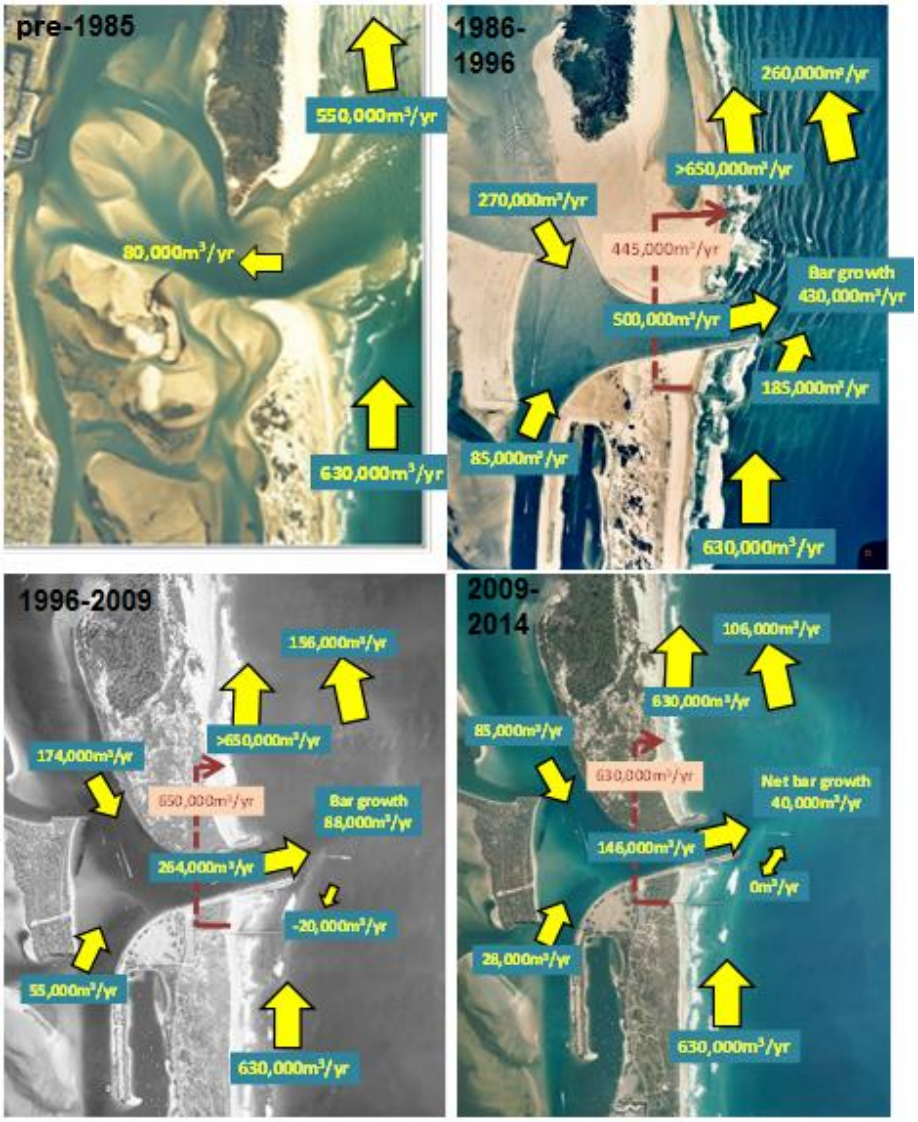


Figure 2 (above) and Table 1 (below) – Conceptual sand budgets and net effects

	Average Annual Rates (m^3/year)			
	Pre 1986	**1986-1996**	**1996-2009**	**2009-2014**
Export from Broadwater				
• **North channel**		269,050	173,830	85,250
• **South channel**		84,445	54,555	28,560
• **Total**	**-80,000**	**353,495**	**228,385**	**113,810**
Volume loss in Seaway Channel		150,000	36,000	32,500
Export from Seaway to Bar		503,495	264,385	146,310
Bar Growth		430,000	88,000	40,000
Average Bypassing Rate	0	444,225	650,415	630,000
Potential leakage to Bar	630,000	185,775	-20,415	0
Likely transport from bar to north	550,000	259,270	155,970	106,310

Fact Sheet

Is the Broadwater silting up?

An overview of shifting sands in Gold Coast waterways

The net effect of the average annual export rates shown in Table 1 is a gradual scouring of the Broadwater. The estimated rates are derived from a comparison of the three survey sets mentioned above, the observed scour. While the overall effect is a scouring of the Broadwater, there are some areas that have shoaled over this time, as evidenced by features such as the recently named Curlew Island (off the southeast tip of Wave Break Island).

This pattern is similar to the process of natural succession, where a natural feature such as a braided floodplain (lots of shifting flow paths) will evolve into a channelized estuary (defined, stable flow paths) via the processes of flooding; vegetative colonisation; wind transport of sand dunes; and the activity of birds and mammals.

Dredging (and urbanisation) has accelerated what would have probably occurred over a longer time frame, by concentrating flows in channels, which in turn reduces the scour of vegetation from adjacent shoals, thereby allowing the vegetation to trap wind-born sand. These shoals provide habitat and animals further contribute to the ecological succession of plant communities ('islandisation'). As can be seen from Table 2 and Figures 3 & 4 below, while there is less sand overall in the Broadwater following construction of the Seaway, in the northern Broadwater 'Natural change' has been the predominant force; whereas dredging is the more significant contributor in the southern Broadwater, in part due to beach nourishment projects in 1975 and 2000 that sourced sand from the southern Broadwater.

Compartment	1983-2009 Volume change	Dredged 1983-2009	1983-2009 Natural change	2009-2014 Natural change
BS1	-332,493	180,000	-152,493	32,319
BS2	-2,287,316	2,250,000	-37,316	-70,783
BS3	-312,261	0	-312,261	-75,000
BS4	-716,876	700,000	-16,876	0
BS5	0	0	0	0
BS6	-374,713	0	-374,713	-79
BS7	-538,424	0	-538,424	-28,082
BS8	-115,847	0	-115,847	-569
BS9	-1,005,822	1,000,000	-5,822	-593
Sub-Total	**-5,683,752**	**4,130,000**	**-1,553,752**	**-142,787**
BN1	-888,915	450,000	-438,915	-144,726
BN2	-485,671		-485,671	26,126
BN3	-321,651	190,000	-131,651	20,678
BN4	-802,412		-802,412	-163,984
BN5	-979,197		-979,197	-1,324
BN6	-691,114	180,000	-511,114	48,730
BN7	-795,498		-795,498	-69,781
BN8	-1,813,810	1,050,000	-763,810	-73,443
BN9	-542,023	500,000	-42,023	-68,531
Sub-total	**-7,320,291**	**2,370,000**	**-4,950,291**	**-426,254**
TOTAL	**-13,004,043**	**6,500,000**	**-6,504,043**	**-569,040**

Figures 3, 4 (left, right) and Table 2 (middle) – Measured net volumetric changes by area and time period

So, rather than 'shoaling due to years of neglect', the Broadwater has been scouring as a result of both dredging and stabilisation of the Seaway, returning sand back to the ocean. And, while it is reasonable to call the Broadwater a shallow estuary, like all coastal wetlands it is a dynamic system, a product of historical sea-level changes. It would naturally, and indeed has, evolve – shoal and scour over time – even without the human component of 'natural' processes.

The full report, Seaway Evolution – Morphological trends and processes – GCWA SRMP-006 *is currently being finalised. The summary and extracts above provide the best available estimates of recent changes. The report, prepared by the Griffith University Centre for Coastal Management, is part of the GCWA Scientific Research and Management Program, prepared under the guidance of the GCWA Scientific Advisory Committee. See our website to learn more about Gold Coast waterways or send us an email If you have questions about this fact sheet.*

Appendix E – GCWSC HoA and MoU

Heads of Agreement for a Memorandum of Understanding

For the Planning, Funding, Development and Maintenance of Coastal, Foreshore and Waterways Infrastructure

between

DEPARTMENT OF TRANSPORT AND MAIN ROADS

and

GOLD COAST CITY COUNCIL

Heads of Agreement dated this 6th day of July 2009

PARTIES:

DEPARTMENT OF TRANSPORT AND MAIN ROADS ("DTMR"); **AND**;

GOLD COAST CITY COUNCIL ("GCCC").

PURPOSE:

1. This document records the intent of DTMR and GCCC to enter into a Memorandum of Understanding (MOU) to work collaboratively to plan, fund, develop and maintain coastal, waterway and foreshore infrastructure of interest to both Parties.

2. The MOU to be entered into by the Parties is to also record details concerning the administration of this collaborative arrangement.

SCOPE:

3. Infrastructure projects that relate to the Broadwater, Southern Moreton Bay, adjoining rivers, coastal and foreshore areas within Gold Coast City where both Parties share an interest are to form the subject matter of the MOU.

4. The MOU will facilitate the establishment of a governance arrangement to identify infrastructure projects, obtain funding, prioritise works, and deliver and maintain infrastructure on an ongoing basis, together and in collaboration with other stakeholders.

KEY PRINCIPLES:

5. This document is not intended to create legal relations between the Parties.

6. It is not the intention of the Parties in this document or in any MOU or other agreement to be entered into between them, to create a partnership or joint venture between the Parties.

7. A joint Steering Committee will be established to progress projects of shared interest.

8. There will be full disclosure to relevant State agencies, Ministers, State Cabinet, and Gold Coast City Council of the projects and programs as required.

9. DTMR and GCCC agree to share costs in line with an agreed budget for navigation channel maintenance dredging and other infrastructure projects to be determined on a case by case basis and subject to each Party's interest.

10. It is acknowledged that successful implementation of shared infrastructure works/programs will require engagement with other persons or entities.

PROJECT TIMETABLE:

11. It is proposed that the MOU and establishment of a Steering Committee will be progressed in accordance with the following timetable:

i completion of the MOU – 3rd Quarter 2009

ii establishment of the Steering Committee – 4th Quarter 2009

OBLIGATIONS AND RESPONSIBILITIES:

12. The Parties will use their best endeavours to progress the MOU and to establish the Steering Committee in a timely manner to address issues such as dredging as identified by the Draft Access Needs Study and to consider work identified by the Draft Marine Infrastructure Masterplan.

13. DTMR and GCCC will work collaboratively to establish and maintain shared infrastructure in accordance with the State's Value for Money Framework.

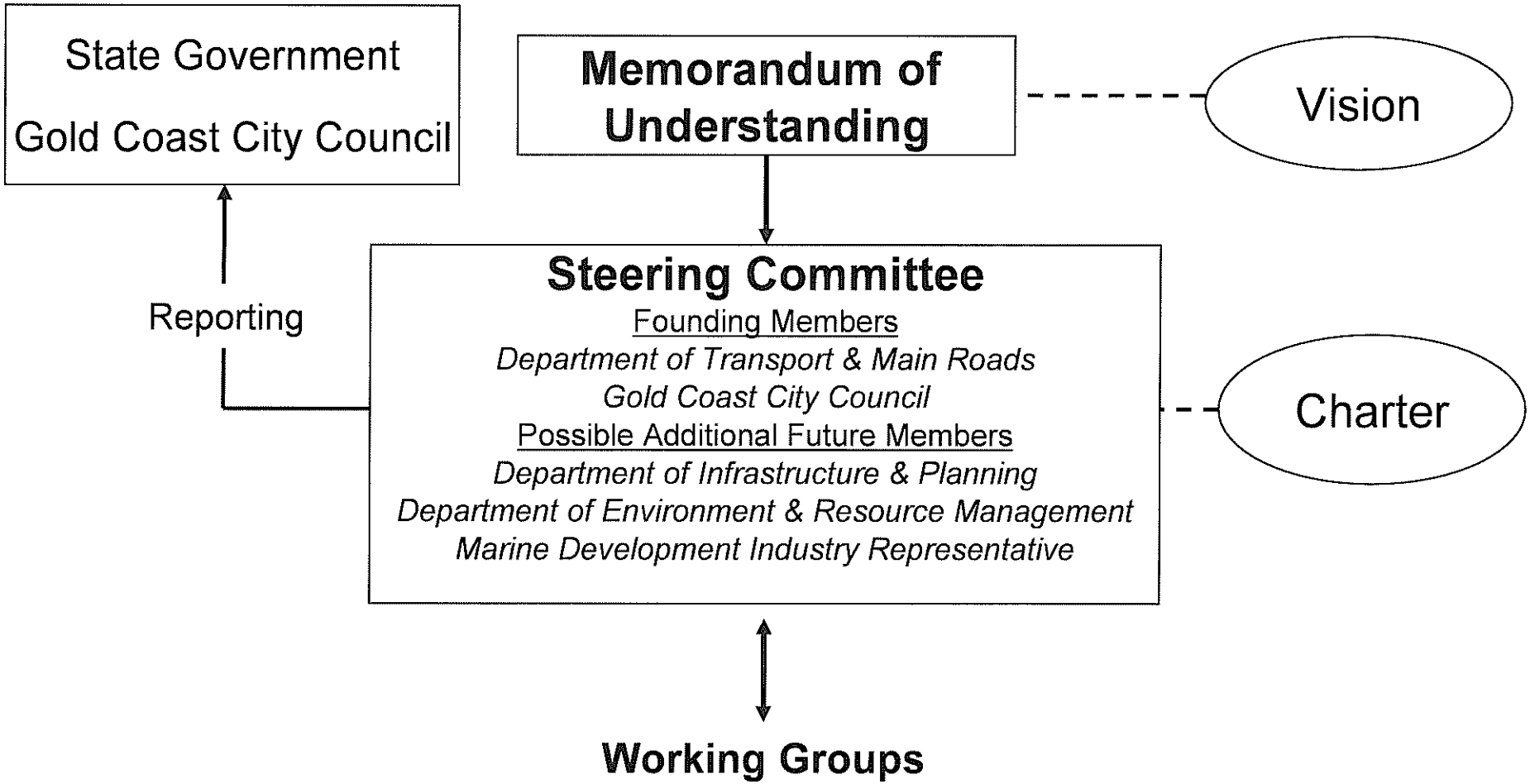
14. The Steering Committee will guide and direct shared project investigations and implementation in accordance with Queensland Government and GCCC objectives and policies. Regular progress reports will be presented to the Queensland Government and GCCC by the Steering Committee.

SIGNED by the parties on the respective dates set out below:

SIGNED for and on behalf of)
DEPARTMENT OF TRANSPORT .....
AND MAIN ROADS) *(signature)*
Rachael Nolan)
Minister for Transport

SIGNED for and on behalf of)
GOLD COAST CITY COUNCIL .....
Ron Clarke) *(signature)*
Mayor)

The Collaborative Arrangements, Stakeholders and Project Schedules



GOLD COAST WATERWAYS STEERING COMMITTEE

MEMORANDUM OF UNDERSTANDING FOR THE ESTABLISHMENT AND OPERATION OF THE STEERING COMMITTEE

between

STATE OF QUEENSLAND
acting through:
DEPARTMENT OF TRANSPORT AND MAIN ROADS,
DEPARTMENT OF ENVIRONMENT AND RESOURCE MANAGEMENT,
DEPARTMENT OF EMPLOYMENT, ECONOMIC DEVELOPMENT AND INNOVATION

and

GOLD COAST CITY COUNCIL

and

Boating Industry Association Queensland Ltd trading as MARINE QUEENSLAND

Queensland Government

Gold Coast City Council

marine queensland

THIS MEMORANDUM is made

BETWEEN: STATE OF QUEENSLAND (The State)
acting through:
Department Of Transport and Main Roads (TMR),
Department Of Environment and Resource Management DERM),
Department Of Employment, Economic Development and Innovation (DEEDI).

AND: GOLD COAST CITY COUNCIL (GCCC)

AND: MARINE QUEENSLAND PTY LTD (MQ)

PURPOSE:

The purpose of this Memorandum of Understanding (MOU) is to set out the manner in which the State of Queensland (The State), Gold Coast City Council (GCCC), and Marine Queensland (MQ) will work together to plan, fund, develop and maintain coastal, foreshore and waterway infrastructure within Gold Coast City.

BACKGROUND:

A. The State, GCCC and MQ are committed to improving the provision and quality of coastal, foreshore and waterway infrastructure within Gold Coast City. In doing so, the parties are mindful of the need to identify infrastructure priorities and value for money opportunities having due regard for:

- improving accessibility throughout Gold Coast waterways and to adjacent inland waterways and coastal waters;
- recognised environmental values, coastal processes and amenity;
- contributing to a sustainable community and healthy lifestyle by providing waterway access to natural open space areas and recreational facilities;
- contributing to continued economic prosperity of the Gold Coast and Queensland by supporting employment within the marine, tourism, and development sectors.

B. The State (TMR) and GCCC entered into a Heads of Agreement, on 06 July 2009, to guide the preparation of this Memorandum of Understanding.

C. The State, GCCC and MQ have prepared this Memorandum of Understanding to provide agreed key principles, scope and governance arrangements for the establishment and ongoing operation of a joint Steering Committee to oversee coastal, foreshore and waterway infrastructure work on the Gold Coast.

D. This Memorandum of Understanding also provides agreed principles for funding contributions managed by the Steering Committee. A Funding Agreement has been prepared to address funding administrative matters between funding parties.

E. The parties agree to use their best endeavours to establish the Steering Committee in a timely manner, meet their respective commitments and adhere to the principles contained in this MOU.

AGREED TERMS:

1. DEFINITIONS & INTERPRETATION

In this MOU, the following definitions will apply:

ANS Gold Coast Waterways Access Needs Study;

Business Day means any day that is not a Saturday, Sunday, or a public holiday within the Gold Coast Local Government Area;

Commencement Date means the date at which all parties have signed the MOU or if signed on different dates, the date the last Party signs the MOU;

Confidential Information means all information that is by its nature confidential and which:

- is designated or marked by a Party as confidential; or
- a Party knows or ought to know is confidential,
- but does not include information which is or becomes public knowledge other than by breach of this MOU or any other confidentiality obligation or is otherwise required to be disclosed by law;

DEEDI means the Queensland Department of Employment, Economic Development and Innovation;

DERM means the Queensland Department of Environment and Resource Management;

Financial Year means each period from 1 July to the following 30 June;

Funding Parties means TMR (The State), GCCC and MQ;

Funding Agreement means the separate agreement between the Funding Parties in relation to this MOU, signed by the Parties on 15 July 1010;

GCCC means the Gold Coast City Council;

Gold Coast means the Gold Coast Local Government Area and associated waterways;

Intellectual Property Rights includes all copyright (including rights in relation to phonograms and broadcasts), all rights in relation to inventions (including patent rights), plant varieties, registered and unregistered trademarks (including service marks), registered designs, circuit layouts, and all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields;

Marina Owner Levy means the marina owner levy as defined by the Transport Infrastructure Act 1994 Transport Infrastructure (Gold Coast Waterways) Management Plan 2000;

MIM means Southern Moreton Bay to Broadwater Marine Infrastructure Masterplan;

MOU means this document and includes all schedules to this document;

MQ means Boating Industry Association Queensland Ltd trading as Marine Queensland;

Navigation Channel means a navigation channel identified by the Gold Coast Waterways Access Needs Study or as identified by the Gold Coast Waterways Steering Committee;

Party/Parties means the organisation/s that is/are signatories to this MOU;

Project Manager means the nominated officer accountable for a particular project as identified by the Steering Committee. The Project Manager has overall responsibility for resources, consultants, budget and timeframe in accordance with an agreed project plan approved by the Steering Committee;

Project Proposal refers to a submission to the Steering Committee made in accordance with the Funding Agreement on the appropriate schedule or an alternative approved mechanism;

Responsible Organisation is the Party, or other authorised government entity, that has been assigned to undertake work on behalf of the Steering Committee;

Representative means an employee, agent, officer, director, auditor, adviser, partner, consultant, contractor, joint venturer, sub-contractor or other representative of a Party;

Schedule refers to the schedules to this MOU. Schedules may be amended as agreed by the Steering Committee;

Steering Committee means the committee of representatives established to implement an agreed coastal, foreshore and waterway infrastructure program in accordance with clause 4.1 of the MOU;

Term refers to the period described in subclause 3.2;

Terms of Reference means the operational guidelines to be endorsed by the Steering Committee and attached as a Schedule to this MOU;

The State means The State of Queensland represented by DERM, DEEDI and/or TMR;

TMR means the Queensland Department of Transport and Main Roads;

VfM Framework means the document entitled 'Public Private Partnerships Guidance Material - Value for Money Framework' and the PPP Guidance Material: Supporting Documents published by the State in August 2002 as revised from time to time;

Working Group means a group established under this MOU to address a common interest issue, such as navigation channel dredging. A working group is established to provide technical advice and recommendations to the Steering Committee.

2. SCOPE

2.1 This MOU is limited in its intent to the activities and funding arrangements related to the Gold Coast Waterways Steering Committee.

2.2 The Steering Committee will oversee a program of shared interest projects that relate to tidal waterways, coastal and foreshore areas within Gold Coast City.

2.3 The Steering Committee will share knowledge and information, identify suitable projects of shared interest; allocate funding and coordinate resources; prioritise works; undertake studies; and oversee the delivery and maintenance of infrastructure.

2.4 The Steering Committee may identify management issues related to the program of work, consider strategies to address these issues and report findings back to the State (TMR) and Council for consideration.

2.5 The Steering Committee may decide to amend its scope and membership to include Redland City Council in future. Any change of scope will not be undertaken unless equitable funding and resource allocations are made by the Parties, including Redland City Council, as agreed to by all Parties.

3. TERM

3.1. The inaugural Steering Committee meeting will be held as soon as possible following the execution of this MOU by all Parties, to consider a preliminary infrastructure program for the 2010 – 2011 financial year.

3.2. The term of this MOU commences on the Commencement Date of this MOU and is ongoing until such a time as the MOU is terminated.

4. GOVERNANCE ARRANGEMENT

4.1 The Steering Committee is comprised of the following membership (or delegate):

i Director General Department of Transport (Chair, or as decided);

ii Director General Department of Environment and Resource Management;

iii Director General Department of Employment, Economic Development and Innovation;

iv Chief Executive Officer, Gold Coast City Council; and

v Chief Executive Officer, Marine Queensland.

4.2 Steering Committee members will work together in good faith with respect for each other. In this context good faith includes, but is not limited to:

i acting fairly, reasonably and honestly;

ii doing all things reasonably to be expected in the context of this MOU;

iii giving as much weight to the interests of the Steering Committee as to the party's own interests;

iv providing advice and working constructively to resolve issues in a timely manner; and

v not impeding or restricting another party's performance of its obligations under this MOU.

4.3 Each Party (including its delegate member of the Steering Committee) must take all steps, execute all documents and do everything reasonably required to give effect to this MOU.

4.4 Decisions will be made in good faith on a majority vote basis, having due regard for source of funds and any associated limitations on the use of these funds by the Steering Committee.

4.5 To avoid any doubt, nothing in this MOU, including a decision made on a majority vote basis under clause 4.4, will act as a fetter or an estoppel about the exercise of a discretion or the making of a decision under Queensland law in respect of the Parties, or will prevent the Parties from fulfilling their statutory obligations.

4.6 Each Party is to be a champion of the Steering Committee within their respective organisations and in the public realm.

4.7 Steering Committee members or delegates will:

i Attend all meetings;

ii Review documents;

iii Report back to their respective organisation; and

iv Support the Steering Committee as required.

4.8 The Steering Committee will:

v Allocate funds to undertake studies for infrastructure planning and permitting purposes; infrastructure delivery; navigation channel maintenance; and for administrative purposes;

vi Share knowledge and information to enable the Parties to perform their obligations under this MOU;

vii Elect a Chair for a period of 12 months. The Steering Committee Chair is responsible for secretariat support to set meetings, prepare and distribute an agenda and minutes for each meeting;

viii Oversee and provide direction to Working Groups with regard to a program of work, project priority, resource coordination and funding;

ix Endorse a Terms of Reference Schedule for each Working Group and ensure nominated resources are provided for by the respective parties;

x Review the role, need and performance of the Working Group on an annual basis;

xi Assign a responsible organisation and project manager for each project having regard for capability, experience, risk, funding provision, and procurement opportunities;

xii Provide direction on all significant project scope issues;

xiii Provide direction on all significant project budget issues including approval of variations over 10%, or as determined by the Steering Committee for a particular project;

xiv Provide direction on any other significant issues impacting on project procurement;

xv Resolve any issues that cannot be resolved at Working Group level; and

xvi Receive minutes and/or reports from each Working Group.

4.9 The Steering Committee shall undertake its function in accordance with State and GCCC objectives and policies.

4.10 Steering Committee meetings are to be held on a quarterly basis or as determined by the Steering Committee.

4.11 A Party must advise the Steering Committee of any Conflict of Interest that exists or may be perceived to exist with an item to be discussed by the Steering Committee. A Party with a Conflict of Interest will be excluded from Steering Committee consideration of the relevant item.

4.12 The Steering Committee will provide confirmed meeting minutes to the Minister for Transport and GCCC following each meeting in a timely manner.

4.13 The Steering Committee will approve various Working Groups, as deemed necessary from time to time to provide advice and carry out work under this MOU.

4.14 Each Party will provide resources to support the effective function of the Working Groups, including providing core members as specified in the attached schedules.

4.15 Working Groups will:

i Implement the directions of the Steering Committee;

ii Present meeting minutes to the Steering Committee which will include project opportunities, project priority recommendations, estimated budget and funding opportunities, project progress, and any other relevant issues. Project management plans (which consider as a minimum responsible organisation, risk, resources, funding, media/communication and information management matters) will also be provided as required;

iii Draft a Terms of Reference for endorsement of the Steering Committee. The Terms of Reference will form a schedule to this MOU;

iv Undertake research and targeted consultation to identify issues and consider project opportunities;

v Share knowledge and work together in good faith with respect for one another; and

vi Elect a Chair for a period of 12 months. A Working Group Chair is responsible for secretariat support to set meetings, prepare and distribute an agenda and minutes for each meeting. A Working Group Chair will also report back to the Steering Committee on behalf of the Working Group.

4.16 All officers undertaking work for the Steering Committee remain directly accountable to their respective organisations.

4.17 Working Groups may also involve individuals or representatives from organisations or the community not party to this MOU.

4.18 The State and GCCC will delegate liaison officers to coordinate work between the Working Groups and to facilitate effective cross communication between the Parties. Liaison officers may attend Steering Committee meetings as non – voting members and act as representatives of the Steering Committee to the Working Groups as required to communicate decisions or coordinate requests. At least one liaison representative must be in attendance at all Working Group meetings.

4.19 Project agreements may be established between Parties which clearly stipulate obligations, interests and responsibilities separate to this MOU.

4.20 A diagrammatic Governance Structure is included at **SCHEDULE 1**.

4.21 The Steering Committee may amend this MOU as agreed by all Parties.

5. FUNDING AND PROCUREMENT

5.1. Funding contributions and funds administration for the Steering Committee are to be in accordance with the Funding Agreement.

5.2. Additional funding may be sought by the Steering Committee from the Parties on a project basis, or from other sources such as grants or PPPs. The Steering Committee will address the State's VfM Framework, as appropriate, when considering PPP arrangements.

5.3. Procurement shall be undertaken by the State or GCCC noting that GCCC must comply with its enabling legislation that may impose greater constraints than may apply to the State.

5.4. Only legitimate expenses invoiced and subsequently certified by the Steering Committee, or its delegate, as being consistent with the agreed budget may be drawn down against the budget.

5.5. In the event that this MOU is terminated per section 12, the pooled funds shall be used to satisfy all outstanding obligations, after which the balance of funds shall be returned to the contributing parties, in proportion to their respective contributions for the most recent fiscal year, unless the Steering Committee should unanimously decide on a different mechanism.

6. INFORMATION MANAGEMENT AND CONFIDENTIALITY

6.1. The Steering Committee will keep complete and accurate records of meetings and decisions. An agenda will be set for all meetings and minutes kept. A record of each meeting will be circulated by the Chair to all Parties. The Steering Committee records will be maintained by the Department of Transport and Main Roads.

6.2. Minutes, reports and other recorded information will be made available to the Parties upon request and within a reasonable timeframe.

6.3. Minutes, reports and other non confidential information will be publically available. The Steering Committee may also received correspondence directly from community stakeholders.

6.4. The Parties will disclose, in a timely manner, all relevant information and data required to support the operations of the Steering Committee and its Working Groups in accordance with this MOU.

6.5. The Parties acknowledge that this MOU (or any part of it) may be disclosed under the *Right to Information Act 2009* (RTI Act) and the Parties representing the State provide no guarantee that any information (including Confidential Information provided under this MOU) provided by a Party will be protected from disclosure under the RTI Act.

6.6. If disclosure under the RTI Act, and/or general disclosure of information provided by a Party in connection with this MOU, would be of substantial concern to that Party, because it would disclose trade secrets, information of commercial value, the purpose or results of research or other information of a confidential nature, this should be indicated by that Party.

6.7. Each Party will treat all Confidential Information owned by the other Party as confidential and will not, without the prior written consent of the other Party (not to be unreasonably withheld or delayed) disclose or permit the Confidential Information to be disclosed to any other person.

6.8. A Party is not in default under clause 6.7 if Confidential Information:

i is disclosed by a Party:

(a) to its Representatives or advisers who are bound to keep the information confidential; and

(b) solely in order to comply with its obligations, or to exercise its rights, under this MOU;

ii is disclosed by either Party to its responsible Minister administering the Party from time to time;

iii is disclosed by either party, in response to a request by the House or a Committee of the Parliament of the State;

iv is shared by a Party within its own organisation, or with another agency, where this serves the State's legitimate interests;

v is required or compelled by an order of a court or by any law to be disclosed; or

vi is necessary for the conduct of any legal proceedings arising in relation to this MOU.

6.9. Working Groups will provide minutes of meetings and other relevant information to the Steering Committee.

6.10. Project records will be kept and maintained by the responsible organisation in accordance with an approved project management plan. These records will be made available, within a reasonable time, to the Parties upon request. Auditable financial records will be kept of all project expenditure where funding has been provided to a project by the Steering Committee.

7. COMMUNICATION, MEDIA PROTOCOL AND PUBLICITY

7.1. The following provisions reflect the intent of the Parties, but are made in recognition of the Parties' respective limits to control matters that may, for example, reside with the elected government, rather than the Department or its appointed officers.

7.2. Subject to relevant media contact protocols established by their respective organisations, no Steering Committee or Working Group member shall publically speak on behalf of the Steering Committee unless directed to do so by the Steering Committee, either on an ad hoc basis, or as established by the communication strategy discussed below.

7.3. A communication strategy will be established by the Steering Committee that addresses the following key principles:

i Shared responsibility and accountability;

ii Strategic Planning and early identification of media opportunities;

iii Joint media releases agreed to by the State, GCCC and MQ representatives;

iv The Director General Department of Transport and the CEO GCCC are joint spokespersons for the Steering Committee;

v Efficient media release drafting process to respond to media enquiries in a timely manner;

vi For each project the responsible organisation shall nominate a media officer unless agreed otherwise;

vii Circulation of media releases to relevant elected representatives prior to provision to the media; and

viii Equitable advertising (e.g. at project sites, within publications, media or at events).

7.4. Wherever possible, the Parties will keep each other informed of any media enquiries received about the Steering Committee or any of the jointly funded or managed infrastructure projects.

7.5. The Parties must acknowledge the financial and other support provided by one another to the Steering Committee as equals. All media, publication and communication material produced by, or on behalf of, the Steering Committee must incorporate, in equal proportions, the State, GCCC and MQ Logos.

7.6. At sites where activities are funded, in whole or in part, by the Steering Committee, including media or related events, signage shall be erected and maintained in accordance with approved Project Proposals.

7.7. Signage is to be displayed in public view where the activity is taking place. The signage shall be maintained for a period of time agreed to by the Steering Committee on a project by project basis.

7.8. Recognition of the Steering Committee must be made in all publications, promotional material, correspondence, and information displays where activities are funded or supported by the Steering Committee.

7.9. No Party may use another Party's logo without the prior authorisation of the Steering Committee.

7.10. The Steering Committee will determine an agreed date where projects or activities involve an Official Opening or public function.

7.11. A representative from the State, GCCC and MQ must be invited to Official Openings or other public functions for projects or activities supported by the Steering Committee. Invitations to such events must be provided at least 4 weeks prior to the event taking place.

8. ISSUE RESOLUTION

8.1. Issues that arise between representatives of a Working Group, project or activity undertaken by or on behalf of the Steering Committee shall be resolved by the process set out in this section.

8.2. In the first instance representatives performing any function contemplated by this MOU must attempt to resolve any issue or differences at their management level.

8.3. If an issue cannot be resolved as detailed at section 8.2, it shall be brought before the Steering Committee for resolution. The Steering Committee must have due regard for section 4.2 when considering any issue or difference.

8.4. If the Steering Committee fails to reach a satisfactory resolution of an issue, the issue shall be reported to the Minister for Transport and Mayor GCCC for resolution.

9. NO AGENCY

9.1. No party is, by virtue of this Agreement, the agent or partner of any other Party and each Party must ensure that it conducts itself so as not to infer otherwise.

10. LIABILITY

10.1. The Parties agree that they enter into this MOU entirely at their own risk.

11. WITHDRAWAL FROM THIS MOU

11.1. A Party may, at any time, by providing written notice to the Steering Committee, withdraw from this MOU. A withdrawal takes effect 10 business days after receipt of the written notice by the Steering Committee.

11.2. On receipt of a Party's notice of withdrawal, the Party is entitled to be refunded any funds contributed by the withdrawing Party which are uncommitted at the date of notice, on a pro-rata basis.

11.3. Any funds contributed by the withdrawing party which have been spent or legally committed for expenditure, are not refundable.

11.4. A withdrawing party retains their rights in intellectual property created or commercialised up to the date of their notice of withdrawal.

11.5. The withdrawing party does not acquire any rights in any intellectual property created or commercialised after the date of notice of withdrawal.

11.6. In the event of a Party withdrawing from this MOU, the Parties agree to act to take all reasonable measures to minimise loss resulting from that withdrawal and to minimise disruption to the projects and activities under this MOU.

12. TERMINATION OF THIS MOU

12.1. The Parties may resolve, through a unanimous vote of the Steering Committee, to terminate this MOU and dissolve the Steering Committee.

12.2. The following clause survives the expiry or termination of this MOU:

Clause 6 (Information Management and Confidentiality)

13. NOTICES

13.1. A Party giving notice or notifying under this MOU must do so in writing or by Electronic Communication:

i directed to the recipient's address, as varied by any notice; and

ii hand delivered or sent by pre-paid post or Electronic Communication to that address.

13.2. The Parties' address details are as specified in the Schedule.

13.3. A notice given in accordance with subclause 13.1 is taken to be received:

iii if hand delivered, on delivery;

iv if sent by pre-paid post, 5 Business Days after the date of posting unless it has been received earlier; or

v if sent by Electronic Communication, at the time that would be the time of receipt under the Electronic Transactions Act 1999 (Cth) if a notice was being given under a law of the Commonwealth, which is currently when the Electronic Communication enters the addressee's Information System.

14. GENERAL

14.1. A Party must not assign or subcontract the whole or any part of this MOU without the prior written consent of the other Parties, such consent not to be unreasonably withheld or delayed.

14.2. The Parties agree that nothing in this MOU is intended to be legally binding. Notwithstanding that the conditions of this MOU are not legally enforceable; the Parties must perform their respective obligations and receive their respective benefits in good faith.

14.3. The Parties will comply with the requirements of all Acts of the Parliaments of the Commonwealth and the State of Queensland including regulations issued under any such Act and with the lawful requirements of public, local or other authorities applicable to this MOU.

14.4. This MOU may be executed in any number of counterparts and by the Parties on separate counterparts. Each counterpart constitutes an original of this MOU, all of which constitute one MOU.

SIGNED by the parties on the respective dates set out below:

SIGNED for and on behalf of)
STATE OF QUEENSLAND)
By David Stewart,)
Director General)
Department of Transport)..... D Stewart
) *(signature)*
15 / 6.
(date)

Witnessed by DEANA ARDEN)..... D. Arden
Of TRANSPORT AND MAIN ROADS) *(signature)*

15 / 7 / 10
(date)

By, John Bradley)
Director General)
Department of Environment and)
Resource Management) *(signature)*

..... / ..... / .....

Witnessed by)
Of) *(signature)*

..... / ..... / .....
(date)

By, Ian Fletcher)
Director General)
Department of Employment, Economic)
Development and Innovation) *(signature)*

..... / ..... / .....

Witnessed by)
Of) *(signature)*

..... / ..... / .....
(date)

SIGNED by the parties on the respective dates set out below:

SIGNED for and on behalf of)
STATE OF QUEENSLAND)
By David Stewart,)
Director General)
Department of Transport)……
) *(signature)*

…… / …… / ……
(date)

Witnessed by)……
Of) *(signature)*

…… / …… / ……
(date)

By, John Bradley)
Director General)
Department of Environment and)……
Resource Management) *(signature)*

2 / 7 / 10

Witnessed by Margaret GEORGA)……
Of Dept of Environment &) *(signature)*
Resource Management

2 / 7 / 10
(date)

By, Ian Fletcher)
Director General)
Department of Employment, Economic)……
Development and Innovation) *(signature)*

…… / …… / ……

Witnessed by)……
Of) *(signature)*

…… / …… / ……
(date)

SIGNED by the parties on the respective dates set out below:

SIGNED for and on behalf of)
STATE OF QUEENSLAND)
By David Stewart,)
Director General)
Department of Transport)……
) *(signature)*

…… / …… / ……
(date)

Witnessed by)……
Of) *(signature)*

…… / …… / ……
(date)

By, John Bradley)
Director General)
Department of Environment and)……
Resource Management) *(signature)*

…… / …… / ……

Witnessed by)……
Of) *(signature)*

…… / …… / ……
(date)

By, Ian Fletcher)
Director General)
Department of Employment, Economic)……
Development and Innovation) *(signature)*

12 / 7 / 10

Witnessed by REBECCA GOODAIR)……
Of DEPARTMENT OF EMPLOYMENT, ECONOMIC DEVELOPMENT AND INNOVATION) *(signature)*

12 / 7 / 10
(date)

SIGNED for and on behalf of)
GOLD COAST CITY COUNCIL)
By Dale Dickson)
Chief Executive Officer

..... *(signature)*

21 / 6 / 10
(date)

Witnessed by:)
Of)

..... *(signature)*

21 / 6 / 10
(date)

SIGNED for and on behalf of
MARINE QUEENSLAND
(ACN: 009 930 741)
in accordance with s127 of the Corporations Act 2001

on this day _____of_____ 2010

By) .....
Name – Sole Director/Director (print name) (signature)

By) .....
Name – Director/Secretary (print name) (signature)

NOTES FOR COMPANIES SIGNING AGREEMENTS:

- Seal is not required – but may be used.
- Sole director companies simply insert name and sign as **sole director** (striking out director).
- Other companies sign by **two directors** or by a **director and secretary,** striking out the inapplicable title.
- Where an **attorney or other agent** executes this Agreement on behalf of a company, the form of execution must indicate the source of this authority and a certified copy of the authority must be provided to NRW.
- A witness is not required in any case, except for an attorney or other agent where the source of authority requires a witness.

SIGNED for and on behalf of)
GOLD COAST CITY COUNCIL)
By Dale Dickson)
Chief Executive Officer

..... / ..... / .....
(date)

Witnessed by:)
Of)

(signature)

..... / ..... / .....
(date)

SIGNED for and on behalf of
MARINE QUEENSLAND
(ACN: 009 930 741)
in accordance with s127 of the Corporations Act 2001

on this day 13 of 7 2010

By Stuart Russell)
Name – Sole Director/Director (print name)

(signature)

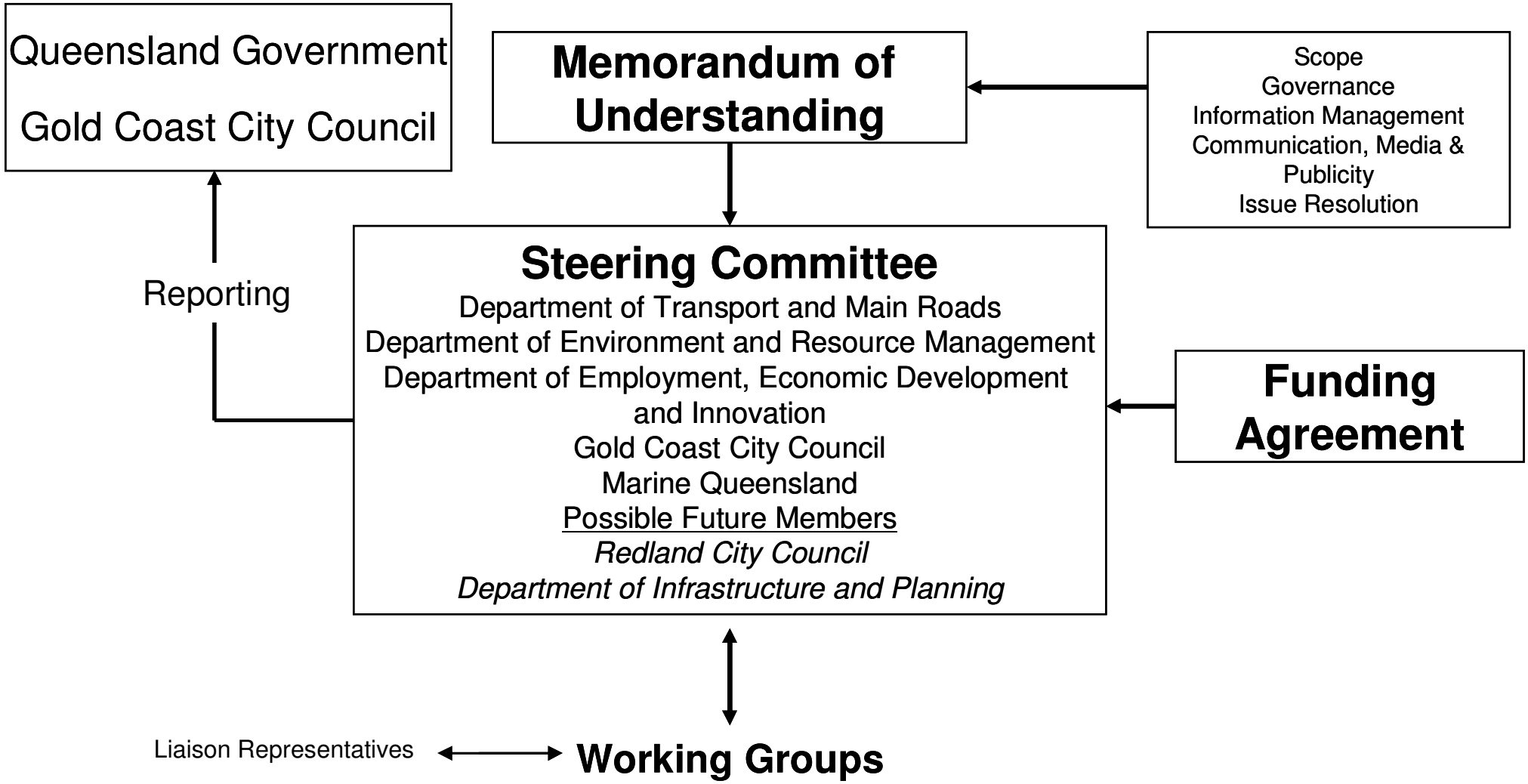
By Donald Jones)
Name – ~~Director~~/Secretary (print name)

(signature)

NOTES FOR COMPANIES SIGNING AGREEMENTS:

- Seal is not required – but may be used.
- Sole director companies simply insert name and sign as **sole director** (striking out director).
- Other companies sign by **two directors** or by a **director and secretary**, striking out the inapplicable title.
- Where an **attorney or other agent** executes this Agreement on behalf of a company, the form of execution must indicate the source of this authority and a certified copy of the authority must be provided to NRW.
- A witness is not required in any case, except for an attorney or other agent where the source of authority requires a witness.

SCHEDULE 1
Governance Structure



SCHEDULE 2

Registered Contact Information of Parties

Department of Transport and Main Roads
GPO Box 2595
Brisbane QLD 4001
msqmail@msq.qld.gov.au

Department of Environment and Resource Management
GPO Box 2454
Brisbane QLD 4001
coastal.support@derm.qld.gov.au

Department of Employment, Economic Development, and Innovation
PO Box 15168
City East QLD 4002
ian.fletcher@deedi.qld.gov.au

Gold Coast City Council
PO Box 5042
Gold Coast MC QLD 9729
gcccmail@goldcoast.qld.gov.au

Marine Queensland
PO Box 3305
Tingalpa DC QLD 4173
don@marineqld.com.au

SCHEDULE 3

Dredging Working Group Terms of Reference

Mission

To provide a system of well maintained navigation channels and manage dredged resources within Gold Coast tidal waterways and adjoining coastal waters in a manner that is cost effective and provides broad benefits.

Objectives (obtainable and measureable)

- Navigation channels are maintained to an agreed standard.
- Opportunities to realise sand management cost efficiencies, including sand commercialisation, are pursued.
- Dredged material (sand and mud) management activities are conducted so as to promote environmental and social outcomes where feasible.
- Knowledge and information of relevant coastal and environmental processes is shared, with research and monitoring undertaken where appropriate.
- Dredged material (sand and mud) may be allocated to protect coastal and foreshore infrastructure in order to strategically respond to the needs of the community and the impacts of climate change.
- Key stakeholders are kept informed of the activities of the working group.

Scope (inclusion and exclusions)

- Dredged material (sand and mud) management activities of shared interest in tidal and coastal waterways (including navigation channel dredging).
- Coastal and foreshore protection studies, infrastructure development and maintenance work of shared interest.
- Excludes non tidal waterways, irrigation channels and stormwater infrastructure.
- Excludes floodplain management as a direct responsibility of the working group; however navigation channel dredging may provide secondary flood benefits.
- Excludes work within tidal waterways, coastal and foreshore areas that is not of shared interest.

Sunset/Review Period

The working group is intended to operate on an ongoing basis subject to an annual review by the Steering Committee to confirm its continued function.

Core Members (maximum of 8)

Organisation	Role or Interest
TMR	Navigation Channel Dredging – Central Representative
TMR	Navigation Channel Dredging – Regional Representative
DERM	Natural Resource and Environment Group (Environment Planning)
DERM	Regional Service Delivery SEQ (Environmental Regulation)
DEEDI	Project Development and Facilitation
DEEDI	Fisheries
GCCC	Engineering Services
MQ	Marine Queensland Representative

Responsibilities of Participants

- Being aware of the terms of reference and their individual role and responsibility within the Working Group.
- Attend all meetings and contribute to the function of the Working Group.
- Implement the directions of the Steering Committee.
- Share knowledge and information openly and work together in good faith with respect for one another.
- Provide advice to the Steering Committee as required.
- Assist with preparation of Working Group reports to the Steering Committee.
- Represent their organisation to the Working Group.
- Represent the Working Group within their organisation and implement agreed actions as required.

Endorsement of Terms of Reference by Steering Committee	
Meeting Minute Date/Number	

SCHEDULE 4

Destinations, Access and Management Working Group Terms of Reference

Mission

To plan for the provision and sustainable management of boating destinations and access to waterways to promote the Gold Coast maritime experience, with due recognition of competing interests and demands.

Objectives (obtainable and measureable)

- Better coordinate between jurisdictions and interests.
- Provide convenient access to waterways and destinations.
- Promote Gold Coast waterway destinations to sustainably manage demand recognising the unique recreational and environmental characteristics of destinations.
- Improve the recreational experience of Gold Coast waterways and destinations for the community and visitors.
- Work with relevant local business representatives and keep key stakeholders informed of the activities of the working group.
- Recognise the critical link between environmental values and the recreational experience.

Scope (inclusion and exclusions)

- Strategic planning and provision of public boat ramps, jetties and pontoons.
- Identification of new destinations, destination improvement opportunities and associated management issues that will provide for a variety of maritime experiences and respond to community needs over time.
- Consider waterway, destination and associated access facility management issues.
- Strategies that improve community awareness and understanding of Gold Coast waterway destinations and access infrastructure.
- Identification of funding opportunities from both the public and private sectors to support projects.

Sunset/Review Period

The working group is intended to operate on an ongoing basis subject to an annual review by the Steering Committee to confirm its continued function.

Core Members (maximum of 8)

Organisation	Role or Interest
TMR	Waterway Access Infrastructure
DERM	QPWS Marine Parks (Moreton Bay)
DERM	Regional Service Delivery SEQ (State Land)
DEEDI	Tourism Development
GCCC	Engineering Services
GCCC	Community Services
GCCC	Economic Development
MQ	Marine Queensland Representative

Responsibilities of Participants

- Being aware of the terms of reference and their individual role and responsibility within the Working Group.
- Attend all meetings and contribute to the function of the Working Group.
- Implement the directions of the Steering Committee.
- Share knowledge and information openly and work together in good faith with respect for one another.
- Provide advice to the Steering Committee as required.
- Assist with preparation of Working Group reports to the Steering Committee.
- Represent their organisation to the Working Group
- Represent the Working Group within their organisation and implement agreed actions as required.

Endorsement of Terms of Reference by Steering Committee	
Meeting Minute Date/Number	

SCHEDULE 5

Marine Industry Planning and Major Development Projects Working Group Terms of Reference

Mission

To provide a forum for raising and promoting marine sector opportunities, and identifying potential solutions for constraints. To Provide advice to government during the preparation and implementation of strategic plans and policies, and when considering major marine development projects. To advocate to improve and sustain the provision of marine related infrastructure on the Gold Coast by all levels of government.

Objectives (obtainable and measureable)

- To improve planning for and recognition of waterway infrastructure within Government policy.
- To consider major marine related development proposals, identify opportunities and constraints, and to collaborate on potential solutions where appropriate.
- To assist policy makers by providing an opportunity for government and industry to work together to identify relevant planning issues and solutions.
- To contribute to the viability and sustainability of the Gold Coast economy particularly with respect to the marine and tourism sectors.
- Key stakeholders are kept informed of the activities of the working group.

Scope (inclusion and exclusions)

- Identify and consider potential impacts of proposed major marine development on waterway infrastructure and the marine environment.
- Provide advice regarding marine related planning issues when considering reviews or amendments to planning policies such as the SEQ Regional Plan; Southern Moreton Bay to Broadwater Marine Infrastructure Master Plan; Coastal Plan; Moreton Bay Marine Park Zoning Plan, and Gold Coast Planning Scheme.
- Identify and support major marine related economic development opportunities.
- The working group will not assess development applications.
- The working group will not prepare policy documents; rather it will review proposed amendments and provide advice back to government.
- The working group will generally not consider small scale private marine infrastructure associated with residential developments.

Sunset/Review Period

The working group is intended to operate on an ongoing basis subject to an annual review by the Steering Committee to confirm its continued function.

Core Members (maximum of 8)

Organisation	Role or Interest
TMR	Waterways Planning and Infrastructure
DERM	Natural Resource and Environment Group (Environment Planning)
DEEDI	Gold Coast Centre
DEEDI	Marine Industries
GCCC	Planning, Environment and Transport Directorate
GCCC	Economic Development
MQ*	Marine Queensland Representative
DIP	Planning Representative

* To avoid any potential Conflict of Interest, MQ will be excluded from any discussion or information relating to major development proposals.

Confidentiality of Major Development Proposals

Information and discussion relating to major development proposals will be treated as commercial in confidence at all times. Minutes must identify confidential information. A non confidential version of the minutes will be provided to Marine Queensland and for public distribution.

The Chair must notify the Steering Committee Chair of Confidential Information which must not be provided to Marine Queensland as a Party to the Steering Committee.

Responsibilities of Participants

- Being aware of the terms of reference and their individual role and responsibility within the Working Group.
- Attend all meetings and contribute to the function of the Working Group.
- Implement the directions of the Steering Committee.
- Share knowledge and information openly and work together in good faith with respect for one another.
- Provide advice to the Steering Committee as required.
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Endorsement of Terms of Reference by Steering Committee	
Meeting Minute Date/Number	